

ECHOLOCATION AND FLASHSONAR

DANIEL KISH

Jo Hook



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American Printing House for the Blind
Resource Services
1839 Frankfort Ave.
Louisville, Kentucky 40206-0085
Phone: 502-895-2405
Customer Service: 800-223-1839
Fax: 502-899-2274

Project Staff

Daniel Kish, Author

Jo Hook, Author

Terrie (Mary T.) Terlau, Project Leader

Laura Zierer, Research Assistant

Adam Clark, Manufacturing Specialist

Matthew Poppe, Graphic Designer

About the Authors

Daniel Kish is an internationally-acclaimed expert in the field of echolocation/FlashSonar. He obtained a master's degree in Life-Span Developmental Psychology from California State University, San Bernardino, and a master's degree in Special Education from Cal State Los Angeles. He is the first totally blind person to hold both national certificates in orientation and mobility: Certified Orientation and Mobility Specialist (COMS) and National Orientation and Mobility Certificant (NOMC).

After losing both eyes to retinoblastoma by the time he was 13-months old, Daniel began using active echolocation/FlashSonar to navigate the world as a toddler, and has spent the majority of his adult life teaching others to navigate using echolocation/FlashSonar. In 2000, Daniel founded World Access for the Blind, a nonprofit dedicated to the development of an instructional philosophy and evidence-based instructional techniques for teaching persons with visual impairments to navigate freely, effectively, and joyfully. He serves as the president of World Access for the Blind and provides what he calls perceptual navigation instruction internationally. He is a prolific writer and international presenter in the area of accessible navigation with the long cane and echolocation/FlashSonar, having consulted on a number of studies in human perception and technical applications. He continues to update instructional philosophy and methods to incorporate new research and instructional discoveries.

Jo Hook first qualified as a Solicitor, and then became a law teacher and legal editor before retraining as a rehabilitation worker for the visually impaired. Jo then gained a teaching diploma and an MA in education and worked as a Senior Lecturer in Rehabilitation Studies at Birmingham City University. Jo currently works part-time as a rehabilitation worker. She is a

proponent of the philosophy and instructional methods of World Access for the Blind and has worked with Daniel Kish during his presentations and instructional sessions in the United Kingdom. She contributes the strong research base for this book. Jo is based in the UK.

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“For me, adjectives such as happy, contented, blissful, enjoyable, do not seem quite appropriate to any general description of this process I have called the good life. . . . But adjectives which seem more generally fitting are adjectives such as enriching, exciting, rewarding, challenging, meaningful. This process of the good life is not, I am convinced, a life for the faint-hearted. It involves the stretching and growing of becoming more and more of one’s potentialities. It involves the courage to be. It means launching oneself fully into the stream of life.”

(Rogers, 1995, p. 196)

Introduction

Daniel Kish writes:

On my first day of first grade, the buzzer rang for morning recess. This catalyzed an immediate eruption of shrill voices bursting with nervous excitement, punctuated by a tempest of crashing and clinking chairs against desks. Every chair against every desk registered on my consciousness—each metal leg striking metal leg and each plastic chair back banging wooden desktop or clunking against the hollow, metal under-shelving. The noise was somewhat new to me, because the year before in Kindergarten, we had spent most of our class time on the floor in a circle. When we did work, the desks and chairs only occupied about a third of the room, and that had been the third nearest the door. Now, the clash and crash of movement filled the entire large, square room from wall to wall.

Although someone had familiarized me with parts of the room previously—the location of the door, the sink, my desk, and the circle time area—I already knew the shape and size of the whole room by its

echoes which came to me from its walls and corners, even though I had not explored these. However, I did not learn how I knew this until years later. Nonetheless, the image of the room's shape and size presented itself vividly to me at all times. The floor was carpeted, so at least the chairs didn't scrape and squeak against the floor which used to make me cringe. This universe of clatter quickly dissolved into a wave of seemingly countless thudding shoes carrying a ringing chorus of voices, all stampeding toward the corner of the room to my left, and slightly behind me. I occupied the last desk in the last row of desks nearest the corner of the room opposite the door. They thought this desk would be easy for me to find, which it wasn't. The desk nearest the door would have been easier, though. In retrospect, it was rare that my desk was positioned nearest the door, possibly because they may have thought I would have clogged up traffic or gotten run over. In fact, I'd have been the first one long gone out the door before traffic would have been an issue, but I didn't think of that until later.

With a splunk of the push bar and a subtle whoosh of air, the door was flung open. The room drained of sound as the myriad of gleeful voices streamed away into open space, merging with a swelling tide of noise and movement beyond. I ambled toward the column

of noise framed by the doorway, occasionally clicking my tongue quietly in order to gage my proximity to the wall on my left, and also to avoid chairs left askew along the way. They had tried to teach me to trail the wall with my hand to the doorway, but I found that awkward and slow. Directing myself toward the shrill symphony of kids at play which breathed against me on a cool breeze, I clicked again to center myself as I passed through the open doorway. The muffled silence of the carpeted classroom, now empty, closed in behind me as I entered the oceanic expanse of the new playground beyond.

After a few steps, I dimly felt where the smooth cement turned to somewhat rougher pavement. Under my feet, I could feel a crack that I discerned ran parallel to the long building whispering behind me. I knew by experience that this crack was an important feature to remember, and I wished my feet were not so rudely encased in shoes.

I paused to consider the strange, chaotic scene stretching out in all directions before me. Clicking and swiveling my head from side to side, I scanned the expanse, straining to penetrate the heavy curtain of commotion. The world suddenly seemed bigger and noisier than anything I had ever encountered—teeming with flocks of darting voices, swarms of

bouncing balls, and battalions of scuffling shoes, all darting and swirling in a mesmerizing tapestry of motion. Like the chairs against the desks, each individual sound, each footfall, ball bounce, and shouting voice, called to me, threatening to split my attention into a chaos of fragments blown in the wind.

This playground, and this extent of activity and commotion, was completely new to me. Prior to starting first grade, I had only been oriented to the primary-students' classroom building, taught to trail the wall of smooth, bevelled bricks with my hand from my first grade classroom five doors down to the resource room where I would learn braille. I didn't need to trail the wall with my hand in order to follow it, for I could hear its presence just as easily, but I could not distinguish the closed doors by clicking, so I counted them by hand until I became familiar with the distance.

I had no cane; mobility training wasn't provided to children my age in 1972. Although this practice has changed in the U.S., it remains this way in most countries. A short introduction had been given to my class that morning about a blind child among them, but we did not have aides looking after special education children in those days, so as I entered the playground I stood near the building all alone.

I wasn't scared though. I generally preferred to be alone, and in all my time in school since I was two years old, I had thought little about not being guided or helped along. I had been clicking my tongue to get myself around for as long as I could remember. I did not even have to think about my clicking, for it came as naturally to me as breathing.

To this day, I have always enjoyed figuring things out and finding my way around new spaces: What is around me? How do I get there? What do I do when I find it? How do I get back? New places have always been like intriguing puzzles to me, and this day was no different. I'd have given anything to be rid of these stupid shoes, though. Having kept barefoot most of the time, I had grown accustomed to reading every nuance of ground with my feet, making the ground with every step a kind of map comprised of tell-tale textures, shapes, and temperatures. As I stood poised to venture into this strange, noisy place, my main discomfort was that I could barely read the ground beneath me.

At first, I found the noise on this new playground oppressive, threatening to swallow me up. But curiosity won out over mild apprehension. I stepped gingerly forward, clicking quickly and loudly to cut through the cacophony while turning my head left

and right to hear where my clicks came back to me as echoes. Clicking and listening allowed me to find the clear spaces, and I walked methodically over the pavement, threading my way between clusters of bodies, undulating blips on my “radar.” Keeping my distance from the boinging thud of bouncing balls and the repetitive clack of twirling ropes, I moved cautiously at first, but gained speed as I found my “fit” into these busy surroundings. From time to time I clicked back over my shoulder. As long as I could hear the hard surface of the building call back to me through the undulating crowd, I knew I could find my classroom again.

The storm of noise stretched in all directions, and the building was fading fast through the bedlam fog as I stepped forward. I hesitated, wondering if I should return to the building while I still knew I could, but the skittering of a ball behind me followed by shoes pelting lightly after it spurred me onward. I knew there must be quiet fields of grass somewhere; softer open spaces like there had been on my kindergarten playground. Noticing a slight downward slope of the pavement, I realized that if I could get back to the slope, I would be able to follow it most of the way up toward the building. Once I got close enough to it, I would be able to hear it.

Eventually, the pressing din gave way to a softer hue, taking on a slightly muffled quality, while my clicking inquiries found no reply. With relief I sped up, eager to find the open quietude of the large field of grass that I knew lay shortly before me. Despite the awful, rigid school shoes I was required to wear, I felt my feet hit grass. Stimulated by the promise of great adventure, I broke into a run, quickly clicking to ensure that nothing stood in my way. Finally emerging from the heavy fog of noise, I felt as freed as a bird taking joyful flight.

Then, suddenly, something whispered back to me from the open expanse, and I jolted to a stop. "Hi," I ventured in a bell-like treble. There was no reply. As I scanned, clicking more softly, the something quietly told me about itself—it was taller than me, and too thin to be a person. As I reached out to touch it, I knew already that it was a pole. I was glad I found it with my tongue and not my head. As I followed the pole upward with upstretched hands, my probing fingers encountered a small metal cap adorning the top of the pole a few inches above my head. I clicked around me, and barely heard something else whispering back. Leaving the pole, I moved toward this next thing as it called to me with a similar voice, telling me that it was also a pole. I detected yet another one and another—four poles in a straight line

before I reached the end of them. Later I would learn that there were actually nine poles in all comprising a slalom course, and that one day I would be able to slalom rows of trees on a bicycle while clicking madly.

A strident buzzer abruptly sliced the air. More annoyed than startled, I froze and raised my hands to my ears. When its dreadful assault finally ceased, I lowered my hands to hear buildings from far away calling back to me from several directions surrounding the immense grass field. I detested the buzzer, but the distant voices echoed back from every direction like my private serenade of wistful music, as if singing to me about just how big this field was, and of the houses and neighborhoods that lay beyond. I stood motionless a moment, amazed. I had never been in anything this vast. I scanned around me, clicking, but I couldn't hear my classroom building over the great distance and bedlam of kids. As I fell in step with the tide of movement all flowing in a single direction, I clapped my hands with a sharp report, and something large called back through the tangle of piping voices and scurrying shoes. As I moved toward it, the grass gave way to pavement, and as I stepped quickly up the slope, clicking and clapping, I heard the unmistakably broad, clear voice of a wall drawing nearer.

As I approached the building, I caught the exchange of other kids talking about me:

—“How does he know where he’s going if he can’t see?”

—“He’s got some kind of radar.”

The crowd noise organized itself and grew less assaultive as voices began to drop into hushed tones. I heard kids in lines facing the wall, their subdued voices organized in rows. I didn’t know why they were lining up or what I was supposed to do and I couldn’t tell where my classroom was. I stood a moment to ponder my next move when someone called my name off to my right. I recognized the bell-like voice of my teacher, Mrs. Mullen. I really liked her voice, and I really liked her. I started to walk along the crack parallel to the wall toward her voice, but kids were standing on it. I moved in toward the wall, clicking and walking between it and the fronts of the lines. A child came running up to me, then. “We’re over here,” came the voice of a boy I recognized. I wasn’t good at recognizing voices, but this one was unusually rough for a first grader, and he had some kind of an accent. He sat at the desk next to mine, but I couldn’t remember his name. As I walked beside him, I could tell he was a little taller, which was good, because it

made him easier to keep track of. "How come you can't see?" He whispered. The voices of all the other children had dropped also to whispering murmurs. "Cuz my eyes are made of plastic," I whispered back. I sensed his body turn, his head cocked to stare transfixed into my face, his breath catching. His shoes shuffled awkwardly as he almost side-stepped along half in front of me.

"We're right here," I heard Mrs. Mullen say, "Thank you Michael for being so helpful." I clicked and listened to find where the kids, now almost breathlessly quiet, were lined up. "Michael," Mrs. Mullen's voice rang quietly, "Why don't you help Daniel find the end of the line?" But I had already turned away from the building and begun clicking along the line of kids, when Michael's hand touched my shoulder. "It's over here," he announced quietly, tugging me in the direction I was already going.

"Michael," Mrs. Mullen called, "let him take your arm." But, by then, we were already there. Michael positioned himself in front of me, evidently not wanting to be the last in line.

As the line began to move forward, I clicked rhythmically to track Michael's movements forward. I'd been taught to place my hands on the shoulders

of the person in front of me, but something about Michael made me uneasy, and I felt uncomfortable touching him. As we filed into the room, I clicked and scanned to avoid kids as they shuffled into their chairs. As I clicked along the wall to my right toward the corner nearest my desk, I noted thankfully that our coming in was a lot quieter than leaving had been. "Your desk is right here," I heard Michael insist in a tone half disgruntled, half surprised. "You're going too far!"

"I know!" I shot back, my very treble voice suddenly edged a little too loudly over the subdued shuffling of chairs and shoes on carpet. I had already sensed the distance from the wall in front of me, and I knew I had arrived at my desk at the end of my row. I reached to my left and found a desk with a braillewriter on it.

"How come you can't see where you're going?" I heard Michael ask, half under his breath almost as if he were addressing the question to someone else beside him.

"Plastic, eyes," I over emphasized each word as I slid into my seat, annoyed at having to repeat myself "and, I know where I'm going."

But as I settled into my chair, my annoyance quickly faded as my mind already raced to the next recess, excitedly anticipating the treasures of the new playground.

“People were saying, ‘we would like more information on this,’” says Prof. Diane Fazzi, Chair of the training program at California State University, Los Angeles, who attended Daniel’s very first presentation on echolocation, delivered by invitation to the California Association of Orientation and Mobility Specialists in 1994. “They thought it was very important. It has a lot of promise. It’s going to benefit a lot of blind people” (Nicolosi, 1994).

Since those first days so long ago, the use of advanced forms of echolocation by people who are blind and its implications for science, teaching, and unprecedented freedom of movement has gained increasing public interest through hundreds of written publications, radio broadcasts, online forums, and programs on nearly every major TV network in the world. The last ten years in particular has seen the impact of focused echolocation training on the navigation of people who are blind become a mounting topic of interest across many disciplines including natural and neural science (Stromberg, 2013 in the Smithsonian; Bleicher,

2012 in Scientific American Mind); human interest (Finkel, 2013 in National Geographic Magazine); health (Rosenblum, 2009 in Psychology Today); business (Shea, 2011 in the Wall Street Journal); education, and entertainment (Ker, 2009 in Mountain Bike Action Magazine) to name a few. Most recently the demonstrable impact of echolocation instruction on freedom of movement for people who are blind has been showcased in high-profile public forums including PopTech (Borthwick, 2011), TED (May 2015), and Idea Festival (2015). Public interest has also been raised by the Marvel's Daredevil series in America whose protagonist, a lawyer who is blind, is a masked vigilante who uses echolocation.

As noted by Professor Mel Goodale, Canada Research Chair in Visual Neuroscience and Director of the Centre for Brain and Mind, "It is clear echolocation enables blind people to do things otherwise thought to be impossible without vision and can provide blind and visually-impaired people with a high degree of independence" (Goodale quoted by University of Western Ontario, 2011).

By way of example, as reported in Der Spiegel Magazine, a top European publication, "One of the trainers is Juan Ruiz, a well-known flash-sonar expert [trained by Daniel since 1994]. In several

YouTube videos he can be seen riding a mountain bike through rough terrain. Indeed, before making his way to Berlin, Ruiz made a stop in Italy, where he set a new Guinness World Record. A television studio in Milan was outfitted with an obstacle course featuring ten columns spread out over a 20-meter (66-foot) path. The cameras rolling, Ruiz mounted his bicycle and pedalled away, constantly clicking. The spellbound audience followed Ruiz's progress as he navigated his way forward guided by what seemed like a sleepwalker's instincts. One column after the next seemed to enter his field of vision. He curved to the left and to the right and, after 48.34 seconds, rolled over the finish line without a single mistake" (Dworschak, 2011).

It is in light of this prolific wave of public interest that the present authors, two enthusiastic mobility specialists, have observed a corresponding eagerness among blindness-related practitioners and consumers who are blind to expand their body of knowledge and refine their understanding about how to learn and teach echolocation to support blind navigation to a level of sophistication that is now known to be possible.

As Ken Lord (2010), mobility instructor of nearly 50 years and President Emeritus of the Mobility

Association of South Africa, neatly summarizes after arranging and attending two, 2-day workshops led by Daniel and members of his Team, "Blind humans using flash sonar, which is much more than just echolocation, can move about as though they have a crude but effective form of vision. They can be well oriented, negotiate obstacles gracefully, quickly, safely, and be extremely independent—thus enjoying a wide variety of meaningful life activities. A blind traveler can receive multi-dimensional information from distances of many meters, depending on circumstances. Echoes make information available about the nature and arrangement of objects and environmental features such as overhanging branches, walls, doorways and recesses, poles, up curbs and steps, flower boxes, pedestrians, fire hydrants, parked or moving vehicles, trees and other foliage, and much more. Echoes can give detailed information about location (where objects are), dimension (how big they are and their general shape), and density (how solid it is). . . . The blind participants, with a crowd of 40-odd mobility instructors and parents observing, were taught to create and use a series of unobtrusive tongue clicks, . . . Lessons progressed to obstacle detection which included openings, poles, trees, and vehicles. . . . but to me, the cherry on top was the ability to detect the shape and outline of a vehicle and with a little practice pronounce that it

was a bakkie, passenger car, or a 4X4. . . . Hopefully O&M instructors and blind people themselves will take forward what was learnt at both workshops” (Lord, 2010).

It seemed a good opportunity to support the O&M profession to take the lead in addressing this wave of interest on all fronts, especially the rapidly growing number of requests for this training streaming in from blind consumers throughout the world. So, this book was brought into being to provide the necessary materials to enable people to understand not only what echolocation is, but how it can be easily and consistently taught and learned to a sophisticated level of daily use.

Daniel Kish is not only widely regarded as one of the most famous echolocators worldwide, but he is reputed to be the most experienced teacher of echolocation skills, having taught for over 20 years in more than 40 countries (Cloutier, 2015; Utne, 2009; Levitt, 2015).

Prior to her position as Senior lecturer specializing in Orientation and Mobility, Jo Hook held a career as an attorney (solicitor). As such, she strives to establish her practice and instructional approach on evidence-based or proven research rather than personal opinion

or unsupported adherence to long tradition. This blend of many years of practical knowledge and academic interest hopefully makes this book informative, interesting to read, and easy to follow.

The authors seek to bring to light the wealth of academic support that exists for echolocation from many fields and disciplines which clearly demonstrates that it is not an untested idea or a skill that just a few people can perform. Rather, it is a useful, proved skill for orientation and environmental interaction that is readily applicable to a broad diversity of individuals who are blind and visually impaired. “It’s very exciting,” says Gordon Dutton, formerly of the Royal Children’s Hospital in Glasgow, “I have seen echolocation being used—it’s quite stunning. It has been demonstrated to me that it absolutely works. Of course there will be skepticism and doubt, but the benefits are without question. It will make a massive difference to the lives of blind and visually impaired people” (Macaskill, 2008). In fact recent research has shown that it may go much further than that, with “converging evidence for the idea that echolocation may play a role in peoples’ successful adaptation to sight loss” (Thaler, 2013a, p. 9).

According to Kenneth Jernigan (who was blind himself and a noted leader in the blindness field),

“independence is the ability to go where you want when you want without inconvenience to yourself or others” (Jernigan, 1993). In a similar vein Huebner and Sidwell (2004) define independence as “the ability to travel efficiently and comfortably, when, where and by the manner that one chooses to use in order to fulfill one’s personal life need” (Huebner & Sidwell, 2004, p33). One choice that leads to independent travel for those who are visually impaired or blind is to use a long cane. However, the long cane has its limitations such as “the inability to detect obstacles that are not rooted to the ground, for example, wall-mounted bookcases and overhead signs. Long canes allow for immediate ground-based detection, but do not provide sufficient information to accurately perceive the environment” (Davies 2008, p. 2).

As Eric Weihenmayer, the first person who is blind to summit Mt. Everest and all seven of the world’s highest peaks, writes “I wish I’d known FlashSonar [Daniel’s coined term for active echolocation] a few months ago when I was walking through the airport and slammed my forehead into an overhanging metal beam. I hit the deck with blood pouring down my face and into my eyes. I still have a big scar and worst of all, I lost my latte” (Weihenmayer, 2013). The long cane can only allow for physical perception of what

it can reach. Echolocation can allow for perception of the environment beyond the cane's reach. Austin software developer Nolan Darilek, blind since birth, said Daniel Kish's training is almost martial arts-like in its discipline, unlike any he's ever experienced. Until he began working with Kish, he'd consigned himself to striking objects with his cane, drawing attention as he gets around. "I don't want to bludgeon my way through life," said Darilek, 30. "I want to move through it gracefully" (Ramirez, 2011).

However, echolocation also has limitations: It is relatively difficult to interpret echoes of objects that are roughly below knee height (Kohler, 1964). The simplest way of explaining how the cane and echolocation can complement each other is to say that echolocation is best used for objects at knee height and above, as well as objects out of physical reach, whereas the cane is best used for detecting objects within physical reach below knee height—what we call ground level objects.

As a boy's father observes, "Daniel's mobility training works by combining information gained by use of the long cane, a compass to orientate yourself, and echolocation. Daniel took us to a fenced recreation ground and asked Samuel to locate different apparatus by clicking.

He then had Sam use his compass, cane and clicks to find his way around the enclosure” (Lockwood, 2008, p. 39-40).

The authors are both very aware that “the essential problems of the blind. . . . are associated with mobility and with mastery of the environment” (Juurmaa, 1969, p. 80). Dr. Gordon Dutton (2008) comments, “developmentally in young blind children it is the lack of awareness and active engagement with the surrounding world which leads to major problems. It is therefore likely that young children in particular could benefit enormously from being trained in echolocation” (Dutton, 2008, p. 2). As Wiener, Welsch, and Blasch (2010) state decisively, “The traveller with visual impairment who is able to make good use of reflected sound learns to travel in a more sophisticated, more graceful manner than those who cannot” (p128). However, Ashmead and Wall (1999), point out, “the nature of this auditory ability remains poorly understood” (p. 314), and Feinstein (2001), observes, “Sadly, echolocation is not talked about, nor is it taught. It’s only learned intuitively or by example” (Feinstein, 2001, p. 4). Although information about echolocation has, in recent years, become more readily available in the mainstream media and various scholarly disciplines as noted above, information about it in the body of

literature associated with the orientation and mobility profession remains scant, and no comprehensive, systematic instructional methodology is known to have been published. Consequently, it is the authors' observation that echolocation is not commonly taught by instructors or learned by people who are blind to a sophisticated level.

There are likely to be many reasons for this. One of these, as suggested by Davies (2008), is that it may be seen as socially unacceptable. As three-time Australian Paralympian and accomplished athlete, Gerrard Gosens, puts it, "I live in a sighted world and for me it's about developing my skills to work into a sighted world. . . . The primary form of a mobility device should be either a white cane or a seeing eye dog" (Marshall, 2013).

Although the production of the clicking signal is audible, the authors maintain that the loudness of the click is not usually noticeable by others in a typical day to day environment. As one mom put it in a letter to a listserv: "On the topic of using a tongue click, I can again tell you from firsthand experience that it is hardly noticeable at all. . . . I also think the tongue click in no way resembles a blindism or mannerism (as cited in Kish, 2011, October, p. 7).

Both authors are passionate about people having information and opportunities available to them to make informed choices and achieve their full potential. "I strive to give my child access to all of the resources I can to help him become who he wants to be. . . . We want him to be as independent and free as he can be. To give him that, we want him to have access to all the options so that he knows what is possible and can make his own choices. . . . Echolocation training is most definitely helping to accomplish that goal" (as cited in Kish, 2011, October, p. 7).

The World Health Organization estimates that there are around 39 million people who are blind in the world and 246 million people with low vision (World Health Organization [WHO], 2010, p4). This figure is then said to be possibly 20% over- or underestimated because of difficulties obtaining accurate data. Echolocation could potentially benefit about 285 million people worldwide. It is intended that this book, which explains echolocation, provides the groundwork for most effective teaching and learning, and provides specific training exercises to enhance echolocation skills, can fill this informational gap to help more people to bring these skills to the high standards that are now achievable and expected. "Most blind people have learned to do this to some degree," Comments Erik Weißenmayer (2013) "but it's passive

and not developed with a conscious process. . . . So it was especially gratifying when, by the end of the day, I was finding metal poles in a pavilion and even locating thin metal sign posts. It all took immense concentration, but the good news is that it's fully possible, and only gets better with practice."

Many of the concepts presented here may seem elementary to some, while at the same time esoteric or very advanced to others. For example, many instructors already embrace the opportunity to provide cane training and training in perceptual development to toddlers and even infants, while many others still stand reluctant or skeptical. Some wholly embrace a hands-off, non-directive style of instruction, while others remain more directive. Some make family involvement a regular component of the instructional process, while others may only see the family once a year when meetings require them to do so. Some instructors regard blindness as a challenging condition that can be adapted to, while others regard it as a severe and limiting disability. The authors recognize that readers come with a very broad range of knowledge, and we have attempted to appeal to and offer useful perspectives and information for that broad range. This book can be used as a self-teaching guide for those looking for opportunities to improve upon their own echolocation skills, for parents to gain

greater understanding of their children's learning, and for teachers or Orientation and Mobility (O&M) specialists to train others to use auditory information more effectively.

The authors did not want potential readers to be put off by overcomplicated theories or an overly formal writing style. This book should be accessible to all, and those who want to delve more into the research can easily do so by following up some of the many references.

Finally, the authors also offer a friendly invitation to members of the field to stretch our thinking beyond long held traditional frameworks. For all their wisdom and insight, the pioneers of the Orientation and Mobility profession in the 1950's were noted experts in mid 20th century medicine. They were not experts in blindness, and they did not have access to modern knowledge of human perception, neurology, and biomechanics. With one exception, they were not blind themselves, nor were they daily users of the techniques they were developing. They filled a significant gap for blind people at a difficult time and are to be credited for their ground-breaking contributions at that time. That said, we propose that pioneers establish beginnings; they do not dictate endings. These pioneers of the 1950's, at a time when

people who are blind were routinely kept out of many sectors of mainstream society, would have had little idea of the challenges and possibilities that lay before people who are blind in the 21st century.

We find it useful to view our proposed model up-front as a dynamic, organic, open system of information exchange and development, as a system born of a loosely structured confluence of information and perspectives from many disciplines. What we did three or five years ago we may not do today, and many of our practices of today will likely fall away three to five years from now.

In striving for a more evidence-based approach, this book seeks to be clear about the clinical reasoning behind what we propose. Clinical reasoning is a term used by other professions to describe their ability to explain with logical understanding why an instructor or therapist would take a particular course of action with a particular client. This practice is relatively new to the Orientation and Mobility profession, and we applaud its formation. When asked “why”, orientation and mobility instructors are often still at a loss. Many students and parents have come to us and said, “They just can’t give me a reason,” or “she just said we’ve always done it this way,” or “that’s just best practice.”

We make every attempt to offer substantive, comprehensive, and well-supported reasoning behind everything we propose. When situations arise where the answers aren't clear, we seek to find them with complete earnest. We hope we have done this to the reader's satisfaction.

Chapter 1 — What is Echolocation?

This chapter introduces and explains the basic concepts of echolocation and how this skill can be used by those with a visual impairment to enable them to travel more effectively in the environment.

An Explanation

Echolocation is the use of reflected sound to gain information about the environment. The echolocator creates or emits sounds called echo signals, which strike surfaces in the surrounding environment and then return as echoes. “These waves reflect off walls, the ground, and any other obstacles in the environment before returning to each ear with an independent time and intensity” (Davies, 2008, p. 27).

The terms sonar and echolocation tend to be used interchangeably. Both refer to the use of reflected sound for navigation purposes. Sonar is actually an acronym that stands for Sound Navigation and Ranging. That term tends to be reserved more for technical applications, such as use in submarines or electronic sensors, although not exclusively so.

The term echolocation was first coined by Donald Griffin in the 1940s following his extensive research into the use of sonar by bats to assist them when flying at night to avoid obstacles. He stated that “since it must be the properties of such echoes which serve to inform bats about the nature and position of any obstacle that lies in their path, I have suggested the term echolocation as a convenient designation for this type of perception of objects at a distance” (Griffin, 1958, p. 77). Griffin’s pioneering research into the movement of animals (primarily of bats) led him to question “whether our knowledge of echolocation as it is practiced by bats and other animals has any practical applications to the problems of orientation confronting blind people every day of their lives” (p. 299).

Research conducted under controlled experimental conditions has shown that “echolocation improves blind people’s spatial sensing ability, in that it improves their ability to determine distance, location, motion, size, shape or material of surfaces” (Thaler, 2013a, p. 2). This use of sound can make the human traveler aware of information in the environment such as the location and nature of overhanging trees, walls, doorways, recesses, pedestrians, street furniture, vehicles and much more. As Dewald van Deventer (2014), one of Daniel’s students from South Africa,

puts it, “With this incredible skill, we can walk with more confidence, knowing what is around us, avoiding obstacles, without touching them. We can navigate parking lots, find the entrance of a building, walk around trees, instead of almost walking into them. . . . We can use loud clicks to hear a building fifty meters away. . . . In fact, it even goes further, to bicycling, and hiking. . . . This skill has empowered so many blind people, that it is no longer necessary for them to be guided by sighted people.”

These sound echoes can provide real, concrete images of space called auditory images that bear a gross resemblance to the spatial characteristics of visual images. As Dewald van Deventer, totally blind from the age of 10, puts it, “I believed for a long time that I could still see. . . . I thought I could see shadows and shapes. I didn’t believe I was completely blind—I thought the outlines were still there.” (Van Deventer, 2015). A proficient user of echolocation can use sound echoes to move among crowds of pedestrians without touching them and can distinguish a tree from a telegraph pole. As Ryo, one of Daniel’s Japanese students, has written (unpublished, 2011) “On my mobility training on Friday, I went to an underground shopping mall near [the] rehabilitation center. . . .

Before, I relied on handrails when walking aisles whenever possible, and I used to follow the guide block, the yellow tiles that are buried along the sidewalks and aisles, but I was quite confident, I just walk right in the middle of aisle without interfering with oncoming people traffic! . . . I can safely avoid the poles and signs on sidewalks, and my veering problem while walking down aisles inside a restaurant is no longer observed. . . . my mobility coach as well as other two blind friends of mine who still rely on guide blocks and handrails surprised how much faster I move around! . . . He told me it's remarkable achievement!" (unpublished, 2011). When describing this process, Kish (2009a) says, "Blind humans can fill the darkness with dynamic images derived, not from light, but from sound" (p. 3).

At a very basic level, echolocation is often self-taught. This basic echolocation enables the user to interpret basic information about surroundings near the user, but an advanced level of echolocation can enable a traveler to travel more rapidly and gracefully through more complex environments, as well as participate more autonomously in a wider range of activities.

As one mom stated about her 7-year-old son, "Samuel picked up the clicking quite easily. John [father] watched amazed as Daniel took Samuel to a shopping

center and saw them navigate around a store. It seemed incredible, but even after a few sessions I could see the difference it was making to Samuel. . . . Combining echolocation with his cane, Samuel began making his way to the letter box near our home in Poole, Dorset, and navigating supermarket aisles. He's even used it for activities like swimming and tae-kwon do. At school if he gets disorientated in the playground he uses a few clicks to work his way back to the building. We're so proud and hope he'll be able to choose the quality of life he wants rather than having it mapped out for him" (Rubner-Institut, 2008).

Ryo tells us, "Finally, I am now in touch with the conference organizer for an applied security conference that will be held in Tokyo in two weeks, and I got an official invitation! He thought I would not be able to make it this time, but after following what I have. . . . done in Long Beach [echolocation training], he is certain that I will be okay to be a part of conference staff this year! I will participate in interpretation and media relation, as I used to do before losing my eyesight. The echolocation and perceptual mobility training opened up the whole new world. . . . making impossible possible!!" (unpublished, 2011).

Davies (2008) states, "sophisticated echolocation to enable independent travel can take considerable training" (p. 26). However it is the authors' experience that, even after just a few hours of echolocation training, students are able to interpret the reflective characteristics of different objects, and begin to use echolocation to obtain more detailed information about the environment.

Van Deventer, who is South African, invited Kish to his home country so that Kish could teach him the technique. Although van Deventer found that learning echolocation is a process that requires constant practice, he is astounded at how quickly he has picked up the skill. "My first day, I doubted myself a lot, but I was able to count tree branches and poles," he says. "I continue to surprise myself every day" (Brown, 2011).

Juurmaa (1969) found that after just a half hour of training his blindfolded participants could judge an obstacle at a distance of 1.5 meters. "It seemed incredible, but even after a few sessions I could see the difference it was making to Samuel" (Rubner-Institut, 2008).

It is often noticed that users of echolocation tend to carry themselves with an erect posture, interact

with the environment gracefully, and look engaged. Children with echolocation skills have been described as developing “more autonomy, postural security, and knowledge of the object world” (Cutter, 2003a, p. 1). The mother of a child who has been taught echolocation skills points out “here is something positive that [echolocation] does do. It keeps the head up nicely, because when you click you scan your environment you lift your head up instead of hanging it down” (as cited in Kish, 2011, October, p. 7).

As Marta Fonmudeh (2013), an O&M Specialist in Australia, relates in a case study of one of her students after several sessions of echolocation training during Daniel’s workshops, “Annie is now ‘in charge’ of her mobility. . . . Annie has made a great shift in her posture, confidence level, and ability to travel independently. . . . She feels more relaxed and more confident asking appropriate questions to aid in her wayfinding. She is not self-conscious in public as she ‘clicks’ away. . . . She states she is empowered and more in control of the process and expresses her drive to continue on that journey, to keep improving her skills and experiences.”

Issues in Echolocation Acquisition

Although the specific mechanisms underlying the technical aspects of echolocation in humans have

been fairly well studied and are well understood, particularly concerning people who are blind, no systematic study of comprehensive training for complex echolocation has been reported. Most of the studies in this area are based on simple trial and error methods that concern very basic skills. They may address the question of whether or not echolocation can be learned. However, the application of echolocation skills to complex mobility and the question of how such skills should be actively taught for optimal effect remain to be systematically researched.

Nonetheless, collective studies of hundreds of humans clearly indicate that all hearing people can learn to perceive and interpret echoes to some degree—either by focused or incidental learning. It is not a special endowment “nor a rare ability practiced by a few skilled individuals” (Teng & Whitney, 2011, p30). It is a skill that can be learned by any individual who has the motivation and desire to learn. “It is, perhaps, a little known fact that all humans have an innate ability to echolocate” (Baker & Smith, 2012, p. 1).

Although few investigations have been reported concerning the specifics of how echolocation may be learned, most investigations have indicated improved performance in the participants on the

given tasks being studied. For example, Hausfeld, Power, Gorta, and Harris (1982) report considerable improvement for all 18 of the participants who were sighted-blindfolded on both the shape and texture discrimination tasks. Magruder (1974) found that in a 2-day study of distance, direction, and object perception, her participant's estimates of distance improved over 38% from one day to the next given practice and feedback.

Those investigations that do specifically examine the issues behind training echolocation have generally found very positive results. In one of the first of these, Worchel and Mauney (1950) studied the effects of practice on the ability of seven children who were blind to perceive their relationship to a large Masonite® panel. Both the position of the panel and the starting point of each child were varied randomly along a pathway. All of the children were asked to approach the panel, and indicate when the obstacle was first perceived (first perception), then to stop as close as possible to the obstacle without touching it (final appraisal). Initially, the children's perceptions of the panel were erratic and inconsistent. Collisions were frequent and forceful. Over the course of 210 trials spread over 4 days, all children showed marked improvement in perception of self-placement with respect to the target. Final appraisals dropped from

as high as 150 cm down to less than 30 cm for all participants, and the frequency of falsely perceiving the target decreased by more than 75%. Frequency of collisions between the pre- and post-tests decreased from 56 to 19, and the force of collisions decreased very markedly as well. All of the children showed the majority of improvement over the first 30 to 60 trials.

This study was later replicated by Ammons, Worchel, and Dallenbach (1953) with 20 adults who were sighted-blindfolded using the same procedure. Again, the participants' ability to localize the target and avoid collision decreased substantially over the course of a few days' practice. However, these participants showed much slower progress for the first few trials before picking up suddenly. Participants indicated a sudden awareness of the parameters of the task—of what to pay attention to and how. Once this insight was achieved, learning progressed rapidly before tapering off.

The present authors have also observed this burst of insight manifest in many students receiving echolocation training. Daniel calls this the "hook stimulus" or the "aha! moment." This will be further discussed in Chapter Four.

These trends are similar to those found by Kohler (1964) in which 20 participants learned to increase ability to judge distance over a 6-week training period.

It is uncertain from the study whether the more gradual initial progress might be attributed to the fact that these were participants who were sighted rather than participants who were blind or that they were adults rather than children, or perhaps both. It is Daniel's experience that children do tend to learn more quickly, especially if they have been blind for more than 3 to 5 years, but learning is well within the capacity of even older adults.

These observations of the effect of onset of blindness are roughly consistent with Juurmaa (1969) who found among 52 totally blind participants aged 17 to 50 years that those blind for less than 5 years (13%) evidenced no capacity to detect the presence of a large panel.

In earlier studies, however, Juurmaa, Suonio, and Moilanen (1968; Juurmaa, 1968) successfully trained three adult participants with progressive vision loss who evidenced no echolocation ability at the beginning of training. Training involved avoidance of multiple different-sized obstacles and determination of

height and breadth of the obstacles. The participants walked down a path on which one, two, or zero obstacles of varying size were placed. The participant was instructed to indicate when he first perceived each obstacle, to stop 0.5 m before reaching the obstacle, and to provide an estimate of the obstacle's dimensions. Sessions ran about 30 minutes per day for 4 weeks. With instructor feedback, participants learned to avoid collisions quickly and in an insightful manner similar to the results of previous studies.

In a study by Greystone & McClennan (1968), 26 children who were blind were instructed to navigate an obstacle course with the assistance of an electronic clicker. The obstacle course consisted of a series of walls with an opening at a different point along each wall. The effect was a maze of off-set openings through which the participants had to travel. After the children had undertaken the task as a pre-test, they were given the electronic clicker and told to practice at home over the summer. When the school year resumed, the children were tested again with the same course. Collisions and hesitant stops were reduced by about 50%, and time to complete the course was reduced by about 16%. No data were available regarding the nature of practice that took place over the summer.

Finally, Clarke, Pick, & Wilson (1975) studied 16 teenagers who were blind in a course of training to improve the ability to negotiate a complex obstacle course using echoes. Forty-minute training sessions took place twice weekly for 8 weeks. The participants were introduced to a variety of object perception tasks involving a diversity of objects including up-curbs, furniture, pipes, etc. For example, in one task, participants were asked to rotate about a room full of objects and describe any object they sensed around them. Feedback was provided regarding accuracy. All participants improved significantly on all tasks.

The research is clear that anyone without severe hearing loss can learn at least basic echolocation, and many appear to be able to learn more complex skills as well. Teng and Whitney (2011) demonstrated in experiments that some persons who were sighted “could be readily trained in coarse echolocation ability” some even “with a level of proficiency that approaches that of expert echolocators who are congenitally blind” (p. 29). As Ammons et al. (1953) put it, “The implications of this conclusion are far reaching: That all persons, blind but otherwise normal, are capable of learning to perceive obstacles; and that there is no reason, other than the lack of courage or the will to learn, for any of them leading a vegetative existence in which he has to be led about” (p. 551).

If echolocation can be passively or actively learned under appropriate conditions, then it stands to reason that, given the right conditions, echolocation can be actively taught or encouraged to a yet more sophisticated level.

Passive and Active Echolocation

Echolocation in its broadest sense has been defined by Rosenblum, Gordon, and Jarquin (2000) as “auditory information [that] supports a blind individual’s ability to navigate through the world” (p. 3). However, echolocation can be understood and utilized in a sophisticated manner.

To begin with, there are two types of echolocation: Active and passive. Passive echolocation occurs when sounds that are incidental in the environment solicit echoes, whereas active echolocation uses self-generated signals to solicit the echoes (Thomas, Moss, & Vater, 2004).

Passive echolocation relies on incidental sounds in the environment which elicit reflections, like a moving car in a tunnel, or sounds produced incidentally by the user such as her own footsteps. Welch (1964) wrote that “reflections of sounds being produced by the subject as he walks towards the object, footsteps, rustling of clothes, a cane’s tapping, or snapping of

fingers all can be used as sound sources” (p. 1). The images created in the user’s mind while using passive echolocation are usually relatively vague. While this type of echolocation can be used to gain information about large features or general layout, the incidental noises are not ideal for detection of small features or fine discrimination, especially at greater distances. This type of echolocation is more commonly taught than active sonar and is often used by people who are visually impaired when tapping the end of a cane on the ground and listening to the sound bouncing back; indeed some cane users favor particular tips such as the metal button, glide, or ceramic tip to aid this process.

Active sonar involves the use of a signal produced by the listener. The listener can direct a self-generated, consistent signal into the environment. The greater effectiveness of active sonar lies in the brain’s control over and familiarity with the signal which allows it to distinguish between the characteristics of the signal it produces from those of the returning signal (see Chapters Two and Four for more information). The returning signal is systematically changed by the qualities of whatever returns it, and these changes carry information about what the signal encounters. Thus, the qualities of the returning echo correspond with the qualities of the surfaces that returned it.

The brain's familiarity with the self-generated signal allows for relatively easy recognition of echoes even in complex or noisy environments. It's like recognizing a familiar face or voice in a crowd; the more familiar the voice, the easier it is to recognize. The images produced are relatively sharp in focus and detail. It is like the difference between taking a picture in strictly ambient lighting, or controlling the lighting by use of a flash or strategically placed lighting. While aesthetic appreciation may favor the natural look at times, no one can argue that photos and video are always clearer and crisper with sharper detail when the scene is brought under the control of the photographer.

The relative precision of active sonar compared to passive sonar is why it is used most widely in nature (by bats, toothed whales, and some nocturnal birds) and in technical applications. The characteristics of an active signal can also be adapted by the user to fit situations.

Many scientists actually refer to the process as "irradiating the environment" of sonar calls and interpreting their feedback as "interrogating the environment." Sonar calls are sent out actively for the purpose of soliciting information in a directed, intentional fashion. The environment may be said to respond to these calls with information. In this

connection, the more clearly the echolocator asks her questions, the clearer will be the answers. In essence, the echolocator is giving the environment, which would otherwise remain silent or whose voice would be obscure, a clear and distinct voice with which to answer queries. This process is interactive. The quality and scope of the information returned depends on the quality and delivery of the calls, and the calls are delivered and adjusted depending on the information received. Therefore, the preferred term used here is “conversing”; echolocators converse with the environment. Each call essentially makes two inquiries, “where are you” and “what are you.” As the environment responds, the echolocator may adjust her queries to broaden her search or solicit more details. She may raise or lower the strength of her call, focus it elsewhere by scanning, increase or decrease its repetition, and so on until the desired image is constructed.

There are two main applications of sonar—orientation and targeting. Orientation sonar is used to take stock of one’s surroundings (analyze the scene), to establish and track one’s position within those surroundings, and to navigate through them. This often requires awareness of elements at a distance. Targeting sonar is used to fix one’s attention on one or more targets in order to gain information about

them, to intercept them, or to avoid them. The sonar used for orientation usually takes the form of signals produced less frequently, and often at higher volumes, whereas signals for targeting purposes are typically emitted more rapidly and with decreasing volume as the target is scanned and approached (Thomas et al., 2004).

These two uses of sonar correspond to research and observations made independently in the blindness literature by Jansson (1989) who divided the mobility process into two similar categories—moving along (requiring maintenance of orientation), and moving toward (requiring location and recognition of chosen targets while negotiating other targets). This will be discussed in greater depth in Chapter Two.

Passive and active echolocation may be used together in an integrated fashion. Passive echolocation is always happening to some degree, but the images produced are usually mild and unfocused. Active echolocation only occurs when applied by the user, but the resulting images are relatively sharp and extended to much greater distances. In this sense, we may think of passive echolocation as like the peripheral vision system which maintains a constant, broad scope of the general environment, acting as a kind of alert system.

Active echolocation is comparatively like the central vision system in that it allows for the direction of attention toward specific items or features of interest in greater detail and at greater distances.

The word echolocation is conventionally used rather generally and has come to refer often to the commonly applied forms of passive echolocation which is conducive to perceiving the environment at relatively short distances and in gross detail. This term has also been criticized by Ashmead and Wall (1999) as it is often not the echoes of sound that can guide the listener to walk parallel to a wall but the reverberant sound and changes in the ambient sound field. In order to prevent confusion with passive or more rudimentary forms of echolocation, Daniel has coined the term FlashSonar to describe the use of advanced, active sonar. The ideal sonar signal resembles a flash of sound, much like the flash of a camera, and the brain captures the reflection of the signal, similar to the film of a camera. The rest of this book will use the term FlashSonar when referring to this form of active echolocation used by people who are visually impaired to obtain more detailed information about the environment, both near and far.

Exploring the Need for Active Echolocation

Instruction

According to Emerson Foulke (1971), a prominent

figure in the field of perceptual psychology who himself was blind, "The ability to travel safely, comfortably, gracefully, and independently. . . is a factor of primary importance in the life of a blind individual" (p. 1). Since the mid 18th century, the ability of some people who are blind to perceive objects from a distance without physical contact has been of gradually mounting human interest, probably due to its apparent capacity to enhance those assets of nonvisual travel of which Emerson Foulke so eloquently wrote (Norris, Spaulding, & Brodie, 1957; Barth & Foulke, 1979; Warren & Kocon 1974; Zemtsova, Kulagin, & Novikova, 1962).

Anecdotes have abounded featuring some people who are blind who exhibit keen powers of awareness and the ability to move through surroundings with ease and grace without relying on guidance or the need to feel about (Lende, 1953). Examples of documented reports of such abilities can be found as far back as Diderot who wrote in 1749 of a friend who was blind so sensitive to his surroundings that he could distinguish an open street from a cul-de-sac (Hayes, 1935). Hayes tells of a 6-year-old boy who was blind with the ability to ride his tricycle along the sidewalk without a blunder. Felts (1909), writes of an acquaintance who was totally blind who regularly went about the crowded streets of New York with relative

ease and freedom without the regular use of a cane or any sort of guide.

A few experimental reports have examined highly developed abilities in people who are blind to sense the world around them without making physical contact. McCarty and Worchel (1954), for instance, studied an 11-year-old boy who was totally blind and could avoid obstacles placed in his path while riding his bicycle at top speed, with almost perfect accuracy.

In 1974, Magruder studied a man who was blind who could describe with great precision the distance, direction, dimensions, and general nature of novel objects as far as 13 feet away in unfamiliar environments. Personal contact with this participant (L. Scadden, personal communication, May 5, 1993) found that he, too, blind from the age of 4, could ride his bicycle on a regular basis." "The better one becomes acquainted with blind people, or the more one reads about their abilities, the more obvious it is that some objects can be detected well in advance of actual contact" (Griffin, 1958, p. 299).

Many echolocators have learned to use echoes to some advantage, and many instructors have developed some ways of teaching echolocation skills. However, the application and instruction of echolocation

typically falls short of its actual capacity. The use of sonar can be consistently fostered to a far greater degree than has been historically supposed or consistently demonstrated. It has been questioned by some that only a select few can learn the skill to a heightened capacity, but World Access for the Blind (WAFTB) has found notable success with most students of all ages and backgrounds including students with autism, hearing loss, and cognitive impairments. They have also successfully taught very young toddlers. What is sometimes taught and often used is only preliminary to the more advanced degree, scope, and complexity of perception that echolocation can afford.

Echolocation has come to be identified with relatively rudimentary abilities, such as detecting openings, building lines, sizes and maybe shapes of rooms, whether walking straight along a pathway, whether something is over head, and whether an object might be in the way. However, the actual potential of echolocation ranges far beyond this, such as enabling auditory scene analysis, identification and recognition of complex environmental features, perception of small objects and fine details, high speed movement (running or biking speeds), travelling efficiently across open spaces, and navigating unfamiliar places. As Kerrie Brown tells us, "I think the main concept

that it's introduced for me is the ability to explore. So now instead of traditionally I would say, as a blind person, I've been taught routes, so it's a prescribed route from A to B and then you reverse it and come back. But now I feel that I can actually quite easily go off the path that I've been taught and go and have a little explore 'round about and use my orientation and my echolocation skills to come back on track after that. So I feel like it's much more freeing" (as cited in White, 2008).

Thaler (2013a) discovered that "echolocation made a unique positive contribution to salary and mobility in unfamiliar places, such that people who use echolocation had higher salary and higher mobility in unfamiliar places than people who did not use echolocation" (p. 4). The sample size of 37 people makes this a relatively small study, but it does show a positive correlation between echolocation and greater mobility. The authors are not surprised at the finding that "blind people that use echolocation find it easier to move around in novel places than blind people who do not use echolocation," but it is perhaps the first research to evidence this.

Some have raised the argument that, "I know obviously a lot of other blind people and they're saying to me and I'm saying . . . yeah echolocation,

. . . look I've been doing this kind of thing since I was a kid, you know, and no I wasn't taught it . . . so what, why do you need to teach it?" (White, 2008).

Or, "Echolocation is not a 'pioneering' technique; it is the method blind people have always employed to negotiate the environment around them. Some blind people do use tongue-clicking to generate the echo that helps them locate and identify objects in their immediate vicinity. Other blind people clap their hands or click their thumbs. However, most commonly and most effectively, blind people use the simple tapping of their canes to achieve the same result, as well as other ambient sounds, such as the noise of a passing car or the hawking of a street vendor" (Rabby, 2008).

An O&M professional in the blindness field, blind himself, responds, "Watching his [Daniel's] students, it is clear that they can define the characteristics of a room, playground, or mountain trail far better than those of us who simply rely on the echoes produced by our canes. Discussion of whether tongue clicking is weird puts the cart before the horse. First we should research a method to determine its benefits. Then blind people can decide whether the gains outweigh the social idiosyncrasy. That's what we do with the cane. We decide that the benefits of the cane

outweigh the disadvantages of being different from others. So, even though many of us pooh-pooh the tongue-clicking method as weird, shouldn't we try to understand and assess the information it conveys and try to incorporate it into our lives and those of our students? Perhaps the richer tapestry of detail that flash sonar allows would help newly blinded folks frustrated by the limited picture the cane provides. . . . I'm simply suggesting that after investigation we might decide it is one of the many tools we could use in the right situation and at an appropriate time. What we have not yet done is give it a very serious look rather than a cursory glance" (Bullis, 2010).

The literature is unclear about what percentage of people who are blind actually put echolocation to effective use. "To date there are no statistics available about how many blind people use echolocation, but anecdotal reports in the literature suggest that perhaps between 20 and 30% of totally blind people may do so" (Thaler, 2013a, p. 3). The literature does suggest, consistent with the authors' experience, that the effective use of echolocation by people who are blind to enhance navigation is highly variable (Hill, Rieser, Hill, & Hill, 1993).

For example, out of 52 participants who were blind aged 17-50 (Juurmaa, 1969), 12% were able to

perform a simple obstacle detection activity without flaw over dozens of trials. Another 13% were not able to perform this simple task at all. The remaining 75% evidenced scattered performance.

This is roughly consistent with the findings of another study of 26 children who were blind (Greystone & McClennan, 1968) which found that 10% of the children evidenced a high level of performance negotiating a complex obstacle course without making physical contact, while 50% of the children were unable to complete the task without regular tactual contact, if at all. The remaining 40% showed scattered performance.

Shawn Marsolais, several time Paralympic champion and legally blind from birth says, "Before I met Daniel I wasn't even aware that echolocation existed and how useful it could be," (McIlroy, 2011)

One mom writes, "we had seen Justin using echolocation on his own as a toddler. . . . I'm not sure how much Justin knew what he was doing, or how much further he would have taken it. I know that I have heard a lot of blind adults say that they use echolocation to some degree. . . . But in Justin's case, with structured training, his potential in this area is being drawn out and he is learning to use echolocation

more effectively than he would have otherwise.”
(Kish, 2011, October, p. 7).

The authors have observed that students who are congenitally blind, like Justin, are often already partly adapted to using the auditory system for basic imaging. However, the student is often unaware of it, and her skills are usually rudimentary. The student may often accurately describe some of the more prominent elements of an object or scene, but not be able to put this information together to form meaning. So, for instance, she may describe an object as having no corners, but does not realize that it is a ball, or may describe something in front of her as sounding like it is ‘hardly there’ but not identifying it as a fence. To develop this use of echolocation further involves encouraging students to direct auditory attention to the different elements and gain images based on the elements that are heard. “This perceptual ability is manifested in functionally important behavior such as goal directed locomotion, and awareness of the positions of objects in nearby space” (Ashmead, Hill, & Taylor, 1999, p. 21).

Some blindness professionals have contended that echolocation is already taught to a sufficient degree and scope within the mobility profession. “I use it as part of the tool bag of teaching mobility and

orientation; I certainly know it isn't anything new. The bible, if you like, of mobility, which is Foundations of Orientation and Mobility . . . there's a whole section on echolocation. So I just assumed that everybody else is doing the same as me" (White, 2008). In the Foundations of Orientation and Mobility Textbook (Wiener et al., 2010), there are eight pages about the 'use of reflected sound', a partial literature review of research about echolocation, and five basic exercises (covering two pages) in the use of reflected sounds. It is also rare to find book chapters about echolocation, and articles are relatively few compared to other mobility skills. One exception is a chapter in the book Early Focus by Pogrud and Fazzi (2002) which includes a few details about teaching echolocation to children who are blind (the chapter is written by Bleier and Kish). Further, the authors can find no literature pertaining to Orientation and Mobility skills and techniques that give more than a passing mention of echolocation. Echolocation is mentioned once, but very briefly, in the Academy for Certification of Vision Rehabilitation and Education Professional's official Orientation and Mobility Handbook (Academy for Certification of Vision Rehabilitation & Education Professionals, 2009, p. 9). In the USA, the AER University Orientation and Mobility curriculum standards accreditation checklist did not make any reference to echolocation until

2013. Daniel Kish sat on the oversight committee that instated this update.

Echolocation as a systematic curriculum is not even on the syllabus of some Orientation and Mobility Instructor University programs. For example, active echolocation was not on the syllabus of Birmingham City University's Rehabilitation Worker training program until 2009 when Daniel Kish was invited to conduct professional development workshops there. In the UK there is now a professional body for Rehabilitation Workers but they do not regulate the profession. The syllabus of the individual education provider is only determined by the provider's own decisions, although most chose to integrate the National Occupational Standards for Sensory Services.

As Dr. Gordon Dutton, who works closely with children who are blind and the rehabilitation system, states, "I have been an ophthalmologist for over 30 years. I first learned about echolocation only about three years ago and was amazed when I saw what blind people with this skill can achieve," (as cited in Wysong, 2011).

Both authors personally know a number of O&M instructors (including ourselves) who do teach echolocation skills to students, but we do acknowledge that it is not taught by all mobility instructors, and

in a number of individuals it is self-taught. When it is taught, it is often taught at a rudimentary level, as training in how to teach it and the O&M literature supporting it is quite sparse. However, the authors do not entirely agree with Davies (2008) who says, “unfortunately echolocation is not promoted as a means to effective localization as orientation and mobility instructors deem the use of echolocation as socially unacceptable” (p. 34). This appears to be a rather sweeping generalization. Although there are some O&M instructors who have objected to the idea of echolocation, the authors’ experience is that, once the effectiveness of advanced echolocation is demonstrated, many of them then wish to learn more about the skill and how to teach it. As Roger Willis points out “I am aware of echolocation and I do bring it to my students’ attention helping them to understand the echoes from the walls etc. although I do not use this to the fine degree that Daniel Kish does. Daniel has very special skills and it is great that he can teach echolocation to professionals as well as to those who want to learn the skills” (as cited in Lockwood, 2008, p. 41).

A final issue with regard to the focused development and use of FlashSonar concerns the activation of the imaging system in the brain, which is covered in more depth in the next chapter. It is now known

that active echolocation by use of an active signal can reliably elicit bold images in the brain that are closely analogous to visual images. Although all of the aspects of how this process works are not yet known, it is known that the brain requires a certain strength of stimulus in order to elicit enough neural impulses to produce a conscious stimulus. Given that non-echolocators, blind and sighted, who were studied did not evidence visual cortical response, it would appear that a lack of focused training in active echolocation does not appear to present the brain with sufficient stimulation to activate the imaging system to the degree that is possible with focused training. "Once the problem is squarely faced, and once the possible benefits to people who are blind are considered in full perspective, who can deny that the potentialities of human echolocation deserve full and rigorous exploration" (Griffin, 1958, p. 322).

How Does Echolocation Work?

There are a number of requirements that are necessary for echolocation. The first is an emitter (that makes the initial noise or signal); the second is a medium (for the sound to travel through); the third is an environmental feature or item (for the sound to bounce off); the fourth is the receiver (that collects the sound); and the fifth is the information processor (that interprets the information). For

example, in the case of a human listener, the emitter may be the sound of a tongue click or hand clap; the medium is the air through which the sound travels; the item may be a tree that the sound reflects off; the receivers are the human ears that collect the echoed sound; and the information processor is the brain that converts this sound into useful information. The traveler therefore recognizes and identifies the tree, and approaches it and walks around it having interpreted the reflected sound as an item that they may want to negotiate or use as a landmark.

A much more in depth explanation of how the auditory system and brain work together can be found in the second chapter of this book.

Vision and Hearing Comparison

Vision and hearing are close cousins in that they both can process reflected waves of energy. "Vision involves the reflection of light off environmental obstacles which is then processed by the brain. Hearing involves the perception of vibrational information through the use of the auditory nerve centres" (Davies, 2008, p. 7). Vision processes photons (waves of light) as they travel from a source, bounce off surfaces throughout the environment, and enter the eyes. Similarly, the auditory system processes phonons (waves of sound) as they travel from a source, bounce off surfaces, and

enter the ears. Both systems can extract a great deal of information about the environment by interpreting the complex patterns of reflected energy that they receive. As Gibson puts it “there is a flow of energy, the ambient array of radiant energy reflected from every face and facet of every surface and object in the environment” (as cited in Schwartz, 1984, p. 27).

Although Gibson was referring to light energy, his poetic depiction holds for sound as well. In the case of sound, these waves of reflected energy are called ‘echoes’.

Echolocation has been described as “a crude substitute for vision, allowing blind humans to perceive aspects of their environment that would otherwise go undetected” (Milne, Goodale, & Thaler, 2014, p. 1828).

“Now for the first time I truly understood that Echolocation provided something I couldn’t even articulate, long-range vision. . . . Now I could use my new long-range vision to ensure that nothing lay in front of me, so I could walk at a normal pace. This new way of walking felt much more exhilarating. Things seemed to flow together more smoothly, and I could indeed perceive a greater whole much more clearly, not needing to stop and examine each part.

But of course I could examine things too. I could see the line of buildings on my left and the line of cars on my right. These could help me keep oriented. I no longer needed to clumsily shoreline along a bunch of uneven buildings. I could now walk more in the middle and look at them. We also saw various metal boxes for mail, recycling, and the like. Trees, poles, and signs also appeared along the landscape. It really started to happen!" (Seraphin, 2012, May 15).

Vision can be said to supply the user with much more spatial information than sound and is often referred to as being the primary sense for spatial perception. In humans "the correspondence between spatial position and neuronal representation is not nearly as detailed as that of the visual system" (Neuhoff, 2004, p87). This is because the auditory cortex is designed primarily to process and code time and frequency, whereas the visual cortex is primarily designed to process and code spatial information. This will be elaborated in Chapter Two. "Contrary to what is the case with light, the reflection of sound waves is by no means sharp. Therefore acoustic clues can never have the same efficiency with light" (Kolher, 1964, p. 27).

"[Human] ears are extremely sensitive to certain frequencies (20 Hz to 20000 HZ) but the wavelength of sound is approximately 0.017 m to 17 m whereas

that of light is 4×10^{-7} m to 7×10^{-7} m. The shorter length of the wave provides for more information to be obtained in a shorter time period with vision allowing for a more efficient perception than that of sound" (Davies, 2008, p. 53).

However, despite the spatial limitations of sound compared to vision, Schwitzgebel & Gordon (2000) remind us that "although not as vivid as visual experience, echolocation is an important, pervasive and distinctive feature of our sensory phenomenology" (p. 8).

Rauschecker (1998) states that "perceptually, the auditory system has to deal with the same basic problems as the visual system that is: Identify patterns or objects and determine the spatial location of stimulus" (p. 516). If someone needs to rely more upon her hearing due the limitations of her own visual system, it is the process of interpreting these signals that may require further training.

According to Griffin (1958) "If all the physical information carried by an ideally suitable sound could be perceived and analyzed correctly, it ought to yield an image of the blind man's immediate surroundings which would perhaps be as clear and accurate as that obtained by a person with 20/400 vision" (p. 314).

Although vision is commonly talked about as being a more useful skill for orientation, there are some instances where sound can be more accurate. Vision is not as accurate at judging depth as biosonar systems, particularly if the perceiver is some distance from the object, whereas in contrast “biosonar systems are particularly suited to this task as the distance of objects is directly encoded in echo delay” (Simon et al., 2014, p. 1). “The angular resolution of visual systems is much finer than that of biosonar systems because of the much shorter wavelength of light; however, echolocation has distinct benefits over visual perception, especially when perceiving small objects and perception of depth” (Simon et al., 2014, p. 1). Hearing also allows for 360 degrees of perception, and it can allow perception through solid objects and around corners.

What is Detectable?

Although echoes are quiet and subtle, echoes from large, hard, nearby objects are extremely pronounced once you know what to listen for. What is detectable using FlashSonar will vary widely among students, the circumstances in which they are operating, the angle at which the student is encountering the object, and the nature of the items being detected.

Recent research has shown that “sighted adults can learn to discriminate reflective surfaces echo-acoustically in VEAS [virtual echo-acoustic space] with very high accuracy” (Wallmeier, Nikodemus, & Lutz, 2013, p. 8). Most of these subjects who were sighted could detect a change in the azimuth (which is the measurement of localization of sound source in the left to right plane) during an echolocation experiment of 6.7 degrees, with the best subject achieving 4.8 degrees (Wallmeier et al., 2013). Thaler, Arnott, and Goodale, (2011) found one early blind subject who could detect a 3 degree displacement by clicking at the object.

Teng, Puri, and Whitney (2011) found performance thresholds in their three best subjects who were blind of less than 2 degrees. To put this in context, participants who were sighted in the same experiment using sight to judge distance achieved a threshold of 1.4 degrees. This “precision of echolocation is comparable to visual acuity in the periphery, which, when compared to foveal acuity, is quite poor” (Milne et al., 2014, p. 1835).

The authors note that these experiments were conducted under highly controlled conditions, and it has yet to be studied how such levels of precision

found in this experiment translate into a typical environment or movement situation.

To give more practical examples in a typical environment and movement situation, the maximum resolution of sonic, unaided, human FlashSonar would constitute a surface area of about nine square inches (a circular or squarish target) at about 18 inches distance from the listener with a solid target presented alone in open space under fairly quiet conditions. This example is general and drawn from a synthesis of the research and from Daniel Kish's experience as an echolocation user and teacher.

A pole of about an inch in diameter can be perceived at about two feet. A fire hydrant may be perceived from several feet away, but not up close unless the student is very short. Likewise, a 4-inch curb is also easier to detect from distances of about 3 to 10 feet, but not too close. A chain link fence may be detectable at 6 to 10 feet. A parked car may be perceived at 10 or 15 feet; add another 5 feet for a van or truck, another 10 feet for a bus. Ashmead, Davis, and Northington (1995) suggest that the longest distance that a listener can easily perceive objects is about 22 yards, but it may be further if the listener already knows what might be in the vicinity and is trying to locate it.

A tree may be detectable from 15 or 20 feet. A large building is detectable for hundreds of yards with a strong sonar signal. While features in terrains such as mounds, large rocks, up-curbs, or mud puddles may be detectable, drop-offs are almost impossible to detect. Low objects such as curbs seem taller than they are from several feet away.

These may be difficult to perceive up close.

Types of Information That Can be Obtained

The amount of information that can be determined by listening and interpreting echoes is wide-ranging. Echoes can give detailed information about location (where objects are), dimension (how big they are and their general shape), and depth of structure (how solid they are and their textural qualities). By processing this information, a person can then work out what the object is and use that information for her orientation and directing her mobility.

For instance, different materials within the same room will reflect, absorb, or transmit the sounds to varying degrees (Wiener et al., 2010). Soft furnishings absorb sounds, particularly high frequencies resulting in a dead room, but a room without many objects in it or with harder objects in it will result in more acoustic reverberation known as a live room.

Location can generally be perceived in terms of approximate distance from the observer and also in terms of direction from the observer (i.e. in front or behind, to the left/right, high up or low down). Dimension refers to the object's height (tall or short) and breadth (wide or narrow). Depth of structure refers to how solid or sparse, how reflective or absorbent an object is, along with major textural characteristics. Much can be perceived about the nature of an object or multiple objects. For example, an object that is tall, narrow, and uniform from bottom to top may be recognized quickly as a pole. An object that is tall, narrow, and solid near the bottom while broadening and becoming sparser near the top would be a tree. More specific characteristics, such as size, leafiness, or height of the branches can also be determined.

Something that is tall, very broad, and solid registers as a wall or building, whereas something solid and broad, yet short in height, perhaps waist high, would register as a retaining wall or large planter. Something broad and sparse in sound would register as a fence. Something short and fairly narrow, a little wider than a person, with a sparse, scattery sound might be a bush, whereas something with a sparse, scattery but broad sound might be a hedge or tightly packed row of bushes.

An object that is broad and tall in the middle, yet shorter at either end, may be identified as a parked car. The differentiation in the height and degree of slope at either end of the car can identify the front from the back end; typically, the front will be lower, with a more gradual slope up to the roof. Distinguishing between types of vehicles is also possible. A pickup truck, for instance, is usually taller near the front, with a hollow sound reflecting from its bed. A sport utility vehicle (SUV) is usually tall and boxy overall, with a distinct but blocky geometry at the rear. And finally, something that starts out close and very low, but recedes into the distance as it gets higher is a set of steps. "In terms of object distance, the cue that indicates distance most reliably is the time delay between the outgoing signal and the returning echo, and this cue is independent from other aspects of the sound. Thus, echolocation has information sufficient for size constancy" (Milne, Anello, Goodale, & Thaler, 2014, p. 79). Milne demonstrated that "a blind echolocator can accurately identify the size of an object independent of its distance. These results suggest that size constancy operates for object size perception via echolocation" (Milne et al., 2014, p. 4). This verifies the use of echolocation as being able to identify the size of objects in the navigation process without necessarily being confused by distance cues.

More or less concentrated scanning by the listener may be necessary to make some of these determinations. Scanning is a process whereby a person obtains information using mainly head movement (from left to right and up and down) to perceive the environment better. Eye scanning is a technique used by people with restricted visual fields so that they systematically move their eyes and head in order to broaden their field of vision and find objects. Eye scanning is critical for people who are fully sighted to operate visually, but perhaps not to the same degree as it is for those with a visual field restriction. If the eye is not permitted to move, its capacity to resolve details is very dramatically reduced, as is its capacity to link those details into an image that can facilitate movement (Wang, Crewther, & Yin, 2015).

Acoustic scanning is similar to visual scanning used by people who are fully sighted. Acoustic scanning is used for the same purpose: To interpret the direction from which sound is coming. Directing the head towards the sound or its echo helps determine its location.

By using this information, a scene (comprised by multiple items and features of varying locations and characteristics) can be analyzed and imaged, allowing

the listener to establish orientation and direct her movement within the scene. Natural scientists and psycho-physicists refer to this collection of information as auditory scene analysis. This process was expounded on by Albert Bregman (1994) and is well known in the world of natural sciences. As with the visual system, when this process is used frequently, it becomes an unconscious rather than conscious act.

Auditory scene analysis represents the most sophisticated form of echolocation, because in the real world, one comes upon all kinds of surfaces from every angle which are situated in every possible manner. In order for echolocation to be useful, the auditory observer must be capable of integrating the echo information about various characteristics of space and objects within space into a gestalt of spatial awareness. "It is one thing to distinguish among a small set of previously agreed targets, and quite another to make out the features of a totally unknown environment" (Mills, 1963, p. 135).

In addition, the integration of this information must allow freedom of motion. It must provide an active gestalt that presents continuous dynamic information about changing relationships between an auditory observer in motion and the complex network of surrounding surfaces. As Rieser (1990) puts it,

“During locomotion, an observer’s network of self to object distances and directions changes, and the accuracy of perceptual/motor coordination depends on the precision with which one keeps up-to-date on the changes” (p. 379).

Unfortunately, few studies exist that approach echolocation as a dynamic complex process. In the 1960’s, Juurmaa conducted a series of studies involving over 50 participants who were blind to determine the relationship between echolocation and spatial orientation ability (Juurma 1967a, 1967b, 1968, 1969). The echolocation tasks involved surface detection at different distances and obstacle avoidance. The orientation measure involved such tasks as having to find one’s way back to a starting point after being lead very circuitously away and returning to an original orientation after being spun about. Juurmaa found that those who did well at the echolocation tasks also showed a high ability to establish and maintain orientation, while those who did poorly at echolocation struggled with the orientation task. This finding suggests that participants were able to use echoes from the walls of the test site to assist them in orientation tasks.

Another study examined the application of echolocation to the negotiation of an obstacle course.

It was found that the participants who were blind encountered much greater difficulty negotiating the course when the subjects' hearing was fully blocked than when the subjects' ears were free. No such difference was found in a group of sighted-blindfolded controls, indicating that echo information was being utilized by the participants who were blind to facilitate travel (Mickunas & Sheridan, 1963).

Magruder (1974) investigated the integration of echo information in natural settings. While this was not a study of motion per se, such skills of integration would seem highly salient to successful movement. An adult who is blind was positioned in about a dozen distinct, outdoor locations—split up between two separate days. The participant was asked to estimate the distance, direction, and height of every object that he could perceive and to identify each object. Each estimate was compared to discrete, objective measurements. Out of approximately 60 possible objects, distance estimates were off by about 53%, and height estimates by about 47%. Angle estimations were only off about 20% on average, with 54 out of 56 angles estimated to within 5 degrees of true direction. The participant was able to correctly identify 74% of all objects. The accuracy of all judgments fell sharply with increasing distance. For example, distance judgments rose to about 90%

accuracy with objects closer than 7 feet. Although some judgments were correct as far as 20 feet away, inaccurate judgments seemed most predominant beyond 13 feet. Also, the close presence of large objects to either side, such as buildings, made judgments about other objects difficult.

Although the research remains scant on this point, it nevertheless seems evident that the interpretation of echo information can provide a complex dynamic awareness of surrounding space. Such an awareness would seem invaluable to the process of orientation and mobility. "This is a life changing skill," Says Julee-Anne, voice teacher and choir conductor who is blind (as cited in Marshall, 2013).

FlashSonar and the Long Cane

The long cane is an effective exploration tool described by Jacobson as the most reliable technique for "detecting and sensing the environment for nonvisual locomotion and travel" (Jacobson, 1993, p. 101), but it cannot detect objects that are above waist height. The long cane can only detect obstacles that are about two steps ahead of the cane user, so the object has to be in quite close proximity to the user to be detected. As Michael Bullis (2010), O&M instructor who is blind puts it, "Canes are effective at creating a picture of the immediate area where we are traveling, but

they are not so good at helping us formulate images at thirty or forty feet. Although the echoes from a crisp metal cane tip can fill in some blanks in the environment, they cannot create nearly the detail that active echo-location does" (para. 6).

Although the sense of touch can also be used by individuals who are visually impaired to locate some objects, "the person must make contact with an obstacle before avoiding it. If instead, they rely on auditory information to evaluate the environment, information can be processed without the need for physical contact" (Davies, 2008, p. 13).

FlashSonar can be very effective at detecting objects above knee height but can miss objects below knee height such as low benches or planter boxes. Kohler (1964) states that "low obstacles not reaching up to a person's knee which are also rather narrow are usually undetectable" (p. 47).

Using both the long cane and FlashSonar skills together can result in a very competent traveler. Thaler (2013a) points out "the majority of our participants use the long cane, and all of our participants who echolocate, also use the long cane. This suggests that the benefit of echolocation we found might be conditional upon the long cane being

used as well. It also suggests that echolocation and long cane may have complementary functions” (p. 8). As Dewald puts it, “The ideal mobility aid that we use together with this skill, is the use of a full-length cane, which enables the person to be even more aware of his/her environment. This way, you have a kind of two-layer preview system; your cane, which informs you about curbs, steps, and uneven terrain. And FlashSonar, which shows you what is ahead: A building, a car parked at the curb.” (as cited in van Deventer, 2014).

Some travelers with low vision, especially those with field loss or light adaptation issues, could use echolocation in combination with residual vision to improve environmental awareness and avoidance of objects. “Unlike Mr. Kish, she [Shawn Marsolais] can use her extremely limited peripheral vision to verify what she picks up with echolocation. ‘If I think I hear a pillar I can check with the corner of my eye,’ she says. Her brain also fills in missing details. ‘If I know it is a mailbox, I do kind of see it in red’” (McIlroy, 2011).

A telephone survey of 77 people who had low vision or were O&M practitioners determined that the most difficult issues for those people with regards to orientation and mobility are drop offs, lighting

conditions, street crossings, changes in terrain, and objects/obstacles (Smith, De L'Aune, & Gersuschat, 1992, p. 58). A long cane could be used for detecting drop offs and changes in terrain; FlashSonar could help identify and locate objects/obstacles and aid the user with road crossings and poor lighting conditions. We will elaborate on specific use and teaching of the long cane in combination with FlashSonar in Chapter Three.

Teaching FlashSonar

There are three primary considerations to teaching, using, and evaluating FlashSonar: Target distinction (how detectable are the targets); environmental variables (noise and clutter); and the perceptual factors in the student (hearing issues, presence of vision, attention capacity). Each of these will be examined separately below.

Target Distinction

Targets that are very narrow, such as a pole, may not bounce back as much sound and may be more difficult to detect. The sparser (less dense or solid) the target, such as a fence, the larger it will probably need to be to bounce enough acoustic energy back to a human listener to be detectable and identifiable.

A particular concern with using human FlashSonar is figure ground. This concept when related to acoustic information is very similar to the same concept as it relates to vision. It has to do with the extent to which the target can be distinguished from its surroundings. Acoustically, we are talking about physical geometry and texture of the target relative to its surroundings. These need to be quite distinct for a target to register in the human auditory system. However, experience, concentration, and contextual clues can narrow this gap. A target needs to be about 9 square inches to be perceived at a distance of 18 inches from the listener. This gives a general idea of how distinct a target needs to be in order to be registered, let alone identified. Juurmaa (1969) found that it was easier for his research participants to tell whether an object was present or not than to try and judge its size, demonstrating that object size is a more complex echolocation skill than detection.

Objects that are very close to each other tend to blur together, with larger, denser objects predominating. For example, while a man of average height may be detectable at about seven feet under normal conditions, that same person at the same distance may vanish if standing next to a wall or large column. However, he might still be detectable against a chain link fence. When working with an individual, the

teacher will need to gauge the level of perception for that particular student.

Ground level targets can also be challenging because the presence of the ground itself, the distance of the target from the ears, and the relatively poor angle of perspective all tend to blur ground level targets, unless they present a large surface area or are otherwise quite distinct. A 4-inch-high curb may be detectable from 9 or 10 feet, but a park bench might only register at 5 or 6 feet, and a coffee table near a couch might not register at all. Here children have a huge advantage. The children's reduced height has the effect of literally making the whole world larger from the auditory perspective. They can detect shorter objects much more easily than adults whose heads are further above these same objects.

Environmental Variables

Environmental variables are factors that increase or decrease target distinction. Other noise in the environment will make FlashSonar signals harder to hear, so targets generally need to be bigger or more solid to register, and sonar signals need to be stronger. Reverberation or strong wind or rain can also make sounds harder to distinguish. With strong wind, scanning left and right repeatedly with the head or inclining the head, such that the effect of the wind

is minimized, can be helpful. Echoes are subtle and may be easily masked by noise, although FlashSonar can be used to extract images through moderately high noise levels. Clutter or congestion can obscure a target by causing it to blur with other targets that are too close. When initially training a student, it is best to choose a quiet, open space, or focus on highly distinctive targets until the student becomes more advanced in her skills.

Perceptual Variables

Perceptual variables include attention, visual functioning, auditory functioning, familiarity with the environment, and self confidence, and will vary according to the individual student. Echoes are subtle and require one to be able to attend or at least be motivated to hear them. Familiarity usually increases registration. It is always easier to find a target when you know what you're looking for. Frequent and passive users of a human guide may find FlashSonar more difficult to learn. This is not to say that using human or dog guides will disrupt perceptual development, but passive dependence on being guided may do so. "It is very important to remember that a human guide is seen as a passive, not an active, form of movement and to remember that using a human guide is not independent mobility" (Scott, 2010, p. 27). When working with a student, a place

to begin may be to have them maintain active and mutual engagement in the guiding process. Once learned, FlashSonar can be used to allow the student more freedom to move around comfortably without a guide when necessary or desired. It can also be used in conjunction with a guide to enrich the travel experience by heightening appreciation and awareness of the environment.

Broadly speaking, better hearing enables the highest potential for using echoes. However, while high frequencies are required for the perception of small objects and detail of surfaces (for more information see Chapter Three), most useful sonar skills rely more heavily on low- to mid-frequencies. “Many blind individuals who have high-frequency hearing loss are still able to use [very functional] echolocation skills” (Carlson-Smith & Wiener, 1996, p. 5). Even if hearing sensitivity is reduced across large portions of the spectrum, effective sonar navigation is often possible. Unilateral hearing loss can make passive or active sonar very complex. It is possible to echolocate with hearing aids if the aids do not interfere with the ability of the pinna (the outer visible part of the ear) to pick up directional sound. Some students have learnt to partly adapt to echolocating effectively with ‘behind the ear’ aids.

Vigilance is perhaps the most important factor. Because there are many cues that must be analyzed and integrated for successful navigation by persons who are blind, concentration is often divided among many elements. Since sonar information is relatively subtle, it requires at least a moderate degree of continued concentration for effective use. Training awakens the natural capacity for sound orientation and helps develop it to maximum efficiency (Kohler, 1964).

Is Echolocation More Effective When Moving?

There has been some research about whether people using echolocation are better at locating obstacles and judging distances when moving or when stationary. Rosenblum et al. (2000) investigated whether the listener's movement facilitates echolocation of surface distances. There were sixteen female and four male participants and all were sighted. The experiments took place outdoors in an open field with a drywall as the echolocating object. There were 40 training trials with each participant who used sound while approaching the wall and then stopped as close to the wall as possible without touching it. Then the participants took part in 20 moving trials and 20 stationary trials. The result was that "echolocated distance accuracy was somewhat enhanced during moving versus stationary trials for some distances"

(Rosenblum et al., 2000, p. 15). However, it was also noted that “the fact that our listeners displayed some success in both moving and stationary conditions suggest that both classes of acoustic dimensions were usable for echolocating distance” (Rosenblum et al., 2000, p. 16).

One possible explanation for this is that “identifying the location of static sound sources from a fixed listening location is a condition that probably occurs less often than more dynamic examples of localization tasks” (Neuhoff, 2004, p. 88). Therefore better motion distance detection may reflect participants being more practiced and accustomed to judging distances when moving. Dolphins and bats are the most studied echolocators in the animal world. It has been observed by Stroffregen and Pittenbergh (1995) that the more impressive echolocation skills of bats and dolphins are those used in motion and related to action tasks such as intercepting prey and negotiating obstacles.

Research conducted by Ashmead et al. (1995) concluded that “participants were more accurate and consistent when they heard the sound while walking than while standing still” (p. 243). The explanation given for this is that the individual when moving can make “availability of motion-related change in sound

pressure” (p. 243) and that this may be “in large part to the use of a naturalistic locomotor task” (p. 244). There is, however, a range in which echolocation was suggested to be most effective; “for normal walking speeds and fairly brief sounds, distance would be perceived best for things within about 20 m” (p. 255). The authors note this distance may be extended two- or three-fold for those who are proficient in echolocation.

In practical terms, echolocation would be most useful if used while moving because persons who are blind can walk and analyze the environment rather than stop and analyze then walk on, giving them a more consistent flow of movement. However, as every learner is different, some people may be more suited to starting with movement based action exercises while others are more suited to starting with stationary exercises. It is, however, important that echolocators are free to move their head, even if their body is stationary, because the ability to determine the shapes of similar objects “is critically dependent on the use of head movements” (Milne et al., 2014, p. 1834).

Generating Echo Signals

An active signal is the basis of the FlashSonar approach. “Noises generated by the blind persons

themselves . . . are far more effective than noises originating from the surroundings” (Kolher, 1964, p. 31). Kellogg noted in 1962 that the participants who were blind in his research into echolocation “employed tongue-clicking to some extent—a sound reminiscent of the solar ‘pings’ of the porpoise. Sometimes they snapped their fingers a few times. They also resorted to hissing and, on rare occasions, to whistling” (Kellogg, 1962, p. 59).

“Bats use their own generated echo signals for echolocation and “actively probe their environment with short pulses of high frequency sounds” (Griffin, 1958, p. 77). Griffin then compares the short duration of bats’ sonar to the discreet clicks of humans making their own echolocation signals.

Sonar signals fall in a range of what we may call “activeness”, defined by adaptability and amount of control that the user has over the signal. Griffin (1958) speaks to the need for user control over the echo signal. “Background noises would ordinarily be outside the blind man’s controls, but his own emitted signals should be designed with all the wisdom that can be brought to bear upon the problem” (p. 317).

Accordingly, Rojas, Hermosilla, Montero, and Espi (2009) identified the following signal characteristics over which the user may exercise control for optimal results: Intensity (volume), reproducibility (how consistently can the signal be reproduced), duration (brevity of the signal), interval between signal productions (repetition rate, or how rapidly can signal be produced), spectral content (what does the signal sound like), usability (how easy or comfortable is it for the user to produce), adaptiveness (how easy is it for the user to tailor the signal), noise immunity (how well can it cut through noise without being masked), and directionality (how focused is the signal, and how easy is it to direct). Only a fully active sonar signal can ensure these criteria.

Kohler (1964) states that “sound impulses are more favorable in a fundamental respect than continuous sound” (p. 37). This is because the longer the signal, the more it will overlap with the returning echo, thus masking the echo. As Griffin (1958) tells us, “One immediate suggestion we can derive from the bats is the use of pulsed sounds—clicks with a short enough duration to allow echoes to return after the outgoing sound has ended. . . . pulsed orientation sounds are used by all the bats, (and the two known types of bird) which engage in echolocation. In the great majority the pulses last only a few milli-seconds,” (p.

318). Signals that are briefer in duration give more opportunity for the echo to return separate from the signal.

As early as 1958, Griffin observed that “sound sources for use in echolocation by the blind seem to work best when they are beamed, that is, when the emitted sound is concentrated into a fairly narrow angle, and when the beam can readily be moved back and forth by the user to scan his environment” (Griffin, 1958, p. 310).

Hand claps “are louder and longer than palatal clicks, so their reverberation decays more slowly the actual level of noise” (Rojas, Hermosilla, Montero, & Espi, 2010, p. 2074). The sound is difficult to reproduce with the same sound for every pulse (Rojas et al., 2010) so the echoes are more difficult to interpret, but are useful for “long distance, low-accuracy, echolocation” (p. 2074). The fact that hand claps require both hands also makes them less usable, although they are a good signal for spot checking targets at great distances. Finger snaps “cannot be made with a repetition rate as high as palatal clicks. Their performance can be severely compromised if high speeds are required. . . . The reverberation of finger snaps decays slower than palatal clicks, but faster than hand claps in most cases” (p. 2075).

Cane taps are subject to surface characteristics which make them less consistent and are more difficult to direct (Schenkman & Jansson, 1986). The same may be said for footsteps. “Complex sounds are more easily located than pure tones” (Stevens & Newman, 1936, p. 305) which is important for echolocation. Stevens & Newman discovered that “noises (a click and hiss) were localized more readily than any of the tones” (Stevens & Newman, 1936, p. 306) which makes the human oral click appropriate for FlashSonar. Ladefoged and Traill (1994) found that tongue clicks were the most difficult of all human produced signals to mask by white noise, suggesting that click signals are best suited for soliciting echoes in noisy environments.

The “spectral content of the palatal [oral] click is different for each individual, almost constituting a sound signature for the echolocating person” (Rojas et al., 2009, p. 328), which enables the brain to recognize the sound signature and lock into it easily.

Phoneticists have classified and analyzed five distinct types of tongue clicks—alveolar (produced with the back of the tongue like a clock sound), lateral (produced with the sides like the giddy-up signal to horses), palatal (produced with the tip just behind the top teeth, sounds like a finger snap), dental (produced

with the tip off the top teeth, sounds like tsk tsk), and bilabial (with the lips) (Ladefoged & Traill, 1994). Due to differences in articulation and sound production, the terms alveolar and palatal clicks are often used interchangeably even by many phoneticists. For the sake of our discussion, we will tend to use the term “tongue click” or “oral click”.

Rojas et al. (2009) studied the three most common organic sounds used in echolocation: The oral “ch” sound (made by a quick backward movement of the tip of the tongue from the teeth), the lip “ch” sound (produced by a quick vacuum between the lips) and the oral click (palatal or alveolar). The oral “ch” sound is easy to produce but difficult to use for longer than a few minutes. They found it to be useful for early echolocation training as it is easier to distinguish between pitch of near and far echoes. For novice users the lip “ch” sound is difficult to sustain for long and causes a noticeable facial expression. The oral click can be used for several minutes continuously without the sound degrading and this signal was very distinctive for each user.

“Repetition rates [for the oral click] can be sustained comfortably with good accuracy for several minutes without significant performance degradation” (Rojas et al., 2009, p328) with “rates of two pulses per second

can be sustained almost indefinitely” (Rojas, et al., 2009, p. 328). The conclusion was that “any serious student should move to palatal [oral] clicks” (Rojas et al., 2009, p. 329).

Some people have raised concerns that tongue clicking or other self-generated signals may be considered socially inappropriate. From Glass (2015), Bob Ringwald, a musician who is blind, states, “I really didn’t want to go through life clicking all the time. A lot of people think blind people are strange. So I didn’t want to be any stranger than I already was.” Eric Woods, an O&M specialist who is blind, retired, tells us, “A lot of instructors don’t like people to do that, because it does look funny. . . . And it’s socially unacceptable—not unacceptable, but it’s socially different. And so it has been discouraged. I’ve heard plenty of people discourage it” (Glass, 2015).

Dewald van Deventer (2014) gives his perspective, “The first time I heard about FlashSonar, or better known as Echolocation, I didn’t believe that it could be possible for humans. Yeah, a few weirdo blind guys, I thought. But I was wrong, because, quite quickly, I found out exactly what it could do!” (van Deventer, 2014). Kerrie Brown (2008), also blind, insists, “I’m holding a five foot white cane in my hand, I think that probably—attracts slightly more attention than

a small click, so I don't feel self-conscious now about doing it at all" (White, 2008).

Michael Bullis (2010), an O&M specialist who is blind, seconds this "I do acknowledge that we're uncomfortable with the idea of blind people being defined as 'clickers.' But, let's be honest. We already stand out in a crowd by virtue of using a cane—something we've been working for seventy years to get the public to understand. When I was a young man, I observed some blind clickers. I thought they were weird and, quite honestly, they were usually blind people who exhibited other less than socially normal behavior. My mom wouldn't have tolerated my clicking. She explained, more often than I care to remember, 'You live in a sighted world.' This meant that I should try to blend in—not be different. . . even though many of us pooh-pooh the tongue-clicking method as weird, shouldn't we try to understand and assess the information it conveys and try to incorporate it into our lives and those of our students?" (Bullis, 2010, para. 7).

Some students can be unconscious of trying to elicit echoes by such behaviors as tongue clicking, hand clapping, finger snapping, foot scraping, cane banging, or yelling. What the student is really trying to do should be called to her attention. If her endeavors are

obtrusive, they should be redirected to more discrete and more useful echo signals. However, the student's behaviors should be respected as they are an adaptive attempt to elicit perceptual information from the environment. Attempting to extinguish adaptive behaviors without providing a more suitable means of perceptual adaptation could prove very frustrating for everyone concerned as it often results in a reduction in the student's capacity to move effectively. It might be analogous to preventing a child who is sighted from staring by fixing her eyelids so that they can only open half way. It just replaces one problem with another.

The type of click most often advocated in this book is the discrete use of a tongue click, which the user adjusts according to environmental situations. It is not generated louder or more frequently than is needed, nor is it made with facial tics. Stroffregen and Pittenberg (1995) argue that self-generated (monostatic) sounds afford signal modification and thus a more controlled form of perceptual exploration.

Although it is possible to produce sonar signals that are distracting, it is rare to find an instance of the general public expressing any concern about the use of a tongue click by students who were taught to use FlashSonar. Indeed a reason that many people

who are visually impaired refuse to use an artificial electronic sound producing aid is because of “a lack of desire by blind people to make distracting noises which could call attention to their handicap” (Welch, 1964, p. 2). This has not been the case with the self-produced clicks. The authors have observed and had students report that the sighted public consistently does not seem to notice or care about the clicking noise. This is true among both children and adults. As Justin’s mum points out “a tongue click . . . is hardly noticeable. In fact unless you were listening specifically for it, I don’t know that you notice it. Okay, if you are blind you almost surely would, but I am commenting as a sighted person. It is hardly noticeable at all. . . . The tongue click in no way resembles a blindism or mannerism” (as cited in Kish, 2011, October, p. 7). Because of the emphasized auditory attention among blind people, blind people may assume that sighted people are giving the clicks more attention than is actually the case.

If arguments against the use of anything unusual had always been applied, spectacles, critical to the visual functioning of so many people in today’s world, might never have been used for fear of looking strange. One could also apply the same argument to using a cane, a wheelchair, or any critical adaptive device or technique that stands out as unusual, but that also changes

the lives of those who use them for the better. The authors think that form should follow function, not the other way around. Which is more awkward: A blind person who can't find her way efficiently, gracefully, and safely from one point to another, or one who gains the information needed to do so by a little discrete clicking? FlashSonar is a specific skill that is useful for the visually impaired that we hope will not be dismissed before it has been explored with the particular individual.

Unless or until technology allows humans to produce a more ideal signal, the authors recommend certain types of tongue clicks as the ideal signal. These are intended to be unobtrusive, hands free, and completely under user control without need for reliance on external elements or circumstances. "Once developed [this skill] is readily available. Furthermore, unlike electronic travel aids, it does not require a battery or other power source and does not make any distracting noises that would call attention to one's blindness" (Carlson-Smith & Wiener, 1996, p. 1). Indeed one criticism of some electronic mobility aids is that they generate extra noise. They can also block noise "through earphones [that] necessarily occlude the user's normal sense of acoustic orientation and thus detract more than they add" (Welch, 1964, p. 2).

What is required for effective FlashSonar is a sharp, solid snap, click, or popping sound that the user can control to create a soft or loud volume. This is usually produced by pressing the blade of the tongue (the flat, middle part) firmly against the roof of the mouth, then pulling sharply downward to break the vacuum. The tip of the tongue should stay more or less stationary and NOT flop down to the bottom of the mouth to form a second 'pop'. When the tongue produces double pop, it is called the 'cluck click.' A tongue click should produce a single, sharp signal, not a double click or clucking sound.

Failing the sound being produced by the blade, a respectable sound may be produced by the sides of the tongue against the molars. This produces the "giddy up" click. Another click suitable for temporary purposes is the "tsk tsk" click, the kind often made to express disapproval. This is produced by the tip of the tongue against the top teeth. Whatever the click, it should ideally not cause an odd facial expression, or be used too often or too loudly without cause. Soft clicks should generally be used to detect targets that are close or in quiet environments.

For more information about how to make an effective click signal, see the section of Chapter Four called 'generating the click'.

The next chapter will provide a more detailed explanation of how the brain processes and interprets perceptual information.

Chapter 2 — How the Brain Develops and Operates

This chapter examines perceptual development of the senses specifically applied to navigating with low vision or no vision. It explains how perception usually occurs and the differences for someone with a visual impairment.

Perceptual Development

Perception is the process of gathering information about the environment and interpreting this information into meaningful awareness of what is detected. A person's ability to perceive information is the key to her ability to direct herself toward achievement. Without information about the world, what is there to comprehend, who is there to engage with socially and by what means, and with whom and how does a person relate psychologically? Humans establish and execute intent by drawing meaning from what our senses register. The more information someone can access, the more adaptive and more varied is her interaction with the world.

Perception involves three main functions—feature discrimination (what are the characteristics of this

object, and what is its relationship with other features in the environment?); event updating (what is happening around me? how might I be affected?); and perspective updating (our changing orientation to the environment as we move through it). These functions allow us to access and anticipate information through the perceptual process in two principal modes relative to movement—spatial referencing (establishing our relationship to points of reference through awareness of what lies around? where am I relative to everything?) and preview (what lies ahead and how to negotiate a path). These two modes support navigation and interaction with the environment in a manner of one's own choosing.

Referencing refers to the process of recognizing and discriminating elements in the environment; this allows the person to set a physical goal toward which movement can be directed and to maintain orientation with respect to surrounding elements. Preview refers to the ability to perceive adequately the features of an environment and their layout in advance of one's position. Barth and Foulke (1979) make the case that preview enables effective planning and appropriate responses with respect to conditions ahead, which allows humans to direct their movements efficiently, safely, and gracefully.

Both of these modes of gathering information can be divided into near, intermediate, and far distance. Humans use this information about what lies ahead and around them to govern interactive movement that is concurrently meaningful to the self and to others; this can be referred to as mutual meaning. Without this information, the flow of mutually meaningful interactive movement may be disrupted.

The ability to direct our interactions with the environment is connected to the perceptual imaging system. The brain uses perception to construct dynamic, operational images that represent everything that we experience. Perception is used to gather ever increasing amounts of information in order to build ever increasing comprehension of our experiences leading to a functional understanding of the world around us and how to relate to it.

Perception occurs in two stages—awareness and imaging. Awareness simply refers to the stimulus knowledge that something is present to the senses. Imaging occurs when this awareness takes on form and substance in a person's mind. An image doesn't need to be visual; it can be tactile or auditory as well. During one of Daniel Kish's workshops, a 7-year-old boy with low vision donned a blindfold for auditory and tactile training. Moving his cane, he chanced

to touch Daniel's shoe and said, "I just touched someone's shoe." It is one thing to know that your cane has touched something, even to sense that the thing is soft instead of hard, but something about the boy's perception of the sensation conducted through the cane told him, not just that he'd touched something, and not just that that something was firm and resilient, but that it was a shoe. Likewise, the brain can build and present images drawn from any sensory input and any experience. The richer and clearer these images, the richer opportunities can be to interact with the environment through these images.

Perceptual Processing

One must be able to access a breadth of environmental information in order to establish and execute directed thought and action relative to the environment. For example, a child who is sighted stepping on to a school yard at recess for the first time may look around and in short order determine the size of the playground, what and where all of its major play structures and elements are, and what the children are doing. The reach of her perceptual scope instantly covers hundreds of yards in every direction with little effort. With this information, she can decide immediately how to proceed from a wide range of options that this information presents to her.

A child who is blind who is new to the playground, by contrast, may be able to make relatively few immediate determinations about the play area beyond several yards. She may have little idea what play structures or other elements exist. She may gather some idea of what some children are doing near her, such as bouncing a ball or running past her or she may hear certain noises in the distance which may provide clues or kindle curiosity. Given this relatively scant information, a child who is blind may be presented with a number of choices:

- She may remain immobile, feeling uncertain about what her options are, and how or where to move into the environment given little idea of what she is moving into and having little or no idea of which elements to engage or how to engage them.
- She may ask for help to learn what things there are to do, how to approach them, and what to do with them.
- She may scope out the environment on her own, one piece at a time, working out how the pieces fit together, what elements there are, what their relationships are to each other, how to engage and interact with them, and ultimately how to

get back to where she needs to be when she's all done.

- She may insist that someone orient her to the playground or gain access to it for herself prior to the first recess so that she can enter it with confidence and equanimity on her first day.

Together with any past knowledge of playgrounds, she may make inferences that may speed up all of the above and increase her confidence to figure things out.

Of course, a child who is blind may engage all four of these approaches to one degree or another. Vision allows for extended and detailed perception of enormous amounts of information very quickly, and the man-made environment is designed to cater to a sighted person's ability to establish direction and intent visually. Without the degree of extended and detailed awareness that eyesight can provide, and without a world calibrated to non-visual perception, a person who is blind must engage in a self directive process that uses alternative means to gain and apply information. With this alternative approach, a person who is blind can gain access to the resources and information needed to make personal decisions about her affairs.

Going back to the example of the child who is blind in the playground, she might have the self-directive skills to address her lack of visual awareness of the environment by gaining necessary information to determine how to manage herself in an unknown environment; whereas a child who is sighted in the same environment but with poor self directive skills, even though she has the benefit of visual input, might become confused about what to do given the variety of options, intimidated by the amount of stimulation, or anxious about being away from familiar surroundings. Vision can convey information to allow highly refined precision of interaction with the environment, but it is the inner capacities of self direction, fully achievable for persons who are blind or sighted, that can allow either to reach toward achieving quality and productive interaction with the environment.

It has been queried whether verbal language may be difficult for children who are blind to develop, since much of what people talk about may be beyond the experience or reach of the child. References are often made to phenomena that are visual, such as color cues, or other events and targets that a person who is blind cannot directly access. The concept of our environment is extracted from experience, especially in the concrete phases of development for young

children. This is where a complex interaction between self-directed discovery and mutual social engagement comes into play. The child who is blind can make sense of what people say and do by cross referencing the experiences of people who are sighted with her own physical experiences and conceptual knowledge. She can test her developing language against her experiences, cross referencing one against the other in ever increasing sophistication and comprehension. The process is probably exactly the same as with children who are sighted, but the child who is blind must have self-directed physical experiences to parallel the efficacy of the visual experience. It is through this self-directed cross referencing of language and experience that the child who is blind learns to develop social engagement that is mutually meaningful between her and others.

Self-Directed Discovery

“People cannot learn by having information pressed into their brains. Knowledge has to be sucked into the brain, not pushed in. First, one must create a state of mind that craves knowledge, interest and wonder. You can teach only by creating an urge to know” (as cited in Stoddard, 2004, p. 69).

Self direction can be defined as the ability to conduct and coordinate one’s own affairs and activities

productively toward achievement of one's own choosing. Discovery refers simply to the process of exploring and understanding our surroundings and determining how to act upon them. In order for humans to achieve in a self-directed manner, we must be perceptive, be able to direct our activities, and interact effectively with our environment to locate, acquire, and apply resources. These resources include goods, services, and companionship. The ability to navigate is fundamental to this process. We make choices as defined by our environment, and we manipulate our environment to exercise our choices through movement. In order to do this, we must know what is around us, where to go to find what we are seeking, and how to apply what we find around us to carry out our choices.

For example, one may spot a vending machine, approach it, and acquire an item. The action is acquiring the item, and self-directed execution of steps is required to accomplish this action. If a person could not locate a vending machine because of lack of vision or could not acquire the item, she might direct other resources to help her conduct the activity. She might obtain directions to a vending machine or be shown where it is, or she may listen for telltale sounds or echo signatures that suggest the location of one. An item is then acquired.

The focus here is on the achievement of an activity, buying an item from a vending machine, whether this is done through one's own perceptions and executions, or whether she engages other systems and resources to accomplish the activity. This simply requires the process of recognizing options and strategically directing resources to achieve a purpose. It represents the difference between self execution and self direction. A person does not need to self execute all activities in order to direct herself through undertaking the activities toward achievement of her own choosing. That said, the more one is able to self execute, the more options she has for self direction.

Mettler (1994) advocates the encouragement of students to take responsibility for their own learning early on in the teaching process. He says that "perceptual learning requires active interaction with the environment" (Mettler, 1994, p. 341). Thus self-directed discovery is the process of using one's own perceptual system and engagement of resources to direct interaction with and exploration of the world. Very simply, the brain learns to understand its relationship to the world through this self-initiated, self-determined, self-guided process of exploration, investigation, and examination. The process works something like this: Our senses register elements or events in our surroundings. We endeavor to draw

meaning through our own consciousness from what our senses register, and we use this meaningful information to establish intent about how to act. Very often, we govern our bodies to interact with these elements so that we can understand them better and find adaptive or interesting uses for them. This is most effective when it is self directed because self-directed interaction engages and impacts the nervous system most completely. Ideally this results in more refined access, comprehension, and discovery capacity. The stronger our perceptual process, the stronger, more interactive, and more adaptive can be our intentional action. It is through this self-directed discovery process that human infants who are sighted and almost every animal on the planet learns and grows. This same developmental process pertains to people who are blind as well.

Neural development depends largely on intentional, discovery-based interaction with the environment. This is described by Hadders-Algra (2000) as the “importance of self-produced activity for the creation of optimal neuronal circuitries” (p. 568). Managing our own interactions, rather than passively responding to others’ directives, engages the nervous system more completely. The nervous system matures best by understanding its relationship to the world through self-initiated, self-directed exploration. As Lynn

Stoddard states, "There is a big difference between knowledge acquired from personal searching—finding answers to one's own questions—and unsolicited information. When Plato wrote that 'knowledge acquired under compulsion obtains no hold on the mind,' he was revealing a truth that scientists are only now beginning to understand. It is the reason why traditional education often fails to make as much of a difference as education that is based on personal inquiry. . . . Whenever the brain catches a piece of information through active, aggressive fishing (inquiry), it is hauled inside and processed to become permanent personal knowledge. On the other hand, if information is imposed, rather than sought, it is plastered on the outside of the sphere where it soon is sloughed off and forgotten. Imposed learning is shallow and temporary, while learning gained from personal inquiry is deep and enduring" (Stoddard, 2004, p. 69).

It is important to keep in mind the interrelationship among all these systems. The development or underdevelopment of one can impact the others. For example: Much of our executive function capacity is based on and develops through self-directed interaction with our environment. Executive function is our capacity to initiate and organize our affairs and plan and execute them in an effective way. This

involves a great deal of decision management, much of which occurs unconsciously. When we wish to execute any movement, (getting a glass of water, for example), a cascade of decision making processes are launched into effect about every aspect of obtaining a drink—the path of movement, the place from which to get the water, negotiation of obstacles, whether one really wants it now or can wait, hot or cold water, type of glass to use, where to rest the glass, and many hundreds more. Every movement from scratching one's nose to flying a fighter jet involves a cascading network of planning processes. When movement is restricted or rendered non-self-directed, this decision making cascade can become short circuited and can cause disruption to the whole executive function process. When the executive function process breaks down, (which can and does happen with an excess of passive use of perceptual proxies), the process of self direction in the individual who is blind is compromised accordingly. Perceptual proxy refers to the use of others to take the place of our own perception of the environment, thereby usurping or overriding the perception of the person who is blind. The concept of perceptual proxy and how it can erode the perceptual system of people who are blind is discussed in more detail below and in Chapter Three. For the person who is blind, self direction supported by executive function can be preserved and mediated by assistance, as long

as the engagement and management of assistance is under the direction of the person who is blind, or, as in the case of infants, the assistance rendered supports rather than hinders the development of self direction.

Patterns of passivity and usurping of self-directed achievement often develop understandably from the need to care for an infant who presents very real fragility. The support system may have been compelled to provide every measure of support to ensure the infant's survival. Decisions are made to address the most critical needs, and perspectives and philosophies about the qualities of future activities may be put aside by the real and immediate urgencies of the moment. As the child becomes less fragile, families may ardently desire to relax this pattern of dependency (which had been necessary and healthy earlier but is no longer so). However, they may not encounter professional support to help them shift into a process more supportive of natural growth toward freedom and interdependence.

Perception and Action

As discussed in the popular and edifying book "The Brain that Changes Itself: Stories of Personal Triumph from the Frontiers of Brain Science" by Norman Doidge, one of the principal axioms of neural science

is use it or lose it. "The brain . . . is not an inanimate vessel that we fill; rather it is more like a living creature with an appetite, one that can grow and change itself with proper nourishment and exercise" (Doidge, 2007, p. 47).

The brain is like a muscle; it develops through active experience. Such activity literally builds neural connections, just as physical activity builds fiber in muscles, bones, and connective tissue. Conversely, as is true with muscular development, that which is not used diminishes, or atrophies. For a child who is blind, activities involving direct, physical experiences are critical. The importance of self direction lies in the integrated activation of the brain's three main operations which concern environmental interaction. These include perceiving, where sensory information is primarily received and imaged; action and interaction, which carries out and governs the body's movements; and thinking, which is primarily responsible for comprehension and determining action. When one is directed by others, activation of the brain is limited to reactive rather than active mechanisms and constitutes more limited brain activity, mostly seated in lower rather than higher brain functions. For example, when we are guided, the active mechanisms may become passive, much as they do in any passenger. To be a passenger is not the same as being

the driver of our activities. Just the word “passenger” implies “passivity”. When we direct our own actions, all of the main areas of the brain are activated, and therefore exercised, in an integrated way. Thus, self-directed action promotes whole brain development because it recruits whole brain function.

Neural development depends largely on self-directed, discovery-based interaction with our environment. Directing our own interactions, rather than passively submitting or responding to others’ directives, engages the thinking, perceiving, and movement regions of the nervous system most completely. The nervous system matures best by understanding its relationship to the world through self-initiated, self-directed exploration. A strong perceptual process helps develop strong intentional action. The additional assistance that a person who is blind may need simply constitutes another set of resources that she can likewise engage in a self-directed manner toward achieving a quality of life of her own choosing.

Every action that a human undertakes requires a complex set of decisions to be made in order to govern how we are to execute that action and how it relates to other actions, and the short- and long-term impact of all these actions on ourselves, the environment, and others. The myriad of self-directed

actions in which we engage continually drives the refinement of decision making and organization from the most fundamental to the most complex levels. It is a real handful for the brain to manage. Fortunately, it has many mechanisms for doing so, but all these mechanisms can only develop through experience of actually doing it and gauging its success. In order for this complex of decision making to develop into mature executive functioning, every action we take needs to be supported by our own decisions and executed freely. This does not mean that people who are blind shouldn't engage assistance; rather, it means that, when assistance is engaged, it should ideally be initiated and directed by the student who is blind, not assigned, imposed, or otherwise directed by others.

Movement Without Sight

According to Jansson (1989), the process of blind movement can be divided into two functions: Walking toward and walking along. Two key aspects of movement and navigation may be argued—security and efficiency. (The authors use the term “moving” instead of “walking”, because moving through the environment can take many forms.) Moving toward involves the process of maintaining one's orientation toward a goal. This may be a proximate or distance goal. Moving along refers to the ongoing process of controlling one's course and direction—processing

environmental features and acting in accordance with them.

The ability to maintain one's orientation and effective control over one's direction constitutes efficient travel, but efficiency must also go along with security. Studies in blind mobility have pointed to two key requirements for safe, efficient, and intentional movement—remaining on a chosen path, and avoiding unintentional contact with the environment (Leonard, 1972). (The authors use the term "course" instead of "path", because one's chosen course or direction need not require that one keep to a prescribed or delineated path or walkway.)

Mobility can also be described as having two main functions. The executive function is needed to get from one place to another; and the exploratory or information-gathering function is for interaction with the environment (Gibson & Schmuckler, 1989). The perceptual imaging system naturally endeavors to reference and preview surrounding conditions in order to plan interactions. As an alternative, under many circumstances, FlashSonar and the long cane can naturally provide reference and preview information to address these movement requirements.

For people who are sighted, nearly every interaction with the body or the environment is stimulated visually. People who are sighted see what is around and ahead of them and direct their bodies according to what is seen. It has been argued that, in terms of spatial perception and interaction, "vision is the most accurate and efficient sense that humans possess; that is, it can be used to perceive objects and other aspects of the environment that are not within arm's reach" (Fazzi & Petersmeyer, 2001, p. 99).

Disrupted vision, or loss of vision, can challenge the perceptual system with a more tenuous connection to the external spatial environment. The nonvisual perceptual system may not provide spatial resolution comparable to vision. Vision provides between 5 to 10 thousand times the resolution of the spatial auditory system (depending on the comparative measures used), and about 22 times the resolution of the hand of an experienced braille reader (Van Boven, Hamilton, Kauffman, Keenan, & Pascual-Leone, 2000).

It is, therefore, important that the perceptual system of people who are blind is optimized to perceive as much of the remaining data as possible, as well as to access and apply all other systems of self direction (see more below). Nonvisual perception can, and should, be recruited to supplement the preview

and spatial referencing process. When this happens effectively, nonvisual modalities and strategies can restore a person who is blind's ability to adapt and function. Thus, a healthy process of self direction can reestablish the functionality of connection with the external environment. The visual system can be recruited to help organize and interpret nonvisual information in people who are blind (see section on brain plasticity below).

For many individuals who are blind, intentional, interactive movement can be put on hold because referencing and preview systems may be virtually nonoperative, unless development of these systems is supported, activated, and applied by other means. Infants who are blind may even be reluctant to reach out or move in their environment in an explorative way because little information may be available to stimulate movement. When infants who are sighted begin applying their vision to increase their movement competence, caregivers naturally tend to back off and allow and encourage the infant to enjoy more autonomy. By contrast, in the case of infants who are blind, it often happens that caregivers continue directing or manipulating the infant who is blind's interaction with the environment, or continue to mediate the environment to the infant who is blind, long after this would be age appropriate. In

the authors' experience, this generally results in a disruption to the development of self-directed, intentional movement in the infant who is blind, which will have implications for the long term development of the child. It is also true that without visual information children who are blind may find it difficult to recognize a situation where their movement will attract another's attention; often they may not receive any direct feedback to their behavior (Troster & Brambring, 1992). This reaching out may then be perceived by the child who is blind as being unnecessary because it may not appear to her to result in a social interaction, and, therefore, she may not find it useful or stimulating to reach out again.

Movement is directed and highly stimulated by feed-forward and anticipatory mechanisms, particularly with regard to the referencing and preview systems. Essentially, these systems allow the individual to know in advance what elements exist in the environment and to prepare for the nature of the encounter. Children who are sighted see something, and then they may choose to move or reach toward it. Through repeated encounters with the environment, these children learn to adjust the nature of their movements to accommodate something soft, large, prickly, near, far, at an odd angle, or whatever. It has been said that children who are blind or visually impaired "are

more limited in their ability to learn incidentally from their environment” (Specialist Schools and Academies Trust, 2012, p. 1).

Without early perceptual training or access to perceptual tools, such as the cane or FlashSonar techniques, children who are blind may struggle to activate these feed-forward or anticipatory mechanisms. Essentially this lack of feed-forward adaptation may force the child who is blind into a situation where in every encounter is a surprise, a “jolt” to her system, so to speak, potentially forcing the child into a defensive or reactive, rather than proactive, relationship with the environment. This can be especially demoralizing for children who are blind with additional neurological or sensory disruptions, such as are commonly observed in children who have experienced any form of invasive medical treatments as infants or toddlers. Rutter (1984) discovered that children who had been in the hospital were more clingy and difficult than those who had not. He wrote of the “surprisingly lasting effects of recurrent hospital admission” (p. 57). Such an adversarial and tentative relationship with the environment can be expected to place many children who are blind into a state of movement apprehension which imposes a condition of dependency. This condition of dependency, in turn, compels them to attach to

peers who are sighted or caregivers for assistance and assurance. Thus, for these children, a human guide can become a kind of surrogate for self-directed, perception-guided movement in which the assistant becomes a proxy perceiver. If the development of perceptual tools and movement strategies (which are discussed below) is supported and available during infancy or immediately after vision loss at whatever the age of onset, this trap of apprehension can be largely circumvented for many individuals who are blind in these authors' experiences.

Lack of effective and age-appropriate travel skills is known to present a major barrier to full participation in all aspects of society including employment, recreation, education, social interaction, and commerce. In 1968, researchers (Graham, Robinson, Lowrey, Sarchin, & Tims) found an almost linear relationship between mobility competence and gainful employment in a study of 861 veterans who were blind. In 1974, high correlations were discovered between a range of psychological adjustment variables and echo detection ability (De l'Aune, Scheel, & Needham, 1974). Thaler (2013a) found, "echolocation was associated with higher salary and mobility in unfamiliar places" (p. 1).

Thus, the inability to manage and direct one's mobility can sharply curtail a person's ability to obtain and apply resources and, consequently, to achieve according to one's choosing. The ability to direct one's movement in a goal directed way is directly connected to the quality and effectiveness of the perceptual system and its autonomous direction of movement.

According to a mother of a 5-year-old, "Until we met Daniel [Kish] and Brian [Bushway] our image of Lucas' future was positive but it was fairly assisted. Now we believe anything is possible. The best thing about the training is his pride when he achieves something for himself and is able to say 'I did it all on my own! Wasn't I clever! Haven't I learned this well!' He is a changed boy and much more confident" (Lockwood, 2008, p. 41).

Learning Without Sight

"Just as a sighted person explores the environment with the sensory apparatus available, so does a blind person" (Mettler, 1995, p. 96). For a person who is blind, this information will be built up of kinesthetic, auditory, and tactile perception rather than visual images. Due to lack of visual information, the dynamic, composite imagery of a person who is blind will necessarily contain a larger percentage of nonvisual information—information that may be

elusive to, unrecognized by, or irrelevant to peers who are sighted.

Since visual focus is absent, the mind must develop its own focusing mechanisms of consciousness through the auditory and tactile systems in order to highlight material or stimuli needing attention. At the same time, the lack of visual bombardment of stimuli can also provide the person who is blind with an opportunity to become extremely focused on any detail or matter of interest without visual distraction or confusion.

Although learning to perceive and image the world with compromised eyesight appears to be natural for the brain, this process may be easily disrupted by external forces that impose conditions of restriction or experiential deficits. Chief among these may be the imposition of surrogate functioning (which we have called proxy perception or dependency conditioning), in which the functioning of the student is taken over by external agents by imposition of physical guiding and manipulating, verbally directing, narrative spoon feeding of environmental information, and mediating and modifying the environment to make it more 'blind friendly.' Students with sensory impairments often remain relatively passive while others (such as parents or their peers) may take over. This may result in

the student learning “early on that the responsibility for movement and travel belongs to someone else” (Cutter, 1997, p. 1). This may especially become a problem if the student continues to be the passive traveler with human guide becoming “a custodial practice” (p. 3).

Some people may physically manipulate the student, remote control the student with excessive verbal or physical guidance, or choose direction for the student. This can diminish opportunities for self-directed interaction which is a key catalyst for many areas of development—especially for the perceptual and psycho-emotional systems. Under these conditions, these systems can either atrophy or become otherwise disrupted.

Self Guidance Versus Self Direction

As with most practiced activities, the more one moves by one’s own self direction in an intentional way, the better one’s self-directed movement becomes. The better one’s perceptual navigation and interaction systems become, the more increased opportunities there are for active engagement of all resources, including social resources where necessary for assistance and support. However, self-guided navigation and mobility is only one facet of self direction, and there are other ways to access the

environment that may be more efficient than self-guided movement.

There is an important difference between self guidance and self direction. Self direction refers to the maintenance of one's own autonomy, purpose, and intention. Guidance from others can facilitate self direction, as long as one does not lose direction of the guidance process. When sighted guidance or other forms of visual support are engaged in a self-initiated, self-directed way, the perceptual system may be largely applied to manage the interaction and process the resulting experience. When human guiding is received passively or without mutual engagement, perceptual and cognitive systems can remain understimulated. One need not be always self-guided in order to be self-directed.

Importance of Self-Directed Movement

All humans seek stimulation. The brain is always reaching for information in its insatiable desire to make more of itself and make sense of its surroundings. Children in particular are driven to discover through movement and intention, especially during the first five years of life. "From the earliest sensorimotor schemes to the formation of intentional thought and complex problem solving, the drive to want more and to make more out of what reality at

any given moment has to offer will be part of the foundation of getting to know the world” (Cutter, 2003b, p. 1).

The movement systems are believed to be integral to the development and adaptive use of vision and hearing. Vision is an important part of the discovery process. Without vision, the role of self-directed movement as a perceptual tool becomes even more important in the context of other factors, including self management, mutual partnership, strategic interdependence, intentional discovery, executive function, and comprehension. Along with other management processes, children must experience freedom of movement. If channels of stimulation are disrupted by restricted movement, imposition of external guidance, or lack of intentional action, the brain will seek stimulation through other channels and means. If these channels are not conventional, they are often termed “self stimulation.” However, they are actually adaptive responses to a disrupted condition of development.

Children who are blind with limited experiences with the world in motion may develop an impaired sense of space. They lack understanding of how the world fits together and how they relate to it. Such children can become easily lost, move slowly and with exaggerated

caution, and tend to dislike or fear self-motivated movement and new situations or stimuli. They may also be passive or overly demanding. This may be because the parents or caregivers have continued “to bring the world to them instead of investing our energies in getting them to go out into the world” (Cutter, 2003b, p. 2).

Not engaging sufficiently in self-directed movement or being very passive can result in children having low overall physical capacity including low muscle tone, physical weakness, lack of aerobic stamina, poor coordination, excess weight, and reduced immune function (Buell, 1974). “Blind children lack an important afferent system for correcting motor behavior” which “adversely influences a child’s balance” (Navarro, Fukujima, Fontes, Matas, & Fernandes, 2004, p. 656). These authors assert that this comes from lack of practice and experience. Humans simply don’t develop themselves by remaining idle or sedentary.

When movement is restricted and options for self management are not supported, children may fail to learn that they can act to obtain what they desire. First goes the will to act, then the desire to act. Children become passive and reactive, rather than active. They may wait or whine for things to come

to them or be done for them rather than taking the initiative to obtain what they want or need. They may also sit unproductively unless someone is present to prompt and guide their behavior. They often gravitate to more passive activities, such as excessive listening to music, bouncing, or swinging. "It is important for all children to be explorers of their world. The gift of self-initiated quality movement in the early years is a priceless and lasting one" (Anthony, 2010).

So necessary is self-directed movement to engagement of physical development that, when it is restricted, the brain seeks other avenues. "The body becomes the only source of stimulation because the child does not get sufficient stimulation from the environment" (van der Poel, 1997, p. 64). Self-stimulation (hand flapping, rocking, head banging, finger flipping, eye pressing, etc.) is, therefore, an adaptive response to restricted movement and can be difficult to extinguish once the self-stimulating pattern is established. Self-stimulation is reduced by freedom of movement and active engagement. The body has neither the time nor the inclination to self-stimulate when it is productively active.

Much of children's play and casual interaction teaches the appropriate channeling of emotions. For example, consider what children do to a ball—kicking, hitting,

bouncing, catching, throwing, striking, retrieving, etc. What could be more playfully aggressive, yet, at the same time, perfectly safe and appropriate? Also, interactive play brings children in close proximity to each other where behaviors and interaction styles that are mutually meaningful and beneficial can be observed, practiced, and learned. The nature of many cooperative and competitive games forces the learning of patience, forbearance, and other forms of self management. When children are restricted from such avenues of interaction and self expansion, they often develop expressive patterns that are inappropriate or idiosyncratic.

Discovering for themselves has not only a meta-cognition function for students but also a physical one. For some people who are visually impaired, "vision loss has an impact on psychological changes that affect movement, strength and overall health" (Ray, Horvat, Williams, & Blasch, 2007, p. 110). This may be due to the fact that people (particularly adults) with newly acquired sight loss and children who are congenitally blind that are overly used to proxy perceivers, are often hesitant to move independently because they are concerned about getting lost, falling over or knocking into objects, and looking foolish. Ray et al. (2007) suggest this lack of physical exercise "may be indicative of an inactive lifestyle and lack of physical

functioning because of reduced independence after the onset of vision loss” (p. 110).

A survey by Miura, Ebihara, Sakajiri, and Ifukube (2012) revealed that those with no vision went outside less than those that were visually impaired. The survey was only answered by 41 Japanese people who were blind and visually impaired under 30 years old, but it still suggests a link between visual impairment and lack of mobility.

Mobility can be an issue for elderly people. “Among individuals initially free of limitations, severe visual impairment was associated with approximately threefold higher odds of both incident mobility and ADL limitations. These findings are consistent with earlier accounts, using self-reported vision, of the decline in physical function among physically intact or only mildly disabled elders. This suggests that visual acuity may be an important factor in maintaining mobility and physical function” (Salive, Guralnik, Glynn, & Christen, 1994, p. 291). “There is strong evidence that visual impairment is a risk factor in falls” (Legood, Scuffman, & Cryer, 2002, p. 8) particularly among the elderly, and the fear of this may make some elderly people with a visual impairment less likely to go out.

However, lack of mobility is also an issue for the school-aged child as “with rare exceptions, participation of the blind in physical activities [at school and at home] is sharply curtailed” (Van Hasselt, 1983, p. 90). In a recent survey of 14,000 UK children, of whom 357 were visually impaired and attending mainstream school, “sport participation was the key area of social activity where children with sight loss only were underrepresented” (Harris, Keil, Lord, & McManus, 2012, p. 72).

Research by Renshaw (1930) found that, for the children who were sighted “relative to vision, proprioception decreases in importance with age as a localizing modality” (as cited in Warren & Pick, 1970, p. 431). This change occurs at approximately the time of puberty. However, Warren and Pick (1970) discovered that, for adults who were blind, the decrease in the importance of proprioception does not occur. This finding shows the significance that movement continues to have for individuals who are blind throughout their lives. This may also suggest that FlashSonar is a skill which is suited to the kinesthetic learning style of people who are blind because it allows registration of the environment at short and immediate distances and promotes movement.

Movement is also important to the development of the visual system. "The one thing the visual system needs in order to begin perusing the world is dynamic information. So the inference we are deriving from this, and several other experiments, is that of dynamic information processing or motion processing which is the bedrock for building the rest of the complexity of visual processing, it leads to visual integration and eventually to recognition" (Sinha, Balas, Ostrovsky, & Wulff, 2009). In this connection, it appears that the benefits of self-directed movement, as they pertain to the development and refinement of the visual system, also extend to support all areas of perception, especially for children who are blind.

Another important aspect of movement relates to the gait and style that someone develops. Sleeuwenhoek & Boter (1995) report that "congenitally blind children often develop postural characteristics, such as rounded shoulders, a forward head, a backward lean of trunk, and lordosis [permanent curvature of the spine]" (p. 362). Because echolocation encourages users to listen attentively while head scanning and maintaining an erect posture, the authors have found that FlashSonar training combined with early cane training helps children who are blind develop more natural gait, posture, and overall movement patterns.

Although some instructors have raised concerns that early cane training may induce postural abnormalities, this is not known to have been documented anywhere.

Is Movement the Primary Learning Sense?

The neural pathways for refined perception are not fully developed at birth in any of the sensory channels. During the first two years of life, children learn by sensory and motor experiences (Pogrud & Fazzi, 2002). The sensory modalities under greatest development for children are those associated with movement—tactual/kinesthetic, haptic, proprioception, and vestibular. The nervous system develops primarily through experience based in movement. “Through the process of purposeful movement, young children with visual impairments are able to interact with the environment” (Pogrud & Fazzi, 2002, p. 326). This is highlighted as well in adults who are adapting to blindness. Studies of hundreds of veterans who are blind show that vocational success and psychological adjustment are both correlated with mobility competence (Graham et al., 1968). De l’Aune et al. (1974) discovered that veterans who were blind who performed better in their experimental mobility task exhibited more adequate emotional and interpersonal adjustment to blindness.

Vision and audition can significantly contribute to and support movement. At the same time, movement gives meaning to what we see and hear. It stands to reason that the quality of neurological development is largely contingent upon the quality of our movement because it is movement quality that presents us with opportunities for many meaningful and stimulating experiences. Indeed “vestibular activity can only be activated during physical activity” (van der Poel, 1997, p. 154).

In the person who is blind, additional mechanisms may be developed and recruited to assist in coordinating movement of the whole body in order to explore, respond to, and manipulate the environment. The feet and body in particular may gather information that the brain can process to govern many forms of movement. Natural perception through the feet will support the development of a natural gait, and support the governance of walking, running, and jumping. “It is important to know that the fingers, hands, lips, the tip of the tongue and the soles of the feet are the most sensitive exploring parts of the body for pressure, touch and movement” (van der Poel, 1997, p. 100). Proprioceptive systems (systems that keep track of where body parts are in relation to each other), as well as touch, are critical for the

smooth, graceful, efficient execution of motor functions in personal space.

Although the visual system monitors motor function for the purposes of error correction to ensure precision and motor learning, motor planning (praxis) is largely governed by tactual-kinesthetic systems throughout the body, especially the hands and feet (Smith-Roley, 2001).

The well developed perceptual system of an individual who is blind will gather information tactually through both hands in a bilaterally coordinated effort that is known as hand-to-hand referencing. Essentially, this means that each hand acts as a reference point for the other. When exploring an item, proprioceptive mechanisms guide the hands in reference to each other to allow information to be gathered quickly. The spatial elements viewed by each hand are quickly assembled into a whole image through this bilateral referencing process.

Proprioceptive systems monitor and govern the hands as references to each other so that spatial relationships can be established and updated between them quickly and accurately. The hands are used to perceive the environment and manipulate it at the same time. In fastening a zipper, for instance, the

secondary hand may be used as a stabilizer to secure the base of the fastener and as a point of reference for the dominant hand as an activator to align and bring the fastener together. The fingers of both hands often engage in a communication exchange with each other to refine and support this alignment in the absence of vision. Because of the coordinated exchange of communication between the two hands, the speed at which the environment can be explored and manipulated is more than doubled by using both hands.

In putting toothpaste on a toothbrush, the secondary hand holds the brush, and serves as a point of reference to which the toothpaste is brought, and the secondary hand assists in guiding its application. Refined proprioception and tactile information are exchanged between the hands to line the nozzle of the tube with the bristles of the brush. The spread of paste between the thumb and forefinger of the secondary hand provides an adequate tactile gage of the amount of paste being applied. Eventually, simply the change in feeling and sound of the nozzle against the bristles together with the added weight of toothpaste upon the brush is enough to indicate the application of a sufficient amount.

The process described regarding the hands is likewise active throughout the body, especially the feet. The critical importance of the feet is routinely overlooked. Young children who are blind, especially children with accompanying involvements, often strongly resist wearing shoes. Feet provide tactual flow field and terrain mapping, and are highly brain stimulating. In fact, the feet are the only part of the body in continuous contact with the environment, and capable of providing a rich flow of information. In a sense, it is the feet which provide the most continuous flow of information from the environment, most closely resembling the kind of flow that vision affords. Shoes of any kind obscure or distort the quality of information received as well as the ability to respond through balance and gait to the information received. Hands spend most of their time touching the air, but in comparison, the feet are in continuous contact with the variations in ground surface which are rich with information. Feet have a very large amount of nerve endings, approximately two hundred thousand on each foot. They provide interactive correspondence with the environment, richly stimulating and feeding balance, cognitive mapping, and tactual-kinesthetic systems. They ground and organize sensory activity, especially for those with sensory integration disruptions. Conductive sensations are sensations that are conveyed to the body through a

medium, such as shoes, gloves, or a cane. Shoes and/or a cane can carry vibratory sensation to the body, providing a general sense of texture and contour. This can be useful, but it is not direct sensation. One cannot literally feel the texture of the ground or of objects through shoes or the cane, which is why we call this conducted perception. It is like hearing a sound muffled through many walls, or seeing through smoked glass, or trying to tie your shoes with gloves on. Although the authors recommend bare feet as much as possible to provide optimal activation of the perceptual system, when this is impractical or undesirable, authors recommend footwear with the thinnest sole possible, with as little drop from heel to toe as possible (Sternbergh, 2008; Riches, 2015). The minimalist footwear movement, largely inspired by the needs of top performing athletes who found “performance shoes” to be hampering to their performance, is now replete with effective and stylish minimal footwear options for people of all ages and walks of life.

For a person who is blind, the entire body dynamically references itself in ambulating, climbing, swimming, sports, and all other gross and fine motor activities. Since there is no visual spot checking for error correction in individuals who are blind, the precision and efficacy of function rests entirely on the quality of

proprioceptive and vestibular (balance) mechanisms for tactual-kinesthetic self referencing. Nonvisual motor functioning can become highly efficient when these mechanisms are fully developed.

As Stuart (1995) explains, “the proprioceptive system appears to be capable of elaborating a highly complex system of spatial information processing whose development may take place in the absence of visual experience . . . the proprioceptive system may be the primary agent in the elaboration of concepts of space, with the visual system playing a relatively minor part” (p. 7). For a child who is blind, the remaining channels for learning about her environment include language, which is relatively abstract and of limited benefit on its own, and direct, physical experience. Children who are blind must do what they cannot see.

A recent experiment using a virtual echo-acoustic space investigated the link between self-motion and echolocation. Researchers discovered that “both the vestibular and proprioceptive components of self-motion contribute significantly to successful echo-acoustic orientation in humans” (Wallmeier & Wiegrecbe, 2014, p. 1). Performance was significantly better in the experiments where self-motion was used as compared to those that were stationary.

Brain Plasticity

“We are all born with a far more adaptable, all-purpose, opportunistic brain than we have understood. . . . The brain is a far more open system than we ever imagined, and nature has gone very far to help us perceive and take in the world around us. It has given us a brain that survives in a changing world by changing itself” (Doidge, 2007, p. 26).

Aside from autonomic functions, it can be argued that the healthy mammalian brain executes two primary higher functions—perception and adaptation. As discussed earlier, perception refers to the registration of stimuli and the mental conversion of stimuli to meaningful information in order to facilitate adaptation. Adaptation used in this context refers broadly to the process of responding to events in our environment so as to improve the quality of our functioning.

The brain tirelessly sets itself the task of comprehending its environment and everything it experiences through perception so that it can govern meaningful interaction with the environment for purposes of adaptation through plasticity.

Hannan (2006) describes plasticity as “the brain’s ability to reorganize itself after the onset of a disability” (p. 397).

Visual information regarding form, color, shape, dimension, and orientation is processed by the primary visual cortex, and then continues to the secondary visual cortex. Both of these cortices are in the occipital lobe. The temporal visual cortex uses prior memory and experiences to make sense of shapes, colors and forms. The parietal visual cortex interprets movement, spatial orientation and dimension (Hannan, 2006).

Although vision seems to be the human default for gathering spatial information, the latest in neural research suggests that, when vision is disrupted, the brain still anticipates and seeks spatial information. “Simply stated, loss of vision does not lead to permanent inactivation of the visual cortex” in the brain (Burton, 2003, p. 4005). “When investigating neural activity of individuals who are visually impaired, researchers are interested primarily in how the occipital and parietal lobes function” (Hannan, 2006, p. 398). As visual functioning drops, tactual-kinesthetic and auditory channels must be more intensively used to apply different modes of information access. Bavelier and Neville (2002)

have written about the “remarkable capacity of both the juvenile and the adult brain to be shaped by environmental input” (p. 443).

Recent studies of brain plasticity have discovered that areas of the brain usually associated with visual functioning in animals that are sighted have adapted to process auditory or somatosensory information in animals that are blind (Bavelier & Neville, 2002). In research by Kujala et al. (1995) the visual cortex of humans who are blind was found to be activated by auditory discrimination. Sensory deprivation appears to result in reorganization of areas of the brain expanding those remaining sensory areas that will be of most benefit. For example, subjects who were blind were found to have better two-point tactile discrimination skills and superior auditory recognition memory than sighted subjects (Bavelier & Neville, 2002). Research has shown that, in people who are blind, visual cortical areas have been recruited for auditory processing, but interestingly “sighted people can also echolocate despite the absence of visual cortex recruitment for this group” (Kolarik, Timmis, Cirstea, Pardhan, & Moore, 2014, p. 66).

“Cerebral plasticity [is] optimal during the early years” (Gougoux et al., 2004, p309), and “more significant during the early stages of life than it is

in adulthood” (Segond, Weiss, & Samaio, 2007, p. 33). “The visual cortex becomes involved in non-visual sensory functions and higher cognitive tasks as a function of blindness onset: The functional reorganization is particularly pronounced in early onset blindness” (Nopenny, 2007, p1170). This means that children who are congenitally visually impaired may possess the potential to adapt more quickly to their lack of vision.

A study by Rauschecker and Kniepert in which animals were deprived of sight during adulthood indicates that compensatory plasticity can also occur in later years (Bavelier & Neville, 2002). Hannan (2006) perceives “the possibility of the brain restructuring at any age as the most optimistic hope for those with degenerative eye conditions or late-onset blindness” (p. 406) in learning new skills and interpreting environmental information. “The current view regarding plasticity is not one of a finite window of opportunity, but rather one in which the brain retains a high level of neuroplasticity well into adulthood, although not to the same extent as in the young developing brain” (Merabet & Pascual-Leone, 2010, p49). A comparison of brain functions in subjects who were blinded early and late showed in subjects who were early blinded “significant volume deficits in dorsal visual cortices . . . [and] significant

but less widespread differences were found in the late blinded as expected” (Lepore et al., 2010, p. 136). The potential to adjust to the loss of vision is therefore also possible in older people, but the period of readjustment may be longer.

There are three areas of suggested improvement in the brain of someone who is visually impaired according to Merabet and Sanchez (2009): Tactile discrimination, hearing localization skills, and verbal recall. “This . . . neuroplasticity . . . of the brain may thus explain the compensatory and, in some cases, enhanced behavioral abilities reported in individuals who are blind, such as finer tactile discrimination acuity . . . sound localization and verbal memory recall” (p. 135). Auditory perception is particularly important in the absence of, or restriction of, vision. “To a visually impaired traveler, sound localization emerges as a perceptual skill of paramount importance, one that goes beyond the usual listening skills of a sighted person” (Wiener et al., 2010, part I, p. 27). “Individuals who became blind early in life . . . can process sounds faster, localize sounds more accurately and have sharper auditory spatial tuning . . . than sighted individuals” (Bavelier & Neville, 2002, p. 445).

“Blind listeners have been shown to have improved spatial tuning in the auditory periphery when compared with sighted listeners” (Neuhoff, 2004).

Research by Roder examines “compensatory reorganisation of brain areas in the blind that may contribute to the improved spatial resolution for peripheral sound sources” (Roder et al., 1999, p. 163). “The advantage for blind subjects was found only at spatial positions where auditory localization is poorest in sighted humans, that is, at far lateral locations” (Roder et al., 1999, p. 165). This is of course particularly important for FlashSonar because the learner needs to hone in on where specific sounds are coming from to aid her orientation. The “findings suggest that, when visual input is congenitally absent in human development, the early auditory spatial representations continue to develop and become increasingly refined” (Roder et al., 1999, p. 165). “One possibility is that sensory deprivation leads to more pronounced changes in relative connectivity between cortical areas” (Merabet & Pascaul-Leone, 2010, p. 48).

Interestingly, evolution seems to have created something similar in bats with regard to the size of the part of their brain that is used for processing sounds. “The brains of insectivorous bats show an

extreme specialization for hearing as opposed to vision, with a larger proportion of the control nervous system being devoted to auditory tracts and nuclei than in any other animal" (Griffin, 1958, p. 147). Research by Thaler et al. (2011) suggests that "the brain structures that process visual information in sighted people process echo information in blind echolocation experts" (p. 3). Further "it implies that the presence of low-amplitude echoes activates 'visual' cortex in the blind participants [particularly the participant with early onset blindness], without any detectable activation in the auditory cortex" (p. 6). This suggests that the visual cortex can be deployed as a spatial sound processor. One possible explanation is that those people who are blind who use echolocation daily as a principal means of navigation acquire high level skills through practice. "It's the same principle that governs any muscle in the human body: The more you use it, the better" (Keller, 2015). It is not that better hearing skills in people who are blind make them better at echolocation because both the participants who were blind in Thaler et al.'s study tested within normal hearing range on standard hearing tests. Another possible theory is that individuals with sight may be disadvantaged at echolocation skills as their hearing and vision compete for neural resources.

Further research by Thaler (2013b) suggests that, when people participate in echolocation tasks, echo processing in the brains of people who are blind is achieved in a different area of the brain than that of people who are sighted when they process echoes. It is suggested that “visual cortical areas are recruited for echolocation in blind experts” (p. 14). In the experiments, both the participants who were sighted and those who were blind achieved similar results on a sound locating exercise, but the participants who were blind performed better than the participants who were sighted in an echo task. Interestingly, the researchers were able “to define echo-motion areas in eight out of the twelve sighted brains [which] suggests that echolocation may be more ingrained in the human perceptual capacities than previously thought, and that this might be an inherent opportunity that the brains of blind echolocation experts can capitalize on” (p. 15). Research by Milne et al. (2014) has shown that the echolocators who are blind specifically use the parahippocampal part of their brain when processing echoes. The parahippocampal area is a multimodal cortex often used for both visual and auditory processing of spatial layouts. “Superior spatial navigation performance in the blind has been correlated with a larger volume of the hippocampus” [in their brains] (Merabet & Pascaul-Leone, 2010, p. 4500).

In an experiment by Dufour, Despres, and Candas (2005), the subjects who were blind “showed significantly better right/left discrimination performance than sighted subjects when they had to judge the position of a wooden board on the basis of sounds that are reflected by the board” (p. 515). A comparison of the participants who were blind, early versus late, showed no advantage for either group. The researchers suggest that “higher sensitivity to echo cues might be mediated by changes in the auditory cortex of blind individuals as a consequence of the enhanced, visual deprivation-enforced auditory processing. . . . The blind might take advantage of higher abilities in frequency discrimination when processing echoes, since frequency modulation between the original and reflected sound is an important cue in echo processing” (p. 518). The participant who was blind in Thaler et al.’s research who had lost all sight by the age of 13 months showed “the same kind of contralateral bias for echoes as the calcarine cortex in sighted people shows for light” (Thaler et al., 2011, p. 6). Contralateral bias refers to the fact that the visual cortex shows activation in a manner that mirrors the location of presented stimuli. For example, when a stimulus is presented to the left side of a subject who is sighted, the visual cortex shows activation on the right side. When a stimulus is presented above the subject, the

visual cortex activates in a lower region, and so on. This contralateral bias is evidenced more prominently in the visual cortex than any other brain area. The auditory cortex, for example, does not evidence this bias nearly so strongly. This bias serves as a kind of mapping mechanism on the visual cortex. One can say that the visual cortex literally maps its surroundings in its neural network. The visual system of the brain is believed to be the only part of the perceptual system that represents the external environment directly within the neural network. Thus, in a very strict sense, the external environment is represented within the neurology in a manner that is believed to be correspondent with the external world. When an object is presented to the visual field, it activates a distinct part of the brain that corresponds to the position of the item. The auditory system does not activate the systematic spatial pattern in this way. The tactile system does, but only for stimuli that actually touch the skin. Therefore this is not called externalization. Only the visual system is known to represent or “map” external space within the brain.

Thus, the studies found that echo stimuli are mapped onto the visual cortex in a manner similar to vision, whereas source sounds are not (Thaler et al., 2011). The researchers are unsure at this time if this is because of plasticity of the brain due to blindness or if

it is due to echolocation specifically. Both participants used “echolocation in a way that seems uncannily similar to vision” (Thaler et al., 2011, p. 10). This is interesting because “the processing of echoes may show feature-specificity similar to the normal functions of such brain areas for the processing of vision” (Milne, 2014, p. 102), meaning that processing of shape, texture, movement and so on show a similar pattern of activation in the calcarine cortex for echolocators and subjects who were sighted. Because stronger activity in the calcarine cortex of the brain has been linked with both echolocation and vividness of visual imagery, Thaler et al. (2014) investigated the relationship between them. They found a “positive relationship between the vividness of a sighted novice’s visual imagery generated with their eyes closed (i.e., eyes closed when wearing a blindfold) and their ability to make accurate size-discrimination judgments using echolocation” (p. 1921). In other words, the stronger the activity of the calcarine cortex in the subject who was sighted when asked to visualize an object, the more accurate were her size discrimination judgments when using simple echolocation. The authors theorize that “the positive relationship between [visual imagery] and echolocation . . . might be due to people’s underlying differences in their ability to recruit [the calcarine cortex] for tasks requiring non-visual input” (p. 1923).

Research with subjects who were blind on a size-weight illusion normally attributed to visual judgments “examined perceptions of heaviness in a small group of human echolocators as they lifted sets of objects with different sizes but identical weights” (Buckingham, Milne, Byrne, & Goodale, 2014, p. 2). They discovered that “the blind echolocators experienced a size-weight illusion, reporting that the smallest cubes felt significantly heavier than the largest cubes” (Buckingham et al., 2014, p4). The echolocators in this study experienced the same size-weight illusion as the sighted subjects, further highlighting the role of visual processing with echolocation. Non-echolocators who were blind in this study did not experience the illusion, as they were not able to detect the size differences between the cubes.

Comparisons between an early echocator who is blind, an echocator from around 40 years of age with vision lost at birth, and an echocator from around the age of 17 with sight loss at 14 years of age showed some interesting differences in the way their brains processed the information. The research suggests that “extensive echolocation from a young and perhaps even critical stage of neurological development plays a strong role in establishing how echo-processing is instantiated in the brain” (Arnott, Thaler, Milne, Kish, & Goodale, 2013). “Overproduction

of synapses in the human visual cortex reaches a peak at 8-12 months after birth” (Greenough & Schwark, 1984, p. 86). It is perhaps no coincidence that the superior early echolocator who was blind had lost all vision by the age of 13 months.

Specifically, in the brain of the early echolocator who was blind, it was discovered that “there is converging evidence for the idea that echolocation-related activity in [the early blind’s] calcarine cortex may be organized in a manner similar to the way that light related activity is organized in sighted people’s calcarine cortex, i.e. by eccentricity and angle” (Arnott et al., 2013).

Research comparing spatial hearing tasks between individuals who are sighted, blind, and partially sighted indicated that “partially sighted listeners did not differ significantly in performance from age-related sighted controls, suggesting that auditory compensation for virtual distance does not arise among listeners who have some residual vision” (Kolarik, Cirstea, & Pardhan, 2013, p630). Although this text primarily focuses on how people orientate themselves without vision, it is interesting to note that a study by Neville suggests that those with hearing loss evidence enhanced visual attention (Neville, 1990).

Studies of the sight-deprived brain have “taught us that visual experience is not necessary for the major visual streams to develop and that consciousness in the absence of vision is accomplished through the supramodal nature of functional cortical organization. The more abstract representations of objects, space and motion—in other words, awareness of the external world—is associated with regional brain activation patterns that are essentially similar in sighted and congenitally blind individuals” (Kupers & Ptito, 2014, p. 49).

Hearing

“Audition is particularly important to persons with visual impairments not only because it facilitates spoken communication, but also because it assists with orientation and mobility” (Wiener et al., 2010, part I, p. 85). For people who are blind, hearing can become the dominant sense for conveying spatial information about the world at intermediate distances and for facilitating dynamic interactions with the world. As determined by brain scan research, the capacity of audition to discriminate, recognize, and image multiple events in dynamic space, called scene analysis, is very pronounced. “Functional imaging work using position resonance imaging (PET) and functional magnetic resonance imaging (fMRI) have demonstrated a network of areas that are active

during the perception of sound movement” (Griffiths, Green, Rees, & Rees, 2000, p. 72). In addition, a wealth of widely-publicized anecdotal evidence indicates prodigious capacity. However, the auditory system remains little understood or applied. Recent research has shown that there was brain activation in three main clusters: The right premotor cortex, the left premotor cortex, and the right parietal cortex caused by sound movement (Griffiths et al., 2000).

The ability to analyze sound by people who are blind must be carefully cultivated to improve environmental interaction. It is important to recognize “the value of auditory perception for the visually impaired child in determining direction, distance and position in space” (van der Poel, 1997, p. 90).

The visual system can be said to provide between five and ten thousand times the spatial resolution of the auditory system. The auditory system is primarily a temporal processor (relating to time and sequence), not a spatial processor, whereas the visual system is, first and foremost, a spatial processor, not a temporal processor (Smith-Roley et al., 2001).

Spatial information can be inferred, interpreted, and analyzed from auditory temporal information through additional brain processing for which the visual system, referred to as 'imaging systems', is well suited. The imaging system can be activated and recruited in individuals who are blind through supportive experiences or specific instruction. The auditory system does have some parallel spatial capacity which is largely unexplored. For example, music conductors can isolate what each player is doing yet maintain awareness of the whole orchestra. This process is known as sound discrimination and will increase with use. There is a unit of detectives who are blind in the Belgian police force deployed to assist with identifying sound clues where sight clues are not present, for example helping to determine the location of a criminal calling in on a cell phone by listening to background noise or identifying accents (Soares, 2007). "In the age of steam railways, 'wheel-tappers' would check for cracks in railway carriage wheels by tapping with a hammer and listening to the echoes" (Plumbley, 2013, p. 12162).

The authors believe that the brain learns to see by using systematic stimulus differentiation. This natural process may be fast-tracked with formal instruction. The process of helping someone to learn FlashSonar involves 'tickling' the brain into registering and

processing subtle sound stimuli that may be beyond the conscious experience of the student. These stimuli often flow through our perception without conscious awareness, and the neural system may not have developed the full capacity to register or react to these stimuli. Teachers must help the student to “hook in” to these stimuli so that channels of processing these stimuli can be opened and made alive. This involves helping students to register and process stronger or more intense stimuli so that the brain may then open to processing subtler and finer stimuli. The opening of these channels is often accompanied by a spontaneous sense or expression of excitement or sudden realization—the “aha!” experience. (See Chapter Four for more details of how to do this in relation to FlashSonar training.)

A recent experiment compared the participants’ ability to localize sound using auditory and audified ultrasound signals. It was discovered that “azimuth [horizontal] localization was similar immediately in front of the user among all conditions, but especially for novices, peripheral judgment was better with audified ultrasound” (Davies, Pinder, Dodd, & Burns, 2012, p. 137). Participants needed about 15 seconds of training on the AUDEO equipment used. This “supports audification as a means to provide environmental information to individuals with reduced

visual acuity or complete loss of vision in a manner that requires minimal learning” (Davies et al., 2012, p. 137). However, the researchers do acknowledge that their research only used 15 participants who were sighted, and it is possible that people who are blind may use sound in a different way.

Adults

Everything that has been stated here about perception and learning equally applies to adults as well as children. Whether child or adult, the nervous system must adapt actively to its circumstances. Blindness is a circumstance. The good news is that modern neural science tells us that neural plasticity is much greater in adults than was previously believed. The bad news is that adults must struggle with years of conditioning, programming, and patterning which may actually run counter to what should be a natural propensity to adapt. Psychological conditioning can therefore immobilize the nervous system’s capacity to adapt favorably. Since many adults with a visual impairment became visually impaired later in life, their conditioning is likely to be geared and molded around a visual perspective and modes of function. The England register held by the National Health Service of people registered with a sight problem showed that at the end of March 2008, 64% of people registered as blind were over the age of 75 and 66%

of those registered as partially sighted were over the age of 75 (National Health Service, 2008). The World Health Organization stated that 82% of people with a visual impairment worldwide are over the age of 50 (WHO, 2010). "Although those 65 and over make up only 12.8 percent of the U.S. population, they account for roughly 37 percent of all hearing-impaired individuals and 30 percent of all visually impaired individuals" (Desai, Pratt, Lentzner, & Robinson, 2001). "In 1995, the prevalence of blindness in both eyes was about 1 percent among persons 70-74 years of age compared with 2.4 percent among those 85 years of age and older" (Desai et al., 2001). "One fourth of those reporting significant vision loss [in the US] are 65 years of age or older" (Manduchi & Coughlan, 2012, p. 2).

An additional struggle for adults may be the need to relearn skills. Whereas children are more likely to be learning skills for the first time in parallel with their peers, adults are often placed in the situation of needing to step out of life to relearn whole skill sets, which can dramatically affect the course of their lives. Such training with children is called habilitation whereas adults receive rehabilitation training.

Thirteen adults aged between 25 and 46 years old were used as participants in a study to compare how they could learn to use equipment when blindfolded.

Three participants were blindfolded continuously for 21 days, eight participants wore blindfolds just for the tests, three participants were blindfolded during the tests but also used the device for an additional 4 hours a day, and two people wore blindfolds for the tests but didn't use the device. The device was a camera, and its images were converted into sounds via headphones that were then used to find objects. "Subjects that used the substitution system immersively in their daily life had superior performance to that of the [laboratory users] in all three experiments. Together, the results suggest that the additional daily practice and the opportunities for learning-by-doing in naturalistic conditions it afforded effectively improved performance on the localization tasks we presented" (Proulx, Stoerig, Ludowig, & Knoll, 2008, p5). "In summary, the adult auditory system can learn to localize targets based on an image-to-sound conversion system and immersive practice holds hope for providing the perceptual learning required to localize things quickly and accurately" (Proulx et al., 2008, p5). This is supported by other research which demonstrated that an adult who lost his vision at age 19 but was taking part in echolocation experiments just 2 years later (with results higher than controls who were sighted) had developed compensatory mechanisms in a relatively short period of time (Kolarik et al., 2013).

Material in this chapter pertains to adults in much the same manner as it does to children. In either case, one must adapt. To do this, one must be exposed to an achievement-oriented approach as quickly as possible, lest patterns of dependency develop early to usurp the adaptation process. Early perceptual training and other aspects of an achievement oriented approach are critical and will strongly foster positive adaptation. However, whether one is an adult or child, "the earlier individuals with visual impairments receive special training, the more extensive is the reorganization of their brains that subsequently leads to better coping mechanisms" (Jan et al., 2013, p. 259).

For a more in depth and cross disciplinary treatment of nonvisual development and perception pertaining to navigation and object perception, the authors recommend: *Blindness and Brain Plasticity in Navigation and Object Perception* (2012) Rieser, J. (Editor) publisher Taylor & Francis.

The next chapter explores optimal learning conditions including the involvement of the significant people in the learner's life.

Chapter 3 — Optimizing Learning Conditions

This chapter is about how people learn and develop perceptually and the methods applied to help facilitate the perceptual learning process.

Facilitating Conditions for Optimal Development

The authors hold that the key to optimizing self-directed achievement with little compromise or concession is in approaching disability from a perspective of gain rather than loss. A gain-adaptation model regards the condition strictly in terms of achievement style, not impairment. The focus is on achievement by adapting to one's condition and gaining access to resources. The emphasis is not on whether one can or can't achieve, but on how and what one does achieve.

While everyone faces limits, the authors assert that limits should not be imposed or presumed upon anyone. We all have the right to enjoy the freedom and strength of character to seek and discover our own limits and strengths, regardless of sight. Performing activities that a person never thought he could do loosens up his perception of his limits.

However, the goal in the learning process is not to do all sorts of extreme activities unless the student wants that to be the goal. The goal is to challenge his limits, because it is always beyond one's limits that life holds the greatest luster.

The authors regard blindness as no more nor less than a condition of challenge that requires adaptation. Blindness, like other impairments, may be conceptualized as just another condition requiring adaptation. The literature contributing to an understanding of neural plasticity around adaptation to blindness is new but quickly expanding. We may, however, draw some inferences from the literature pertaining to stroke recovery and traumatic brain injury, which is extensive, and neatly summarized in Doidge (2007). It is clear from this literature that when control over a limb has been lost, the limb quickly falls into disuse. Initial attempts to use the limb fail, and a "learned non-use" comes into play. In time the limb may simply hang immobile. It will not recover without active use once it has reached the point of learned non-use. However, considerable literature shows that, when the limb is involved in an intensive program of use and activity, that limb usually recovers some function. To facilitate recovery, many programs have found it useful to restrict the use of the operative limb in order to activate the non-

operative limb to resume functioning. This is called constraint-induced movement therapy (Blanton, Wisley, & Wolf et al., 2008). While it does not appear critical that the operative limb be completely constrained, it is critical that the limb affected by the brain injury is used intensively and extensively, which may be facilitated by constraining the operative limb (Murayama et al., 2011). Intensive and extensive use is further facilitated by involvement of the immediate family or support system to assist in carrying out a rich routine of activities that continually engage the affected limb (Uswatte, Taub, Morris, Barman, & Crago, 2006).

If we view adaptation to blindness as a form of neural plasticity, then we can borrow concepts of learned non-use and-constraint induced movement therapy to help us understand how this process may affect people who are blind. As with stroke survivors, when people who are blind do not use their perceptual-motor, navigational, and spatial processing systems, these systems fall into learned non-use. Likewise, they can only be expected to recover these abilities through intensive and extensive use. Analogous to constraint- induced movement therapy, this intensive and extensive use is greatly facilitated by the reduction of the imposition of physical and verbal guiding, description and narration, sighted facilitation,

environmental modification, and tactual dependence on physical surfaces and boundaries. As with stroke survivors, this approach catalyzes the unlearning of learned non-use, and activates the utility of the perceptual-navigation system. Thus, the teacher must work to help the student infuse his circumstances with these conditions.

It is Daniel Kish's observation that learning and development occur most rapidly and efficiently and are most strongly sustained when certain conditions surrounding the student are in place. Kish refers to this as a "Freedom Formula". Neither FlashSonar nor any other skill is learned in a vacuum. A rich context that promotes or fertilizes learning will result in stronger, more rapid gains. For example, one learns a foreign language most effectively and rapidly when he is surrounded by that language. This is similar to the process of adapting to blindness.

"Human echolocation is a capacity of any human being, but the extraordinary skill shown by exemplary practitioners like Daniel Kish and Ben Underwood requires much more than just a human nervous system and the right training: The skill requires a community that 'gets it' and supports the capacity. . . . Echolocation is not just the conjunction of a human brain, mouth, ears and objects to reflect back

sound; it's also the product of a social group and society that has its own attitudes and approaches to dealing with blindness. At the same time that people like Kish are helping to spread techniques like echolocation to an unprecedented number of individuals, we can see that other social forces might decrease the possibility of achieving this perceptual skill" (Downey, 2011).

Kish's approach is divided into three sets of principles: Instruction, development and adaptation, and action.

Instructional Principles

The student is central in the process. According to learning and motivation theory and practice, the factors influencing learning and development boil down to three main conditions: (a) motivation (preferably intrinsic motivation under positive circumstances); (b) regular practice and application; and (c) increasingly challenging activities or circumstances. Above all, it is ideal for the student to have and apply a positive and hopeful attitude about his own capabilities.

The authors believe the learner is the center of the instructional process. When teaching in a learner-centered style as promoted by Dr. Karl Rogers, the teacher makes every endeavor to place primary

emphasis on the student's style and need of learning, rather than on the teacher's own agenda or body of knowledge (Smith, 1997).

In this view, it is not about trying to teach a learner the teacher's knowledge, but fostering a student's ability to learn. It is understood that knowledge can be constructed by and within the learner through natural experiences and interactions with the environment. This learning may be facilitated and enriched by a caregiver or instructor through stimulating experiences and activities. However, this is understood to support the process; it does not make the process. The teacher's role is "not to teach blindness skills per se, but to teach the student how to learn blindness skills independently" (Mettler, 1994, p. 347).

It is important to place the emphasis on how students learn and what seems salient to them, rather than on what the teacher feels should be taught, although there is merit in teachers sharing their body of knowledge and perspective as appropriate. Two-way communication must be carefully fostered with the student to understand the student's phenomenological frame of reference—how does a student perceive his world, himself, and others around him through his senses and his mentality? Van der Poel (1997)

mentions that it is “important to introduce level appropriate skills rather than age-appropriate skills” (p. 15) to enable the student to learn most effectively.

This seems to be the most natural way for the brain to learn. It allows the most generalization to the most varied situations in the widest variety of students. Effective teaching is about helping students develop a dynamic means of establishing a relationship with the world for themselves based on their direct awareness of the environment through their own senses, not dictating or establishing that relationship for the student. The former process results in a student-centered relationship with the world. The latter can only result in another-centered relationship, to which the student is a third party. The student’s intrinsic perceptual feedback and comprehension processes are the primary source of learning rather than extrinsic feedback from the instructor. Thus, control of the learning process rests primarily with student-centered factors.

It is often more richly nourishing to touch the flame for oneself than to heed the warning of another. In World Access for the Blind’s program, students literally reach into the flames with the teachers so they understand the heat, but also learn to consider what is best to touch or not touch. This is meant

literally in cooking classes, but also figuratively in all other classes. While hiking, for instance, students are never physically guided, and rarely verbally prompted on where to go. They are instructed on how to decide for themselves where to go and how to get there. Even if they follow the sounds of another ahead of them, they do so under their own perceptual-motor abilities, and not under the helping hand of another. “In learning anything new there seems to be a pattern: We do it for the child, then with the child, and then allow the child to do it alone” (Cutter, 2003b, p. 2). In this way, they form their own comprehension of what is accurate, effective, adaptive, and what fosters within them the most effective and adaptive access to what they want and need. This process of scaffolding often necessitates facing students with situations which are uncomfortable. Challenging situations typically are uncomfortable. This is because the nervous system undergoes a period of disequilibrium when facing a novel situation until the new information is assimilated, and the individual becomes familiar with the factors of the challenge—bringing it back into equilibrium.

On one occasion, Kish was working with a very bright 5-year-old girl in the UK. She exhibited almost no self-directed mobility in her own home. As she was home schooled, she also had little opportunity to apply

herself on her own terms outside the home. She was constantly guided or carried from place to place. When interacting with her, Daniel noticed that she wouldn't even reach out to explore anything, unless her hands were moved to the object. Upon first arriving at the home with the girl's mother and O&M instructor, the girl needed to use the toilet. Her instructor, who had enthusiastically arranged for Daniel to work with her, immediately took the girl by the hand, led her into the bathroom, and motored her through every step of the process from toileting to washing to drying her hands. The girl was then led back to Daniel by the hand, where he began his work. This involved providing her with a cane, first and foremost. As she didn't know her way around her home or garden and lacked confidence in making any movements on her own even in her own home, Daniel recommended that she use her cane around her home.

Work began immediately with Daniel showing her how she could hear where different rooms were by the echoes they sent back when she clicked. At first, she made no movements, clearly expecting someone to guide her from place to place. But, she quickly got the hang of it, and began slowly finding her way to the different rooms as requested. During work out in the garden, Daniel showed her how to find the house from her swings, just by clapping and hearing the clap echo

from the house. Although the girl threw tantrums the entire way, calling for her mother, she did find her way. The girl's mother definitely saw and appreciated the learning development in action from this process of activating self-execution. She explained that she did not feel that she was treating her daughter any differently than she would have treated a child who was sighted (this was her only child). Her interactions were warm, affectionate, and physical in the form of handholding, hugging, and carrying, and this physical manner of interaction was reinforced by her mobility officer, all in good conscience.

Teachers can help students to acquire a set of achievement-oriented, self-directive abilities through the children's active participation in and direction of the learning process. This can occur in challenging situations which may be engineered or facilitated by the teacher and by which the student must discover a way to address. Thus, the instructor can help to reinforce and generalize the development of this array of self directive abilities. The student's intrinsic perceptual feedback and comprehension processes become the primary source of learning rather than extrinsic feedback from the instructor (Nyman, 2008).

Control of the learning process thereby comes to rest

primarily on student-centered factors. Mettler (1994) advocates the teacher “hinting at ways the learner can acquire information to solve the problem, but without ever being so explicit as to remove any degree of challenge for the learner” (p. 340). It is a matter of stimulating comprehension within them, rather than imposing comprehension on them.

In the case of verbal prompts, the authors usually find it best to ask questions rather than give answers. Questions engage much more of the brain than does furnishing answers for many reasons that are beyond the scope of this discussion. The brain most naturally wants to learn by asking questions of its environment, actively drawing information from the environment, not by waiting for the environment or passively receiving information as it is pushed in. If the student “cops out” by answering, “I don’t know,” the teacher can insist that “I don’t know” isn’t an answer, and refuse further cooperation until the student is willing to cooperate by furnishing productive answers. Of course, if the student really doesn’t know the answer, then furnishing strategic hints may be helpful.

The art of questioning versus answering stimulates students to think pro-actively, rather than reactively. In general, the most effective answer from a student is produced as a result of thought provoking questions

such as: “What can you tell me about that? What do you think it is? Where do you think it comes from? What does it seem like?” and so on. Rather than giving away information by narration or spoon feeding, the authors usually find it best (although not always practical or feasible) to encourage the student to discover answers through investigation and critical thinking. “Shall we go find out?” By exploring the environment and discover elements of it for himself, the student takes a more participative role in the lesson, which is more active and engaging for him (Fazzi & Petersmeyer, 2001).

This approach is often referred to as learning through problem-solving (the authors refer to this as self-directed discovery), which nurtures the student’s capacity to learn and grow from information he acquires for himself through his own self-directed discoveries and interactions with the environment. The authors refrain from using the term “problem solving” because they prefer to think of life as a series of opportunities for discovery rather than problems to be solved.

Strategic questions to students that promote discovery tend to engage and develop the higher brain functions of cognition and perceptual processing, whereas informative feedback or directive prompts

(i.e., telling the student what's around and what to do) tends to trigger and reinforce more primitive brain activity associated with action and reaction. Stimulating higher brain function fosters the development of more effective self direction toward higher achievement in a complex, modern world. "Those grounded in a humanistic philosophy posit that self-directed learning should have as its goal the development of the learner's capacity to be self-directed" (Merriam, 2001, p. 7).

Supported discovery learning is advocated by Mettler (1995) because it encourages the student to take responsibility for his own learning and intrinsic feedback very early in his training. This is because otherwise "the instructor who assumes the responsibility for monitoring student safety and who continues to be the authority regarding students performance promotes students dependency which, in turn, is an obstacle to self-assured achievement" (Mettler, 1995, p. 17). To this end, as a rule, our interactions tend to take the form of questions about three times more often than answers or directive prompts.

Ecological systems approach

In respecting the student as the nucleus of the instructional process, it is necessary to address

dynamics of the entire system connected to the student. This includes the student's immediate family (first and foremost), extended family, friends and associates, immediate community (school, work, neighborhood), and anyone working with the student in a professional capacity.

The teaching of FlashSonar skills is like any other learning experience; it cannot be taught in isolation but in consideration of the learner's current knowledge, his motivation, and his family situation. As van der Poel (1997) reminds us, "a visual impairment is no dysfunction-in-isolation. It can never be separated from the impaired child, his family, the society and his living world" (p. 11). Although the authors do not regard visual impairment a priori as inherently "dysfunctional", they have observed that the sentiment expressed by van der Poel with regard to the ecological relevance of family and community to students is well considered.

The dynamics of the system will always maintain more impact on a student than a single instructor. Therefore, it is essential to address the entire system to cultivate a fertile, broadly supportive context for student learning and growth. Most learning does not occur during instructional sessions, but in the application outside instructional sessions. When the

system dynamic is open to and supporting of the learning process, opportunities for learning greatly increase in quality and quantity. "Parent-professional collaboration, responding to the concerns and priorities of families, and other family support activities that are hallmarks of family-centered intervention, are undoubtedly crucial for engaging parents in the intervention process" (Mahoney, Boyce, Fewell, Spiker, & Wheeden, 1998, p. 15). When working with children, it is especially important to involve the parents in the learning process. As Pogrud and Fazzi (2002) state, "professionals working with visually impaired children will have a greater impact if they have an understanding of, sensitivity toward, and respect for the family" (p. 16).

The teaching of FlashSonar skills constitutes a process of engaging the student in the various activities and exercises in a manner that respects the student's learning style. However, it is in the regular and self-directed practice and application of these skills in daily life that the learning is achieved by the student. In this sense, think of learning as a process of facilitating natural development, not the imposition of a contrived system or structure. Sighted children learn to see, not by structured systems and curricula, but by a natural unfolding of development through discovery learning by trial and error, gently guided and supported by

family and community. We regard children who are blind learning to perceive and interact with their environment in the same spirit. In this sense, the teacher is really more a facilitator and will not be present in all situations of daily application; but other family members or friends can support and assist the students in their learning and development. "Parents are considered key team members with full decision-making power of what the goals of the program will be and how they can be best reached" (Poggrund & Fazzi, 2002, p. 330). When the teacher integrates these supportive family or friends into the teaching process, the student experiences and benefits from more opportunities for learning and natural growth.

For many children, the family is their community. They learn about their relationship with the community as modeled by their relationship with and role in their family. They learn how to interact in a mutually contributory fashion through their family dynamic. If the student is overly catered to, overly sheltered, or over protected, the student is denied the opportunities to interact with the family as an equal and contributory member, and thus denied the opportunity to learn mutual interaction with the community at large.

As Daniel's mom writes, "There are many things

children can do to help . . . to contribute. Children need to experience firsthand: Failure, success, helping others, respect for themselves as well as respect for others. They must learn to take responsibility for their actions. We need to let them grow to allow them the ability to make choices. All people deserve the right to make choices. This is independence” (Kish, 2000).

It is not just a matter of professionals counseling families how to support their children who are blind. The inculcation of passivity and dependency conditioning can be just as much imposed by professionals and institutions as by families.

“The overanxious attitude of teachers, parents, and caregivers may also contribute to the slower development of blind children, as may the lack of stimulation from the environment (no or little visual information) and hence the decreased motivation to move because the visual control is wholly or partly absent” (Sleeuwenhoek & Boter, 1995, p. 362).

Professionals owe it to their student’s long term development to monitor all the ways in which their teaching styles and paradigms, personalities, motives, and agendas may impede rather than impel the natural developmental process. As a touch stone, it is useful to ask two questions: “Does this approach help to liberate or restrict a student’s short and long term freedom of choice and achievement?” and “How can I

help the most by helping the least?"

Kish provides the following example. On one occasion, I was working with a 9-year-old boy to learn the way from his house to the nearest post box. This required walking several long blocks along a footpath which ran parallel to a very busy road. This footpath was fairly wide and was well designated by a distinctive raised curb. His mother insisted that she and his instructor had been working with him for months on the route, "But he just isn't getting it." Initially, the boy veered often from the footpath and stepped into the road, repeatedly failing to heed and respond to clear information from both his cane and his feet. Despite the abject gasping sounds from his mum whom I asked to walk behind me, I allowed the boy to step from the footpath into the road each time. Each time, I maintained my position between him and moving traffic, and each time, I inquired congenially, "How did that happen? Were you listening to your cane?" I had made very clear to him as part of our training that, "our cane never lies to us. We just need to listen to it." His mother in something of a fright explained, "Oh, we just never let him go near the road. We always had him shoreline the side away from the road. For the first several weeks, his instructor held his hand the whole time and just showed him every detail along the way so he would know all his

landmarks. Now, we just walk between him for the road while he shorelines.” But as the boy’s wayward ventures into the road decreased precipitously of his own accord without need for my direct intervention, his mother quickly understood the rationale behind my approach. “How will he learn to interact with the road if he not only never interacts with the road, but is also conditioned to fear it? When he has developed his own capacity to interact with the road on his own terms, then there is no need for him or you to fear it.”

It is important for the teacher to liaise and work with other professionals and important people in the student’s life. “Effective collaboration [with other professionals] often increases opportunities for creative instructional approaches through the sharing of ideas and energy” (Fazzi & Petersmeyer, 2001, p. 327).

By involving the student’s family, there is more likelihood of follow through at home. Therefore, there are more learning opportunities for the student and more active partners and advocates in the process (Fazzi & Petersmeyer, 2001). This is especially important when teaching children. “Family can undermine or greatly enhance what we do as service providers. Without support from the family, what we do has little impact” (Kish, Bleier, & Moser, 1998, p.

19). Mahoney et al. (1998) state that “our findings suggest that the impact of interventions on children’s development was directly related to their effectiveness at supporting and encouraging parents to engage in responsive interactions with their children” (p. 15). Scott (2010) writes about a case study where the child received O&M training from the age of 14 months until 4 1/2 years old. “This program was successful because T’s family, her teachers, and other early intervention professionals were strong believers in, and advocates for, the development of early O&M skills, and in particular, the right of young children to learn to use the cane. It also allowed for terminology and techniques to be used consistently” (p. 29).

Perception-based learning

Perception-based learning targets activation of the perceptual imaging system of the brain. This results in the brain’s ability to code data from nonvisual sensory inputs, such as hearing and touch, to process this data to construct images similar in functional character to visual images, and then to direct interaction with the environment with understanding and precision.

Contrast this with mechanics-based learning which primarily involves rote memorization of motor sequences and implementation of mechanical skills in specified situations such as route travel through

familiar places. It does not necessarily activate the neural substrates that underlie perceptual imaging. Mechanics learning tends to rely upon skills developed through prescribed motor sequences that prepare students to react to predetermined situations, while perception based learning allows personal control over understanding and initiating interaction with the spatial environment in all situations, familiar or unfamiliar, under full control of the learner. Furthermore, mechanics learning tends to require reliance on external factors to support functioning, such as guidance from others, prescribed skill sets taught by others, route memorization training, and modification of the environment for blind accessibility. While some of these things do have their utility at certain times, perception-based learning places capacity and responsibility in the hands of individuals who are blind, allowing them to access any environment with less need to rely on external supports or special accommodations.

The perceptual system is the center of our interest. Rather than trying to push a contrived set of skills into the student, you can activate the perceptual system to manifest skills as they are needed through self-directed, solution-oriented interactions with the environment. As Kish (2010) states, this is done by “Engaging the whole brain in a developmentally

natural manner that activates the perceptual imaging system by fostering self-directed freedom of discovery” (p. 38).

It is not a collection of skills that makes perception happen; it is perception that compels skills to develop as circumstances require. Through this approach, relevant skills tend to emerge naturally with each situation that is encountered.

A child who is sighted does not usually need much formal instruction to run or play ball; these skills emerge with observation, motivation, and application. Thus, skills and action arise from perception and desire. Skill sets do not, themselves, drive action. What skills must be taught to children who are sighted before they can see? None. They just do it. With a little casual support, this happens through a natural process of self-directed discovery from birth. Why should it be different for children who are blind?

Rapport

There is a necessity for rapport between the teacher and student based on trust, respect, and amiability. This is imperative because this provides the student with the security to help him face challenges with improved adaptation. There is a difference between tension and stress. The healthy tension of facing

challenges can help us access the psychological and physiological resources to assimilate new information in order to meet challenges. Stress or distress can impede access to these same resources. In other words, a distressed person tends not to be able to adapt to a novel situation and regain equilibrium. When there is good rapport, the student can tune into the relative stability of the teacher and learn to access these resources by a kind of empathic modeling. The teacher can also scaffold the discovery process and provide reassurance where appropriate. By providing a kind of security through camaraderie, the teacher frees the student to engage the equilibration process to face the challenge more adaptively. Rapport is especially key when working with children “if the child does not feel safe and comfortable with that person, the child will have great difficulty learning anything from that person” (Kish et al., 1998, p. 5).

“Lucas [aged 5] has Septo-Optic Dysplasia (SOD) and Retinal Aplasia. He has a little perception in only his left eye, Asperger’s syndrome, and a few behavioral issues associated with SOD. Lucas’ mother Sarah describes Daniel [Kish’s] and Brian [Bushway’s] visit. ‘The first day was just about getting to know Lucas and bonding with him . . . Daniel told us we had to stop holding his hand which, as the mother of a blind child, was really scary. But when you can see

what is possible, that gives you the incentive to do it. Sometimes Lucas was very scared as it was so much for him to deal with, but he formed a great bond with both Brian and Daniel and whatever they did Lucas wanted to copy so that worked really well. . . . They taught him to have confidence in his mobility so much that he got a bike for Christmas and loves to ride it using his echolocation skills. Even when we are walking through a crowded shopping center, we no longer hold Lucas' hand, he is just happy to walk with his cane'" (Lockwood, 2008, p. 41)

The most effective teachers are the most willing learners. Teachers must open themselves to learning from and with their students as much as they teach. They must remain always engaged in the discovery process with the student, rather than conducting the process for him. If teachers are not learning as much as they're teaching, then they may not be teaching as much as they believe they are.

For some younger children, up to about the age of seven, and for children with multiple challenges, it may be useful to train a child who is two or three years older to be a coach and mentor. The older child will be old enough to be watchful and responsible, yet young enough still to be a child and act as a friend and companion.

Children often learn better under these conditions because children can teach things to other children that adults cannot.

Above all, the key is to maintain the student's interest in the tasks and motivation to learn. Some students may seem averse to self-directed travel, but it is vital that this aversion be replaced by a desire to explore and discover, even if assisted to do so. The teacher should remember that "positive emotions allow people to recall experiences with greater clarity" (as cited in Merriam, 2001, p. 77). Helping the student maintain interest and motivation is worth far more than the most carefully designed hierarchy of tasks.

Commitment to the sovereign student right to access societal resources

The authors assume a priori that all students have the sovereign right to opportunities to participate equitably in society at all levels, according to informed choice and personal responsibility. These rights are broken down according to access to the physical, symbolic, social, psychological, physiological, and spiritual environments with reference to societal engagement. This does not mean that it is society's responsibility to facilitate the ability to engage every aspect of the world equivalent to everyone else for a person who is blind. The authors recognize

that blindness can present fundamental challenges to accessing many aspects of the environment. Vision makes use of light which provides a level of detailed resolution that no other sense can come close to matching under circumstances in which light is particularly useful. It is not necessarily society's responsibility to change or address that basic fact. However, to the extent to which society makes itself and its exchange of goods, services, and companionship available to its members, it is in society's best interest to make every effort to involve all its members, including people who are blind, equitably in this exchange process. Thus, the authors consider access to societal resources to be a sovereign right. Full access to these resources optimizes self-directed achievement in society and quality of life. Our goals and objectives are not about what a student needs because the needs are already self evident in their universality—all students "need" to have their sovereign right to access societal resources honored, respected, and facilitated as necessary and appropriate. Our goals and objectives are about strategies to meet these universal needs. These needs can be addressed respectfully for all students whose learning style is understood, regardless of the extent of impairment, given appropriate strategies and recognition of basic challenges. Most students are capable of learning when the learning style is

understood, and the motivation of most students can be encouraged or triggered by a respectful recognition of the students' potential and commitment to their need for access.

In this spirit, teachers must remain committed to student capacity. Say, "yes and," to student capacity, not "no, because." The "no, because" credo is all too often the fallback position of many instructors and family members. One by one, excuses are made as to why a student who is blind cannot or should not participate, paring down the range of "acceptable" activities until little is left but to sit quietly with folded hands, while one is drawn through life by others.

Kish writes: I was working with an 11-year-old boy in Scotland, and the subject came up about what he'd like to do with his life. "I want to go into law enforcement," he informed me, "but they said I can't, because I can't see." Upon further investigating, his real interest was criminal justice, and in particular, criminal psychology. It is often not difficult to turn a "no" into a "let's see."

Whatever a student's interest is, the teacher should be committed to help him find a way to meet it, or its nearest satisfactory equivalent. While respecting safety and reason, the focus is on finding solutions, not problems.

Be interested in the “how”, not so much the “why not.” The results of this approach are most rewarding.

Principles of Development and Adaptation

Freedom first

The reach for freedom is a foundational drive behind development and adaptation at any age. From the first days of life, infants strive to move, to obtain, to understand. This same thirst for freedom continues to drive our adaptation throughout the life-span, although it may not always manifest so clearly in adults. This primal thirst for freedom drives every developmental stage throughout the lifespan which, in turn, grows toward greater freedom. Freedom is first and foremost behind the developmental process. Yet, for people who are blind, especially children, it is commonly held that freedom can only happen once a certain ground-work is first meticulously laid. Thus, freedom is often conditional according to certain structures and contrivances that are felt must be put in place by others-when to use a cane, how to use a cane, what to know, what not to know, how and where to move and not move.

Kish says “In one case during my internship, I was working with an adult client in a rehab facility who had become quite dependent. I immediately began

showing him how to get himself around the facility so he could experience his own freedom as quickly as possible without need for supervision. It was not my intention to orient him to the facility, but to show him how he can orient himself. My intern supervisor expressed her preference that I assess him first before providing instruction. I assured her that assessment included aspects of learning and information processing style, and for this I need to spend time actually instructing him. 'Besides,' I insisted, 'he has no capacity to get around this place.'

"There are people to cart him around until you can orient him,' was more or less her exact response. However, she did not interfere with our progress."

In many countries infants and toddlers who are blind receive ample instruction from early interventionists who may come weekly to visit the child and family. The purpose is to prepare the child to meet all his developmental milestones so that he will be ready to begin school on par with his peers. Much attention is given to many areas of development (cognitive, social, motor, and language). The child is engaged in many activities to stimulate growth and knowledge. The emphasis is often on providing the child who is blind with a set of experiences and activities deemed necessary or suitable to develop concepts about the

world. This presupposes that the nonvisual brain does not have the capacity to discover this naturally. The result can be, more often than not, that a child who is blind by the age of 6 may be quite chatty, charming, and full of knowledge, but cannot move on his own and does not have a self concept of self reliance. He may have been carefully prepared to be dependent on others to bring the world to him or bring him to the world. He does not have freedom to develop his own relationship with his own environment in his own way on his own terms. When this is queried, the answer is often that the child will learn to do this when he is ready or that the child is already doing this, when in fact he is doing this only under the guidance and supervision of others.

The environment is brought to him, or he is brought to the environment. Every detail is spoon-fed to him, every experience carefully monitored or presented to him by hand. When one is directed by others in this fashion, activation of the perceptual-motor systems in the brain is limited to reactive rather than active mechanisms and tends primarily to constitute brain activity mostly limited to lower rather than higher brain functions.

Let's consider another example. Kish writes:
"Where are we? Who is there? What's that noise?"

How do you spell it?” The endless stream of animated queries rang bell-like from a 3-year-old boy named Twam who was totally blind from birth. As I entered the classroom, I discerned that he sat quite still in his father’s lap, authoritatively gathering and absorbing information about his surroundings through a grasp of language advanced well beyond his years. I could tell this, even though Twam’s well-crafted inquiries came in Dutch, translated to me by his early intervention instructor. After a brief introduction Twam immediately began eagerly digesting and appropriately using my vocabulary in my accent. In minutes his English grew better than my Dutch had grown in three days of delivering FlashSonar workshops at Sensis—a major blindness institute in Holland.

Twam used language from a stationary position to explore his world through the perception of others. He did not seem to take physical interest in anything unless it was put into his hands or his hands were guided to the item. Like most blind children his age in most countries, he had no cane, and he had never taken a single step outside his home without a hand held or someone hovering over his every move, poised to direct, instruct, cater, or otherwise rescue him from any confrontational encounter. When I positioned him near a wall and encouraged him to find it by clicking

and scanning with his head, he only stood rooted to the spot and ask, "Where is the wall?" at which point his early interventionist would hasten to take his hand and lead him there. "Ah!" He would exclaim with gleeful realization. "There is the wall."

"I know you know where the wall is," I admonished his instructor with the biggest and friendliest smile I knew how to make. "This is about Twam learning to do this himself." At that point, all of Twam's typical strategies for drawing information through surrogate perceivers were gone, leaving him pensively baffled. He remained stock-still and spoke wistfully as if perplexed about what to do and where to go. Tension hung thick in the room as breaths were held all-around in anticipation of what Twam would do, now that his strings were cut. In essence without a puppeteer, Twam simply did not know what to do. But, I am not unsympathetic to the stresses of this transition to personal freedom, and we proceeded with much cheerful encouragement, which Twam seemed to appreciate with good sportsmanship.

Outside on a playground which was new to him, little Twam continued his plant-like adherence to a single spot of grassy earth. He would not so much as step toward a voice calling to him from within a tunnel two yards away. In the end, inch by painstaking

inch, he finally tiptoed toward the tunnel, all the while asking plaintively, "Where is the tunnel?" then beaming sheepishly amid showers of applause and congratulations as he finally stepped within its walls. "We brought the world to Twam," they explained later at a symposium of hundreds of instructors from all over the Netherlands, "or we brought him to the world. He did not know how to manage his own way in his world. He was disconnected. We made his world for him. He did not make it for himself like sighted children do. We will be doing different things now with Twam, and with our other students."

Twam's stellar accomplishments with language and cleverness were most inspiring, while his incapacity to govern his own freedom was heart-breaking. What would be his fate? Building his sightless world from scraps of information fed to him, pulled along by hand, ever to follow the dictates of others, subject to others' support and availability, never knowing the rich opportunities that lay beyond these contrivances?

The answers came about a year and a half later when I revisited Holland for a follow-up workshop. I thereupon encountered an erect and poised, strapping five year old boy I hardly recognized. Dancing about us as we set out to begin our exercises, Twam burst with the anticipation of going somewhere. His cane,

which had been provided him soon after my last visit as I was assured, glided easily with a light clatter over the textured surfaces before him, and his occasional clicks filled the space around him with a sound vision. "Follow me!" He heartily called back to the troop of instructors, his parents somewhere among us, streaming behind him as he skipped freely ahead with seemingly careless abandon. "This way!" He spoke half in American English for my benefit, having resolved to pick it up when he had learned of my return. "No," he roundly reproached anyone he heard moving ahead of him. "You follow me. I go in front. I am the leader!" And so he was, now that he had found his freedom.

This contrived disconnect would only happen among children who are blind like Twam, and only due to a paradigm that artificially enforces this state of affairs. In nearly every other creature, freedom is paramount from the first days of life.

Need drives learning and development

Most known organisms learn most naturally through experiences and activities that satisfy or address a need—need to eat, need for companionship, need for shelter, need for freedom, need for security, need for contentment or fulfillment or sense of dignity, or whatever. Humans do not learn well from contrived circumstances or fabricated situations. Consequently,

we attach our activities and exercises to a context that embeds the need to learn. For example, a student will never learn to self-navigate while taken by the hand. There is no need to learn to self-navigate while the navigating is being done for us. Therefore, we remove the hand so that the need to self-navigate becomes addressed.

As an extension of this, dependency and limitations cannot lead to independence and freedom. It is a simple formula, almost like an equation: If we put in self reliance and autonomy in the front end, with a healthy dose of nurturing support, we can well expect self reliance and autonomy to come out the other end. On the other hand, if we feed reliance on others for success in the front end, which is what is generally done to people who are blind, that's exactly what we can expect out the other end. Like a mathematical equation, when we put in dependency and reliance on others, that is exactly what we can expect to come out of the equation. It is not logical to suppose that we can teach independence by means of dependency. We call this "dependency conditioning", a process similar to the more popular notion of learned helplessness.

An athlete, for instance, doesn't usually excel without considerable preparation at the front end. What we put in largely affects what we get out. This tends

to be especially true for children who are blind because they tend to learn most from direct physical and verbal interaction with their environment. In other words, they tend to learn the most from their immediate surroundings and the quality of self-directed interactions with those surroundings.

Of course certain personality characteristics may skew the results one way or another. A strong, independent personality with a strong drive to explore will be more resilient to dependency conditioning than someone who is naturally more inclined to look to others.

Nonetheless, nature versus nurture arguments aside, we've observed that human development tends to be rather linear in this way.

Principles of Action

Delineation of an entire model is beyond the scope of this book. But we have elucidated several key practical elements that we address most of the time when we work with students and their support system. These have been consolidated into what Kish affectionately calls his Freedom Formula. These include: Provision of developmental information and introduction to brain development; reduction of external controls over the student; reduction of tactile dependency on physical surfaces (walls, furniture, and so on); introduction of a new form of cane training we call "perception cane training"; systems re-integration into family and

community dynamics; and active echolocation training which we call "FlashSonar." All of these components run parallel to each other and are integrated. They are parallel supports. They are not steps in a sequence, but rather an interactive and dynamic system of perception and action. Humans do not learn best by sequenced instruction, but by what we call "relevance", which simply refers back to need. What is important, meaningful, relevant to the individual at any given time is what stimulates his learning.

Introduction to development and the brain (Brain 101)

One of the first things that may be useful to do with students and families is to lay out fundamental information about human development and the nervous system. This involves a warm, friendly conversation with the student and relevant others about the human nervous system. The teacher can explain in clear, concrete, graphic terms about the nervous system itself, its development, its function, and how its development and function are fundamental to every area of action and interaction. We can't do anything without the brain's knowledge and capacity to do it, and linking student function to brain development greatly assists students and their families in understanding the entirety of the student's situation as well as the efficacy of a perception based

approach. When removed from the abstract, the developmental process relative to brain function becomes exponentially more helpful to students, their families, and their support team. It is similar to the advertisement, “this is your brain; this is drugs; this is your brain on drugs.” Once the impact on the brain is clearly spelled out, the realizations are both sobering and hopeful. All of these principles were covered in depth in Chapter Two, so just the key points are summarized here, with a view toward how a teacher might present them.

Freedom of movement starts with the brain, and is governed by the brain. There are actual neural mechanisms that are responsible for allowing us to move freely. These must be developed. If they are not, then freedom of movement will be compromised.

The brain’s primary purpose is to relate—to interact with and understand itself and its surroundings. For purposes of this discussion, the brain’s functions are summarized into three primary categories: Thinking (cognition, understanding, reasoning, concept building); action (doing, moving, manipulating, responding); and perceiving (using the senses, coordinating and integrating information from the senses). These functions are fundamental to growth and development throughout body and mind. The

brain performs these functions by using information gathered through its perceptual system to make decisions and guide the body to access and interact with the environment—to relate to the world. We perceive, we attribute or construct meaning to what we perceive, and we then take action.

The first principle of neural science is “use it or lose it.” The brain is like a muscle; it develops through active experience. Such activity literally builds neural connections, just as physical activity builds fiber in muscles. For people who are blind, activities that involve their own direction of physical activities and experiences are critical. The importance of self direction lies in the integrated activation of the brain’s three main operations. For this, we must actually use these brain areas.

When we are guided, the active mechanisms become passive, much as they do in any passenger. To be a passenger is not the same as being the driver of our activities.

Developing the imaging system requires all people, children especially, regularly to engage in activities that are richly experiential and self-directed. The clearer the image, the easier it is to understand the environment, and the more control we have over our

interaction. Children who are sighted are generally naturally supported to develop their imaging system through the encouragement of self-directed activities. When vision is disrupted, the brain still tries to construct dynamic images through its ability to adapt and perceive. In the end, the teacher may simply ask the student or parent, "How much freedom do you want?"

Reducing external control

The factor that is perhaps the most disruptive to external development is the imposition of external direction or control such that the student learns to receive and follow passively rather than engage and lead actively. Out of the best of intentions, people who are blind are often erroneously subjected to a great deal of external physical and verbal direction imposed on them by others throughout their early years and throughout the stages of early adaptation in recently blinded adults. These take the form of excessive physical and verbal guidance and undue restriction of movement and self care activity. People who are blind are often carried along on someone's arm for much of their movement activity. "The excessive use of guided instruction deprives the students of as deep an understanding of a skill or information as is useful in environments in which he or she will encounter

contingencies that cannot be anticipated”
(Mettler, 1995, p. 339).

Much attention should be focused on helping the student who is blind and creating relevance to others to reduce external controls over the student. Imposing external control without active involvement of the person who is blind leads to dependency and restriction because he is forced to rely on and respond to the perception of others rather than his own. This is especially true for very young children who are forming self-concept and movement patterns. To control the student is to restrict him from making and exercising his own freedom of choice in the short and long term. The term ‘control’ is used throughout this discussion. People who exercise these controls over the student may genuinely believe that they are doing this in the student’s best interest. However, at the heart of such practices often lies a concern about controlling the student and his relationship to the world. Whether or not this is consciously intended, it is, nonetheless, what is achieved through such practices. Instead, the emphasis should be on supporting the student to develop his own relationship with the world without need for others to dictate or usurp that relationship. Again, this speaks to a fundamental right to freedom.

Reducing external control involves three areas of concern—verbal guidance, physical guidance, and specialized environmental modification. It is the aim to help the student acquire the freedom to choose where, when, how, and why he goes where he goes. Much of this process involves altering the student's current concept of what it means to be reliant on other's definition of guidance versus his freedom to choose.

Generally, reducing the amount of guiding a student receives helps the student increase his management over his engagement and use of guidance and assistance. The amount of reduction depends on the student's system, environment, age, needs, and culture, but it is often around a 75% reduction. In order for skills to develop, the brain and body need to develop the capacity to apply those skills. In order for this to happen, the student must manage himself throughout his environment, making choices for himself and carrying out these choices by his own initiative and self direction. This cannot happen when the student is kept under physical or verbal guidance for any large part of his existence. Again, this does not mean eliminating guidance, but rather bringing guidance under the active control of the student.

Engaging human assistance can be a very powerful way of establishing connectivity with the external environment. In essence, a human guide can help to bridge the perceptual gap that may at times stand between the person who is blind and the environment by helping to connect the dots of his experience where appropriate. For individuals who are blind who struggle with their own perceptual referencing and preview in specific situations or in general, human guiding can help to activate the referencing and preview systems by providing visual information through language or physical guidance. With this visually mediated information, a person who is blind may feel less anxious and more motivated to reach out and to move into the environment more. This can help him function more effectively or conveniently in environments that he may find difficult or impossible to access without vision. Sighted partnership can also facilitate a person's active participation in activities that might be difficult or impossible without sighted support, such as bicycling, skiing, some high speed ball sports, hiking, or some day to day activities such as shopping. Obviously, the amount of support a person who is blind may need or prefer will vary among individuals and activities.

Self-directed engagement of human assistance need not impair brain development, but regular passive

dependence on human assistance can impair brain development through lack of equitability and lack of self determination. If the person who is blind is not directive of his interactions with the environment, whether he is guided or not, then the brain's decision making and perceptual processes may break down.

Practically speaking, get the hands off the student, and get rid of the 'good fairy.' The student should be held responsible for his own self direction.

Traditionally, Students and their families were usually taught how to guide or be guided. In the mid 20th century, the idea of a blind person travelling on his own throughout the world in all areas of daily life may have been inconceivable; being guided may have been seen as the most efficient or preferred option. There is, indeed, a time and place for guiding; all blind people, including the most sophisticated and experienced travelers, will choose to make active use of it as situations warrant. However, this practice has become extremely overused and is implemented in a manner that tends to place the blind student into a role of passive recipient rather than active manager or contributor. The implications of this are misunderstood from a developmental perspective. It threatens the integrity of self-directed freedom by eroding the perceptual system. Guiding is easy—too easy—at least in the short term.

Overuse of a human guide can lead to passive behavior on behalf of the student and reinforcement by others that the functioning of people who are blind is best facilitated by people who are sighted. "An emphasis on human guide tends to reinforce or even create an expectation on the part of the learner that the appropriate social role of a blind person is a passive one" (Altman & Cutter, 2004, p. 74). Human guiding can cause someone to be whisked through the environment without the opportunity to engage what passes by or to take his own initiative to discover. Some people who are blind refer to human guidance as 'hitching a ride' due to the impassive nature of the experience for them while being guided. "Guiding tends to be over-used. An over-reliance on this skill with children does little to improve their confidence and independent mobility. Children who are guided everywhere don't get the chance to practice and develop their O&M skills and can become over-dependent on others" (Scott, 2012, p. 24).

Rather than focus on teaching everyone how to guide, student efficacy is quickly and dramatically improved when we focus attention on teaching how not to guide. Teach methods to allow a student to walk with someone, or with a group, without a need to hold on. Develop approaches to increase walking speed and improve gait pattern. Work on using auditory

capacities to monitor where people are around the student and walk with them as people naturally walk together. This process of self guidance is thus put in the hands of the student rather than kept in the hands of others deemed responsible for the student. The more students can conduct themselves quickly and competently, the less others will feel the need to guide. The more the student is permitted, encouraged, and supported to guide himself, the more he will develop and hone his capacity to self navigate. It may be necessary for a teacher to reduce the amount of 'help' the student is receiving so that he can begin to become more self-directing. It may be beneficial for a student to follow a sound source (rather than be guided) because this practice promises more realistic application and will help with audition skills that are necessary for independent travel. The person with whom the student is walking may choose to maintain a sound source, such as a set of keys, or good conversation. This isn't to say that this should be the only means of travel with others, but it should be commonly practiced for variety and expansion of perceptual skills. Consider the following examples.

On one occasion, a mobility specialist approached Kish and confided to him that he'd heard about a young boy in a neighboring county whose parents made him follow their keys when he walked rather than using

proper sighted guide, even at a theme park. "That's just not fair!" the mobility specialist exclaimed. Kish happened to know the boy and his circumstances because the boy was one of the participants in Kish's initial echolocation research. Kish knew, for example, that this boy was blind from Retinopathy of Prematurity, which often results in perceptual-mobility challenges. Yet, this boy routinely walked himself to school and around his own neighborhood to friend's houses. Kish had observed that use of a sighted guide was discouraged by his parents and that his mom took to hanging her car keys from the strap of her purse when they were out. Kish's only response to this instructor was, "Why do you think this boy's travel skills are so good?"

On another occasion, many years later but also involving a theme park, Kish was presented with a 10-year-old girl, blind from birth. The girl was afraid of amusement parks. Yet her family had taken their vacation at a theme park for the last 2 years during which time this girl 'made life miserable for everyone.' Kish's mission was to help this girl appreciate her experiences at the park, while respecting other's experiences. She started with a long list of all the rides she was 'never going to go on.' Kish simply fitted her granddad with a set of keys that jingled whenever he moved (borrowed from the example set by the

parents of this young boy over 12 years before), and he gave both of them a handheld clicker similar to those used by animal trainers. The girl was asked simply to keep track of her granddad by the sound of his keys and through casual conversation. Whenever she became anxious or confused about where he might be, she could click the clicker, and her granddad would click back. If she started to fall behind, he could click the clicker, notifying her immediately where he was. The clicks carry much more audibly through noise than yelling or calling, while actually drawing less attention from the general public. During the day trip, Daniel coached the girl on how to increase her walking pace and focus her attention to keep up with her granddad. The process of managing herself through the crowds involved so much higher brain function through maintenance of attention and active governance of her own movement that little energy was given to anxieties or apprehensions. With little concern, she went on and enjoyed almost every ride in the park. They said it was like having a different girl—attentive, delighted, and enjoyable to be around.

The more students travel and interact with the environment on their own, the more they will develop the capacity to do so as they wish. This may seem like common sense to some, but it is a piece of common sense that is uncommonly put into practice with

damaging long term consequences. In so doing, the student should be expected and required to maintain the pace of his companion or group, not to set the pace for the group. The less a blind person is able to keep in stride with others, the more likely it is that he'll be grabbed and hurried along, "because it's just easier." When the student who is blind is able to keep pace with his companions, he is more likely to be allowed the freedom to move under his own guidance.

Do not allow the person who is blind in the group to set the pace of the group. The group must set its own pace, which the student who is blind is expected to maintain. Call the student's attention to the sounds of the group if it moves ahead or takes a course that the student isn't following. "Where's your group? Where are you? Do you want to be left behind? What do you need to do to catch up with your group?" Students will often put forth the effort when they know the effort is required and expected. If not, sometimes, Kish places the back of his hand casually against the student's back, not to direct, but gently to compel them forward. In such cases, the students will usually maintain a pace that keeps them just in front of his hand, as they prefer not to be "nudged" in this way, however gently. On other occasions, Kish places his index finger against the child's back, again, not to direct, but only to compel. Students will usually

remonstrate against this, but Kish will gently say, "Everyone's getting away from you. I'm just helping you to keep up." The student may say, "I can do it myself." Kish might say in response, "I have no doubt of that, and nothing would make me happier."

Can you show me that you can do it, so I don't need to help you? My hand is getting very tired."

Of course, a person who is blind may make a personal choice to be guided. However, most people who are blind feel the need for guidance much of the time, especially when traveling with someone, which most people do most of the time. When the student feels the need to be guided, this isn't really a personal choice anymore. In order for freedom to be preserved, guidance should be regarded as a useful option, not a necessity.

Physical guidance can be broken down into "leading" and "puppeting". Leading may be referred to as "human guide", often called "sighted guide". It simply involves leading the person who is blind through the environment. This is like relegating him to passenger status. Encourage and support students to "drive" their own mobility rather than rely on others to drive them. In this context, maintaining physical contact with a companion may arise from a preference to stay

together more easily, rather than a requirement to be lead or navigated by someone.

“Puppeting” is a matter of manipulating the person who is blind through the environment, often moving their arms, hands, and bodies through an action or motion. Traditional forms of formal guiding may strive to minimize this, but it nonetheless all too commonly comes into practice in “motoring” the student, or in “hand-over-hand”, in which individuals who are sighted physically “connect” the student who is blind with his environment. As Carlton Anne Cook Walker (2015), herself a teacher of the visually impaired (TVI) and mother of a daughter who is blind, points out, “When I trained to become a TVI, I discovered that a great deal of teaching was done using hand-over-hand technique.” She notes that children receiving regular physical contact from adults may be at risk for losing independence and self-determination. “When someone moves the child’s body . . . without engaging the child . . . the child has two options. The first, and most reasonable, is resistance. . . . The other . . . is the passive acceptance known as learned helplessness.” Ms. Walker goes on to provide some very practical tips for monitoring and ameliorating the practice of what we call “over-puppeting.” While this, too, may have utility in facilitating a shared experience between two people, this practice can

usurp the student's own capacities for intentional action. Segond et al. (2007) point out that "one of the major challenges for children who are blind is to be aware of their environment, so as to understand it and influence it" (p. 37).

Another form of guiding is verbal, in the forms of "spoon-feeding" and "remote control". In spoon-feeding, the person who is sighted feels inclined to narrate or over describe the environment around or ahead of the student who is blind. "You're coming to a door, and it opens to your left. You're coming to some stairs down, and there are eight of them. You're approaching a table, and here's the chair." etc. As one mobility instructor puts it in a mainstream publication, "Every single thing we see, we have to teach to a blind person," (Nile, 2014).

Although there are certainly strictly visual aspects of the environment that are worth sharing with one another and that can provide mutual enrichment, the practice of narrating the physical environment disrupts the student's own self-directed discovery process by attaching it to someone else. It also continually bombards the student with the message that visual narration is needed or preferred in order for him to function properly.

The most common form of this is the clock face description of food placement and place setting positioning. Friends and family are commonly taught to describe the food and place setting in terms of the clock face. Another approach is rather to encourage self-directed discovery of this small environment as a parallel to discovery of the larger world. What could be more motivating than food, and it's a regular part of one's day. By encouraging the student to engage in self-directed discovery in this simple but frequent circumstance, you are sending him the message that he can and should manage his own affairs without need to rely on others' visually mediated supervision or intervention.

Remote control comes about when people who are sighted verbally direct the student through his movements. "This way. No, to your left. A little more. Now, up. Forward. No, you passed it. Back the other way," and so on. This also takes the form of directing or "commanding" a student to take or not take certain actions. "No, wait. Just let me do it." Or, "You shouldn't go there. It's dangerous for you." This process can become very command-oriented when remote controlling a person who is blind. For example, in skiing for the blind, the skier who is blind is guided by a person who is sighted using what are commonly called "commands". Nobody objects to

a skier who is blind enjoying a common pastime by the use of a guide to facilitate the process; however, the self-directed achievement oriented approach questions why the term “commands” was ever used and questions the fundamental philosophy behind the use of such paternal language if a person’s freedom of achievement is to be truly respected and supported.

In one skiing for the blind program in England, a boom box hangs on the back of the guide for the skier who is blind to follow. Once he has developed the perceptual capacity, few if any “commands” are given. This is the same principle World Access for the Blind uses in mountain biking, wherein the cyclists who are blind are provided a sound source to follow, and occasional information about the environment by a “scoper” who is sighted. The cyclists then make their own decisions about how to control their own bicycle, and only one scoper is needed in a group of several riders who are blind.

On those occasions when physical or verbal guidance may be necessary, preferred, or convenient, it is imperative that the person with a visual impairment be directive of the experience, arranging what is needed, and taking every initiative to acquire and manage the assistance and support he may need. Through perceptual development training, the

student can appreciate and gain information from the surrounding environment, even while under guidance by another. Also he will have additional skills to call upon when he has no assistance or does not wish for assistance. It is imperative that the apparent short term convenience of external forms of guidance and supervision do not come to take the place of or inhibit perceptual development, self execution, and self directive capacity.

Environmental modification involves two areas, modifying the environment to make it more “blind friendly”, and what we call “catering”.

Modifying the environment may be useful when it facilitates long term freedom. Generally this is in terms of allowing the student to access the environment more effectively in a similar fashion as his peers who are sighted. For example, placing braille labels on switches, placing braille signage, and labeling items or packages, simply places the same information that others have into the hands of the student who is blind. It simply allows access. Likewise, making a ball audible, or tactilizing elements of a sports arena, has a similar effect in allowing a person who is blind access to the same information which allows people who are sighted to engage in the sport. However, be cautious about specially modifying the environment

in a manner that artificially contrives a sense of safety or ease. For example, keeping walls or paths clear of obstructions, placing special railings or overly tactilizing the environment with markers, rounding or padding corners, and other such precautions run the risk of creating a kind of false security which does not represent the real world and does little to prepare a person who is blind to meet it. When the environment is modified to accommodate a student's blindness, rather than serving to support a student to adapt to his blindness, it only supports a student to adapt to artificially contrived environments. It does not prepare him to manage the real world. This is particularly the case in many schools for the blind in which children are often encouraged to trail and are discouraged from using their canes. These environments have often been artificially designed to be blind friendly so that one can trail without encountering hazards and can "park" their cane without much concern for its need in this uniquely safe haven. However, the safe haven ends at the exit of the school, and there are many cases in which students were woefully ill-prepared to manage the real world beyond this artificially contrived safe haven.

Catering is when the environment is often brought to the student. As a student reaches for his glass of water, the good fairy gently nudges it into his hand.

His toys are brought to him or put away for him. His shoes are brought to him and perhaps even tied for him, or his food is always neatly prepared for him. His bags are neatly packed and unpacked. He is often told to sit quietly as his life is neatly managed around him. Students who are blind are often relegated to being acted upon or around, often not called upon or allowed to act by their own initiative. Their movement opportunities may be restricted by a host of socially imposed “shouldn’ts” and “can’ts” out of apprehension for safety or heartache over observing the person who is blind struggle to manage or master activities. In extreme cases, the child may even be denied or restricted from access to tools that would support his development process, such as a cane, glasses, active echolocation, accessible computers, and other assistive supports. In such cases, the child or adult who is newly blinded is denied opportunities for intentional discovery and forcibly required to depend on others without the opportunity to manage his own process. In other cases, a person who is blind may be assigned a “buddy” to “look after” him during a school day or outing rather than being permitted or supported to choose how he wants to engage the activity or with whom, if anyone, he wants to go.

All of this is done under the guise of helpfulness, often with the well meant but misguided idea that this

may somehow prepare the student to be independent someday. Parents, relatives, friends, and instructors might feel the student to be (for whatever reason) incapable of doing these things on his own at the level of skill at which his caregivers can do them. The student doing for himself may seem slow, dangerous, or just sad to watch. However, a person who is sighted may learn much by seeing, but a person who is blind learns primarily by doing.

One teenage girl writes: “This holiday, I used my cane. It’s amazing to think that before recently, I had not even walked up my own street without being guided. It does not sound like anything out of the ordinary when I say it like that, but it is. One of my cousins said it is better because you can walk on your own. I completely agree. I find myself clicking loads now, it really helps. In a way, it surprises me how much more confident I am at going places all on my own without even thinking about it. I want to do more of it and get better” (Cobb, 2009).

Reduced reliance on physical surfaces and spatial boundaries

Many people who are blind are encouraged to maintain tactile contact with physical surfaces and spatial boundaries—trailing, shorelining (cane banging), squaring off, and backward chaining are

common conventions. Such conventions tend to condition strong attachments or dependencies on physical surfaces, heedless of the fact that the real world is comprised mostly of open space. How can a person who is blind hope to traverse open space if he finds himself ever dependent on spatial boundaries? Rather, most people who are blind find themselves anxious and disoriented whenever spatial boundaries are too distant or not present.

Promote the use of auditory skills, use of the compass, and FlashSonar from early in the student's training to supplant this dependency on physical surfaces, giving him the ability to manage himself smoothly at non-tactile distances from physical surfaces. For this to happen, however, tactile dependence on physical surfaces needs to be redirected. Of course, as with human guide, there is a time and place for trailing and using similar skills. Indeed, tactile exploration is a critical skill for people who are blind and not to be underrated. However, there is a distinction between tactile exploration for purposes of gathering information and understanding versus the use of tactualization as a navigational tool. As a rule, tactualization as a navigational tool can make traveling slow, awkward, and limited.

Introducing the Full-Length Cane

When the long cane and touch technique was introduced as a traveling method for servicemen who were blind in the 1940s by Hoover, he used canes that were relatively short (less than 44-inches long) (Sauerburger, 1996, p. 8). In the 1950s, the cane length was adjusted to be based upon the user's height (the length of the cane being the distance between the user's sternum and the ground) which is now referred to as the traditional method or sternum method for cane measurement. Beginning in the 1970s, the 'ideal' length of the cane became a bit more flexible. Jacobson (1993) recommends measuring to the student's sternum and adding 2 inches. But the height may then be adjusted depending on "the length of the student's stride, the student's reaction time for locating obstacles in his path, and the student's ability to detect drop-offs" (p. 65). Hill and Ponder (1976) state that "the final measurement [of the cane] will be determined by the individual's ability to take appropriate evasive action when an object is contacted by the tip of the cane" (p. 112).

Introducing the full length cane as early as possible in the student's adaptation to blindness is another integral part of achieving complete perception-based freedom for students who are blind. World Access for

the Blind (WAFTB) has developed a method of cane training that is easier to teach, easier to learn, and easier to use by a wider range of people in a wider range of environments and situations. They have called it "Cane Perception." This is a type of cane and style of use that they believe better activates the imaging system which connects the student to the environment by the student's own self-direction sufficiently to allow graceful, confident movement. This is easily done with a perception-based approach. It can be done for children and adults of any age, as well as for people who are blind with almost any other disability profile.

Again, keep in mind that the cane techniques developed in the mid 20th century were based on very little experience and very little input from users who were blind. To this day, these very techniques have not been systematically studied to determine their effectiveness. This has finally been acknowledged by faculty of the orientation and mobility graduate program at Western Michigan University where faculty have begun research to investigate the effectiveness of a variety of techniques.

Although many of the cane techniques developed by medical practitioners when working with veterans after World War II seemed intuitive and were

much more effective than not using a cane at all, they tended to result in a mechanical, regimented movement and a perhaps disproportionately large emphasis on form over function (how does it look, and is it done exactly according to specifications?).

As a mother of a 4-year-old said, "We have encountered some negative comments from some of the professionals involved with Jamie. For example, one rang me after seeing him with his cane and insisted that we did not use it again until a 'proper' mobility officer had taught him. This was due to him holding the cane differently to the way we are taught in the UK. Here, we ask people to point their index finger down the cane and use it as an extension of the finger. This method was first introduced after WWII to veterans who had lost their sight. However, a child born without sight doesn't point as they have no reason to" (Apsland, 2010, p. 42).

Indeed, this was probably in keeping with the militaristic traditions and background of both the personnel who designed the techniques, and the primary users of the techniques for about the first decade. However, this mechanical style of movement runs counter-productive to modern knowledge of biomechanics and does not lend itself to the grace

and flow of movement valued by the disciplines of perception and action.

If we are to give consideration to Gibsonian perceptual theory, we would argue that movement should go hand in hand with the environment in which and through which it occurs. Thus, it occurs in flow patterns through the environment, dictated by a moment to moment perspective of the environment (Gibson quoted in Schwartz, 1984, p. 27). In this view, if movement patterns are prescribed apart from the environment, then one's movement will be expected to occur out of sync and out of context with the environment. The results are likely to be an awkward style of movement that doesn't fit into context, and may be resisted by the mover. Therefore, by this line of reasoning, a more adaptive and flexible movement style is warranted.

Kish (2009b) writes:

My own cane training around age 12 occurred pretty much according to traditional precepts, which included mid-sternum length. My cane skills were considered exemplary by traditional standards, and I found no reason to question this approach.

During my thesis project in my mid-20s, for which I worked with 24 children who were totally blind, a long time instructor was orienting several of these students to their middle school campus. He quickly replaced their canes of sternum length with forehead length, explaining that increasing the length by about 6 inches generally helped remediate poor cane skills very quickly. I was politely skeptical.

Later, when my cane broke, an acquaintance convinced me to try a nose length replacement. I politely agreed. I hated it at first, because it felt heavy and awkward while my perceptual system tuned to the extended length, much like someone with new glasses. After a few days, I found that my travel took on a greater ease and comfort of rhythm, even faster speed, and fewer unpleasant physical encounters. After some adjustments, I found that chin length seemed to work best for me.

As I began instructing, I noticed preschoolers often preferred to use my cane, taking it in both hands and holding it before them with confident daring. While I conducted most of their instruction with canes of more manageable

length, I noted that the increased length did seem to facilitate their understanding of the cane's purpose, as well as a natural comfort in using it. I never found the need for "pre-cane" devices. One day, a Mexican family came to me with their 6 year old, non-English speaking son who had refused the cane despite their insistence. While we spoke, he discovered my cane and began walking around my office with it. Cautioning his parents not to stop him, I allowed him to do what should come naturally to children—discover. In short order he made his way out the door, striding quickly along the walkway with relaxed poise. His parents were dumbfounded as we hurried along behind him, insisting they'd never seen him do this. Upon approaching the sounds of children playing, he happily explored the playground with this very long cane.

On a more recent occasion, it was brought to my attention that an older gentleman was walking with a shuffling gait and slightly stooped posture. I handed him my cane. Immediately his speed increased and his posture straightened. Though he and I had talked about many things, he couldn't thank me enough for this one simple suggestion.

Not only are my own experiences replete with similar examples, but I hear them commonly from others. One woman recently declared that she'd struggled with one child who was deafblind and one who was autistic. Their canes were used for anything but perception. After providing longer canes to them, she reported that their cane skills revolutionized in a few days.

After working with nearly one thousand students of nearly every type and background, I believe that the reflex to reach physically into the environment is nearly as innate as hand to mouth. Early man, unable to conjure artificial light, probably used sticks naturally to improve their reach and balance. I also believe that the referencing and preview systems are expecting to access near point information at a certain distance. If this requirement isn't met, these systems may not be triggered to engage properly. For now, I can only guess at this magic number, but experience suggests that sternum length seems to undercut this number for most students, especially children. (p. 22)

The preview system of the brain, which monitors the environment in advance of the traveler and plans accordingly, seems most strongly and consistently

activated at about two to three steps distance from the traveler. This happens to be where the human eye falls most regularly upon the terrain while walking under conditions typical to the traveler. This can be said to equal roughly one body length. The body length is a reference fundamentally understood by the nervous system. It does not need to be trained or taught; it just is. Humans are the same measurement in span from fingertip to fingertip with arms stretched out as we are in height. For those using the haptic system (i.e., a cane, to activate the preview system) it would then seem reasonable to capitalize on this body length reference. Therefore, in this view, the tip of the cane should fall approximately one body length in distance from the user. We call the resulting cane a “full length” cane.

To maintain a natural flow of movement, anticipatory mechanisms expect information to be available at certain distances. The eyes, for example, generally scan the terrain about two or three steps ahead, nearer or further depending on circumstance. When information is available in a manner that activates the referencing and preview processes, the imaging system can develop intact to govern this flow of movement. For people who are blind, however, this development tends to be hampered by lack of self-directed experience and perceptual training

particularly in the early years, which means they lack access to the information they need to activate these systems. It is all too often observed that young children who are blind are discouraged or prohibited from using their canes in school out of fear that the cane could be misused or become a hazard to other children. The authors have heard many reports of children being told or forced to leave their canes behind during school outings and “hitched up” with an aide or other peers to lead them around, or in more extreme cases, being driven or carted from one place to another while the child’s peers enjoy the opportunity to walk on their own.

This is exacerbated by activities which over-emphasize safety concerns and are overly structured and rigid. This approach may not foster self direction, and therefore, may not engage the perceptual system to develop naturally. Therefore, the imaging system often fails to develop, generally resulting in an awkward or disrupted interaction with the environment. In extreme cases, the result can be immobility.

A study by LaGrow, Blasch, & De l’Aune in 1997 that used computers to check the surface area covered by the long cane showed that the touch technique did not result in surface preview as had been previously

expected. The suggested way to correct this was "alleviated by using the constant contact technique first recommended by Fisk (1986) or by extending the length of the cane" (LaGrow et al., 1997, p. 50). A further study by Bongers, Schellingerhout, Grivsvén, & Smitsman in 2002 "showed that only the length of the cane and the tip height during the sweep determined the detection of drop-offs and objects in the path of travel" (p. 529). The study showed that a longer cane length resulted in earlier detection of objects. Both these studies suggest that an increased cane length is safer for the traveler. Altman states "the increased prior warning provided by a longer cane length often helps individuals develop greater efficiency and confidence when moving through the environment because this greater response time allows for more effective evaluation of conditions and smoother adjustments in speed and direction" (Altman & LaGrow, 1996, p. 1).

There is still a debate over the most suitable length of cane. Kish argues that adults benefit from canes that are around chin height and that it is especially important that children use canes about as long as the child is tall. "Children have the same referencing and preview needs as adults for ambulation. Yet their biomechanical properties are not the same . . . due to their small size, measuring cane length to the

sternum may afford half the referencing and preview capacity as for adults” (Kish, 2009b, p. 30). Altman & Cutter (2004) state that “proponents of structured discovery believe that . . . a much longer cane (at least chin length) supports the belief that blind people can walk at a normal walking speed” (p. 86). “Longer canes offer more-advanced warning of environmental hazards because they contact environmental features before a shorter cane would” (Rodgers & Emerson, 2005a, p. 2).

Altman advocates for longer cane lengths, stating “the greater cane length allows the traveler to walk at a natural pace and utilizes an arm position that is relaxed and closer to the body . . . the area swept by the cane shaft is enlarged” (Altman & LaGrow, 1996, p. 1). Altman says a longer cane allows for a greater reaction time and results in smoother adjustments in speed and direction for the user (Altman & LaGrow, 1996), although the elderly or frail may be more suited to a more traditional length cane.

Recent research, investigating the relationship between cane length and detection of drop-offs, concluded “we found no significant difference in the participants’ detection of drop-offs between the standard-length and the extended-length canes” (Kim & Emerson, 2012, p. 5). These results may be due

to the fact that canes used in the experiment were not long enough (10 inches) or that the effect is only noticed when the user is doing two point touch rather than constant touch (constant touch was used in the experiments). Another explanation could be that the researchers used blindfolded participants who were sighted who had limited cane use experience. It may also be significant that all the participants were aged over 22 years. Children may need a different length cane in proportion to their height than adults.

One argument against a longer length cane is that “a long cane may have disadvantages such as a greater propensity to trip people or an increase in the weight of the cane” (Bongers, Schellingerhout, Grivsvan, and Smitsman, 2002, p. 529). However, this research concluded that “cane walkers should use a relatively long cane” (p. 530).

The main argument against a longer cane made by LaGrow (Altman & LaGrow, 1996) mainly deals with foot placement preview which has been addressed by the research of Bongers et al. (2002) and LaGrow et al. (1997) discussed above.

As a result of their 2005 research, Rodgers and Emerson (2005a) concluded, “If a cane is either too short or too long, the ability to locate and negotiate

the features of the environment that require a change in walking behavior is diminished” (p. 11). These lengths were found to be 120% more than sternum length or 95% less than sternum length. One of the limitations of this research is that subjects were fully-sighted college students who used their vision during the research. This may be especially significant if, as Willoughby and Monthei suggest, more experienced cane users or young people are more suited to a longer length of cane (1998).

The only qualitative research that has been conducted on a large scale with participants who were blind asked 98 experienced cane users for their opinions about cane length. Forty-one participants stated a preference for a longer cane and eleven were against using a longer cane. Those who preferred a shorter cane said this was “better for walking in crowds and in buildings”. The results “suggest that individuals who are visually impaired need to own a variety of canes, including a heavy-duty cane, an indoor cane and a special-occasion cane” (Ambrose-Zaken, 2005, p. 14).

The WAFTB model has also made modifications to the cane technique itself. While preserving a preference for in-step and in-rhythm technique, WAFTB regards these as preferences, not requirements. The key to the model is that any student’s cane technique must

first be based in movement patterns that are natural and relaxed for the student.

A perception-based approach to early cane training appears to activate self direction and imaging when the brain is most receptive and responsive. WAFTB regards the long cane, not so much as a tool for probing or shielding, but more importantly as an integrated extension of perception. Jacobson (1993) states that the shaft and tip of the cane become an extension of the user's hands and fingers like an extension to our own tactile system. "The traditional white cane is perhaps the simplest example of a visual sensory substitution device; information about distant objects that could have been provided visually is instead collected by the tactile receptors of the hand" (Johnson & Higgins, 2006, p. 628). An effective cane user will use the cane to access information naturally through his hand and arm to allow an unconscious flow of movement without a conscious need to draw upon or apply a matrix of skills or techniques. Interpreting information gathered by the cane becomes unconscious once the natural strategies for cane use have been integrated into the perceptual system. Individuals who are visually impaired hardly think about using their hands to read braille or put on their clothes; likewise, the cane should integrate seamlessly into the perceptual process as a delicately sensitive instrument of perception.

Toddlers who are blind can learn to use a cane to get around safely and efficiently with self direction without need for constant guidance or environmental modifications. WAFTB staff has taught this over and over and has coached parents to teach it to their children. Pediatric Mobility Specialists from the Sensory Consortium in Reading, England share their experiences cane training with very young children after a series of workshops presented by Daniel, "For us it became apparent that many of our toddlers were late in walking, almost fearful of their environment and while they would walk holding a hand or pushing a toy, independent walking and exploring was somewhat delayed. These pupils are using canes effectively to explore unfamiliar areas. Working with Hertfordshire parents within the home, pre-school setting and our DOVES preschool groups has enabled us to demonstrate physical activities and the importance of developing balance and co-ordination. Parents have also been able to see how much more a young child can learn about their environment by using a long cane and how its use enhances good posture, gait and independence. . . . Many of our early cane users are now at school. Evidence would suggest that these pupils are using their cane effectively to explore unfamiliar areas independently, detect obstacles and environmental features, and develop

their problem solving skills and move safely amongst their peers” (Hunter & Marshall, 2008, p. 39).

In Western Australia “O&M training commences as soon as the child is walking” (Scott, 2008, p. 70). “As soon as the child is able to balance and move independently then the long cane is introduced” (Scott, 2008, p. 71). WAFTB advocates introducing the cane even as young as early infancy, as even before ambulation occurs, the cane can become an extension of reach, and therefore help to catalyze spatial awareness. Infants at or before the crawling stage can learn to use the cane as a spatial probe, which in turn can motivate greater movement and interest in self-directed discovery. The grasping reflex of infants is inevitable, and can be capitalized upon for effective cane use even at extremely early ages. Daniel has also observed that the full length cane, used as a perceptual extension as described above, appears to provide the perceptual system with a third point of reference that seems to improve balance, even for toddlers just learning to walk. Just as vision supplements the vestibular system to establish and maintain balance, so the cane seems to provide similar input to similar effect.

As Pediatric, Neural-ophthalmologist Gordon Dutton explains, “Balance is brought about by a combination

of factors. The gravitational receptors in the inner ear generate the brain servo-mechanisms for the integrated harmonious organization of the exquisitely calibrated body movements that maintain balance. This is called the labyrinthine system. In typical individuals, a triad of intrinsic balance, sight and touch mechanisms, provides an integrated balance system, in which one mechanism compensates for another under circumstances that render one of the functions less efficient. When vision is absent the two complementary mechanisms of intrinsic 'labyrinthine' balance, supplemented by light touch come into play; the tactile frame of reference accorded by light touch helps to supplement the labyrinthine system, especially when the ground is not horizontal. The toddler can supplement balance by holding on to a succession of supports. This behavior complements the developing labyrinthine system. For the child with no vision, a long cane provides an alternative light touch support at this early stage in development, and the sight of the blind toddler reveling in their new found freedom is heart-warming" (Personal Communication, 2015).

This same effect on balance by the full length cane has also been noticed with many students who are blind who exhibit difficulty with balance for other reasons—age, neurological, or orthopedic. (See

Jeka, Easton, Bentzen, & Lackner, 1996 for a more detailed discussion of the effect of these tactile-haptic mechanisms on postural control and balance).

The inherent difficulties have caused many to decide prematurely that early cane training is impossible or inadvisable, and consequently it often isn't done. Although some instructors have raised concerns that early cane training may induce postural abnormalities or cause stress to the child's arm or shoulder, this is not known to have been documented anywhere. A different approach could be key. Consider the following examples.

"Harmony got her first cane when she was three years old and from the moment she first used it, we knew that this had been something missing in her life and her mobility and behavior instantly improved" (Lockwood, 2008, p. 41). The cane usage of a toddler may not look pretty, but it quickly becomes effective when properly supported. Do not worry about "bad cane habits" any more than "bad vision habits." Instead gently support refinement of cane use, just as you would vision, recognizing that the perceptual system starts imperfectly for everyone, and develops over time.

A parent of a four-year-old says: "I have always found that the best advice comes from other parents, the people who live it, and not the people who do it for a living. All the parents who had children using long canes early were very positive about the difference it had made to their lives.

We were experiencing real behavior problems with Jamie outside the house as he wanted some independence. He knew his siblings were running ahead and he wanted to do the same but we couldn't for his own safety. He also did not want to hold my hand so we contacted Daniel Kish and were lucky to get the chance to work with him.

It was very hard emotionally as Daniel immediately asked me to let go of Jamie's hand and let him walk independently with his cane along the pavement. I was amazed however, to see that Jamie took to it like a duck to water. He was so happy. Within a few days, he was asking for his cane before we left the house. Jamie now uses his cane outside the home every day. Walking anywhere is now fun and not stressful and amusingly, Jamie now has no issue with holding my hand when he needs to.

. . . Having a cane has made the world of difference to our lives. Jamie is more confident outside the home,

much happier and a lot of the tantrums have now gone. I would strongly advise any parent considering this to go for it, you will be amazed at the difference it makes!” (Aspland, 2010, pp. 41-42).

Young children who are blind and have been dependency conditioned to rely on guidance from others or trailing a hand on surfaces may be very reluctant to take their first steps into open space. If the child is afraid, one way to ease the transition is to have the parent hold an adult-sized cane, while the child holds the shaft nearer the tip.

As one mom relates:

From 15 months old Connie was able to stand on her own, she navigated her environment by crawling and cruising. Only when there was an opportunity for her to walk between two people at home with a clear path would she take some steps unaided, she remained at this same stage for almost 4 months. She clearly had the physical skills to walk unaided, but lacked the confidence to do so.

When we met with Daniel, Connie was 19 months old. He suggested that we introduce her to a long cane. There and then—‘Let her go for it,’ he said.

So we did. That day we used an adult length cane (Daniel's!) with myself supporting the cane from behind holding the handle and Connie holding half way down the long cane.

Connie immediately took the initiative to walk forwards while holding the cane, and she moved it side to side as instructed. We saw that using the cane in this way, Connie held her head up and walked on her own longer than we'd ever seen her do so. At one point when the tip of the cane dropped off the edge of a step, Connie was clearly heard by several of us to say, 'Step'. This moment was truly amazing. To see her confidently walk and understand the use of the cane in such a short time at 19 months old was when we realized the potential this tool held for her. She continued to walk around the park with her head up looking forwards and she was enjoying herself immensely. When the time came to hand back the cane—it took some persuading!

We didn't hesitate in purchasing an adult length cane for Connie, once it arrived within a week of having it she was walking everywhere with confidence using the long cane. We then progressed onto a long cane that was for Connie to use alone and we haven't regretted it (A touch of the Perks, 2015).

In teaching a student to move his cane side to side (in two point touch technique) rather than just pushing it in front (in diagonal cane technique), some students may find immediate benefit when the technique is demonstrated so they can hear it. This may result in grossly exaggerated replication at first, but the more they hear it in the context of actual movement, the more refined the technique may become without ever even having to touch the student. Development of this technique may be encouraged and supported for young students by key verbal expressions like, "the side-to-side technique is an advanced technique for big six year olds. The push technique is for little five year olds."

Another approach may involve the instructor walking in step beside the student on his cane side, their hand placed firmly on the student's shoulder. The teacher may also be using a cane. The teacher and student begin walking in rhythm, with steps matched, left foot to left and right foot to right. The cane movements would also be matched. The teacher and student may chant in rhythm something like, "Every time you take a step you've got to move the cane. Good" (Willis, 1998, p10). Then once a strong rhythm has been established, the teacher gradually releases his hold until the student continues walking beside the teacher, still in rhythm. The chanting may

gradually diminish, also, and the teacher increases the distance at which he walks beside the student. If the student falters, the teacher can restart the chant or resume a light touch to the shoulder. In cases where the student is extremely apprehensive or heavily conditioned to external guidance, this exercise may start with the student holding the guide in standard human guide position. Everything else is the same, including the teacher using a cane. It is fine for the teacher to be using a cane in the same hand of the arm that the student is grasping. When the moment comes, the teacher, maintaining rhythm, releases the student's grasp and moves to the student's opposite side, and the previous steps are maintained until the student finds himself walking in rhythm hardly realizing that the teacher has released all hold (Willis, 1998).

A "perception cane," advocated by WAFTB has the following qualities:

- a) Full length: As humans are roughly the same length high as they are from fingertip to fingertip with arms extended laterally, this implies a biological link between body-length referencing and fluidity of movement. A certain distance of perception is needed to activate the imaging system. For this the cane should be

about as long as the child is tall. People who are sighted use their eyes to scan several steps ahead as previously noted. A child who is blind, who has shorter arms and may move more quickly and erratically than an adult, needs a long enough cane to perceive information about what is around and ahead of him. This fully activates the perceptual system and allows time for the brain to receive and process all the information it needs to make decisions about moving around. At approximately the age of 7, the child is able to extend his arm a bit more and the cane may be shortened to about his nose. By adolescence, it may be shortened further to about his chin, but it is important to maintain approximately one body length between the cane tip and the leading foot for most effective results.

Willoughby & Monthei (1998) state that a good length for an adult's first cane is shoulder height. However, they say that shoulder height is too short for young children, who need canes that are nose height.

It is suggested that as cane travelers become more confident their stride will lengthen therefore so should their cane which indicates

a more experienced traveler “the desire for a longer cane should be viewed as a positive sign” (Willoughby & Monthei, 1998, para. 23). Scott (2012) states that “longer canes (chin length) are preferable as these give greater preview of the ground ahead” (p. 21).

- b) **Lightweight:** The cane is a delicate instrument, like an antenna, and should be as light as possible. In order to be recognized and accepted by the brain as a natural extension of the perceptual system, the cane should not be cumbersome or awkward. WAFTB does not usually recommend rollerball tips or other heavy tips. A big tip may seem easier, but it can only go so far toward covering up technique that lacks finesse. WAFTB’s favorite tips at this time are the ceramic tips or plastic pear-shaped tips.

The “lighter weight material (i.e., fiberglass or carbon fiber) permits a longer cane shaft without increased weight” (Altman & Cutter, 2004, p. 84). The weight of the cane was found not to be significant in recent research. “Neither overall weight nor the distribution of weight has a significant effect on fatigue and accuracy” (Rodgers & Emerson, 2005a, p. 8).

The participants in the research performed cane movements for 45 continuous minutes to test for fatigue. However, movement in an actual day to day environment may have produced different results.

- c) Conductivity: As a perceptual extension, the cane should convey as much information as possible with as much ease as possible. For children, WAFTB generally recommends rigid, non-folding canes. They are generally lighter, sturdier, and more conductive. They are also less likely to lead to “folded cane syndrome” in which the cane spends more time folded and stowed away than actually in use. WAFTB also does not generally recommend foam cane grips, as these tend to insulate the hand from sensations. However, the most important thing to remember is that the best cane is the one being used. On the playground, many children will prefer to use a folding cane because it can be quickly secreted into a pocket or waistband while at play, then quickly extended when traveling back to class or to another part of the playground. In this case, we recommend that a folding cane be chosen carefully—one that doesn’t jiggle at the joints and that remains light and slightly supple in the user’s hand.

The best cane for flexibility (i.e., how far it can bend without breaking) was shown to be a carbon fiber cane, with a vinyl cane being the worst (Rodgers & Emerson, 2005b). The best cane material for transmitting vibrations was found to be carbon fiber with the vinyl again being the worst, suggesting “the cane/s flexibility has much to do with response to vibration” (Rodgers & Emerson, 2005b, p. 9). Cane preference may have to be decided by users based on what they are looking for—resistance to bending, breaking point, weight, or sensitivity.

The first principle to the WAFTB technique is natural movement rather than contrived or structured movement. The following techniques for using a perception cane promote natural movement as well as ease and comfort.

- a) Handshake grasp: Traditionally, the index finger rests along the flat of the cane grip and points along the direction of the shaft. While this may make sense to a person who is newly blind accustomed to pointing, it may not hold the same meaning for someone who has been blind since early in life. It is inadvisable for the hand to be maintained in

this pointer position for long periods when moving the cane from side to side hinged at the wrist repeatedly over many years. Physical therapists have begun raising concerns about this technique because it may stress the wrist and contribute to the development of wrist problems. "Each [blind] subject displayed little variability in posture and movement across the 5 trials, suggesting that generally the same postures and movements are sustained for the entire time a person uses the cane. The lack of variability when using a long cane may increase the risk of cumulative trauma disorders." (Mount et al., 2001, p. 381). WAFTB teaches and uses a more relaxed grasp called the handshake grasp. With arms hanging loosely, the palms naturally face the thighs, with the fingers curled slightly towards the body. Bring the hand comfortably forward, as if to shake hands. The cane is slipped into the hand with almost no adjustment needed. The thumb naturally rests on the grip, with the fingers curl gently beneath. The palm turns slightly upward, as much as is comfortable. In this way, the cane gently dances between the fingers, with looseness in the arm, requiring almost no wrist movement. This greatly reduces stress on the wrist and

generally makes for a more comfortable and less awkward cane experience. Shaking hands with the environment through the cane allows for a smooth and friendly relationship with the world. Some people will prefer their palm to tilt slightly downward rather than upward.

- b) WAFTB suggests a relaxed arm extension, elbow comfortably bent, with hand hovering about midway between the center and cane-side of the body, approximately at the level of the waist. Any adjustments to maintain a relaxed posture and stance are acceptable, as long as the cane adequately covers the body. Many people find they can maintain full coverage with their arm hanging almost at their side. This is how most children hold the cane: A position called “gunslinger.” With time, we gently encourage the hand to extend slightly forward and hover more toward the center, but not uncomfortably so.
- c) Feather touch: With the handshake grasp, the thumb or ball of the hand can easily and comfortably apply a gentle downward pressure against the grip, making the cane’s tip virtually weightless. This resembles constant contact or glide technique in that the tip maintains

slight contact with the ground. However, the tip does not drag or scrape along with its full weight, but glides lightly over the contours and textures of the ground's surface, almost dancing around any rough spots.

These are just some examples of an approach to cane use; there are many other refinements. Over time, the WAFTB student's technique is refined to bring the cane in step, to maintain a more or less uniform arc, and to manage the cane in a full range of situations and environments. For the most part, given this perception-based foundation, the student's cane technique tends to develop naturally with little intervention.

The most important thing to remember is that a student who is blind should never be discouraged or prohibited from using his cane because this constitutes a breach of basic human rights to liberty. The cane of a person who is blind is his eyes, and it should be regarded with the same weight of importance and respect as the right of a person who is sighted to see. An adult would never say to a child who is sighted, "You should not use your eyes," or "If you can't use your eyes properly, you won't be permitted to use them at all." A parent or teacher

would never cover up a child's eyes because they misused them to, for example, give someone a dirty look, copy test answers from someone else's paper, throw something at the teacher, hit someone, or run off when they weren't supposed to. Such a parent or teacher would address the behavior, perhaps by imposing some kind of restriction, but it would never occur to them to restrict mobility by covering up the child's eyes. However, there are all too many documented instances in which students with visual impairments have been encouraged not to use their canes or actually forbidden to use them.

There are many ways to ensure safe and effective use of the cane in public places without restricting a child's right to freedom of access.

- Help to support parents in their ability to advocate for their own child by being sure they have access to information and that they can articulate their needs and concerns effectively about their children. Many parents are intimidated by professionals and administrative policies. But, very often, the law is on their side. They just need to know that and be willing to step forward with this knowledge on behalf of their children.

- Just facilitating proper use through perception based instruction is a good start. Most children understand the proper use of their cane when it is properly introduced and generally do not engage in inappropriate behavior.
- A simple in-service to staff and children is usually enough to soften any hiccups toward use of the cane in the facility. Most children are accepting of it once the novelty of it is explained and addressed.
- Some friendly, informative counseling to administration about the rights of the child and the child's competence to use the cane effectively to promote his own independence usually settles any fears and apprehensions. Administration may do a full turn around on this issue.

A final note about cane attitude—you may occasionally encounter students who do not like their cane and who will resist using it or refuse to use it at all. Kish, himself, refused to use a cane throughout most of his boyhood. The most well-known person with such an attitude was Ben Underwood, who sensationalized the media by proclaiming that he didn't need a cane, that he did not consider himself blind, and that there was nothing wrong with him (McCaffery,

2007). This attitude can arise from several sources. Perhaps the most common is the feeling of stigma that the cane seems to evoke, which, unfortunately, is a legitimate perception in most cultures. In most societies, the white cane erroneously symbolizes weakness, vulnerability, incapacity, helplessness, and dependence. These stereotypes are erroneous because those who are proficient in the use of the white cane do not tend to evidence any of these qualities. Instead, by virtue of their independence, forthrightness, and freedom, they exemplify more positive qualities such as achievement through perseverance, resourcefulness, relaxed vigilance and sustained attention, self-determination, personal dignity, and for some, courage. Regardless of what others might imagine, encourage students to be true to themselves and not to be ruled by the incorrect projections of others. As Chris Danielsen (2007) puts it, "Precisely because it is such a useful tool, the white cane is a symbol of competence and independence, not a badge of inferiority and incompetence. . . . Generations of people, blind and sighted alike, know what the white cane does and what it signifies. Our testimony as blind people, whether in speeches and articles like this one or in the simple act of walking quickly and confidently about our cities and communities as we work, play, and worship, proclaims the truth about the white cane to the nation and to the world."

Another common reason for not wanting to use the cane is that students, who are accustomed to being guided, may feel awkward and exposed when not being guided. People who are blind, who are accustomed to being guided, are also accustomed to not needing to maintain vigilance and not needing to deal with the environment on their own terms. They become comfortable being whisked along through their environment without needing to apply themselves to managing their own navigational process. The shift from guided navigation to self navigation is exciting and stimulating for some, but daunting and unsettling for others. The cane for them represents self navigation, which is a process and prospect many people who are blind anxiously resist.

The authors have found that a more effective approach with such attitudes is simply to maintain patience and allow life to provide the necessary lessons. Do not try to force use of the cane. Such an approach just engenders more resistance. Simply maintain the same high standards as you would with anyone else, sighted or blind. These students are expected to travel without dependence on a guide most of the time and expected to tackle all the same demands of life that are age appropriate. Under these conditions, aversion to the cane tends to sort itself out. In Ben's case, WAFTB proceeded with our

mobility lessons in a challenging, complex downtown area fraught with automotive traffic, street furniture, and broken terrain. He found the experience virtually unmanageable, and was forced to pick his way slowly and awkwardly through the environment. The team said nothing about it to him, but allowed him to observe that all of us using our canes managed the environment quickly and gracefully with relaxed poise. On another occasion, Ben was taken on a moderately difficult hike. The trail was wide, but it did turn and twist and it proffered its share of broken and rocky terrain. Ben's first move was to surreptitiously try to grab his mother's arm, to which she responded vociferously, "You're not gonna hang on my arm." Ben was presented with both a cane and a hiking stick, with some instruction on how we use both implements to optimize our speed and balance, but without compelling him to use both or either. He chose of his own accord to use the hiking stick. While he did not choose the cane in this instance, he did say, "I couldn't have done it without the stick," which suggests an emerging understanding of how a proficiently used tool can facilitate his mobility. He also seemed to mature in his appreciation for people who are blind, who apply their resources to functioning at their best, "I thought I was gonna come and meet a bunch a blind people just sittin' around not doing much. I was cruelly mistaken" (McCaffery, 2007).

On another occasion, a 12-year-old boy in Germany attended a WAFTB 4-day workshop with his mother. His family was one of eight families in attendance. The Freedom Formula was explained when the workshop began, with emphasis on the rule against the use of human guide during the course of the workshop, and the reasons for this rule. Kish writes:

Later on that same day, I noticed this boy walking with his mother with the telltale absence of any sound of a cane in use. "What happened to your cane?" I asked most congenially.

"That is the problem," his mother explained. "He doesn't have it."

"How is it that you don't have your cane with you?" I asked again with the same good-natured congeniality.

"I don't like it," he piped in superb English with a clear, bright voice like a baroque recorder.

"Ah, I understand," I said with an understanding tone. "I didn't like using my cane either when I was your age. Of course, I have mine with me at all times, now," I said, handing him my cane for inspection. He was very small for a 12-year-old and, though I am small myself, my cane extended

well above his head. He was impressed by how light it was for its relative length. "But, I really do understand not liking your cane. However, I found that not using my cane limited me from many things I wanted to do, and I do not want you or anyone else here to be limited." His mother inquired whether he understood, and he did. Indeed, he seemed most attentive to every word. "So, I must ask you both not to use human guide while you are here." There hung a moment of awkward silence.

"How will you manage?" his mother asked him in English. The boy made no verbal response, but his breath caught for a moment, then resumed more heavily.

"Now," I continued reassuringly. "I am not saying you must use your cane. I can't make you use it. There are stairs and broken ground, and we will be going outside a lot. How you get around here is your personal choice. But, there are things you are here to learn that you cannot learn from someone's arm. You said this morning most eloquently that you wanted to learn to know if things were in front of you. Well, how can you learn this if you always have someone to tell you or show you, or guide you around? It would be

like trying to learn math with someone around you all the time doing your homework. So, I must ask again that you do not use sighted guide while you are in this workshop. I hope you find our work more interesting than math."

After a pause he seemed to relax, and he said, "Okay," and they ascended the stairs toward his room. He used his cane without fail for the duration of the workshop, indeed excelling greatly in all the activities, including several technical hikes whereupon he was first to the end.

On yet another occasion, one teenage girl in a workshop at Birmingham City University expressed strong negative feelings against using her cane. "Thank you for bringing your cane, though," I congratulated her. "At least you brought yours. You'd be surprised at how many people just show up without their cane."

"Oh, of course I use it," she insisted grudgingly, "but I hate it."

"Well," I remonstrated jovially, "that's no fun -- using something that you hate. Let's just try this and see what you think. Just for the sake of trying

something different, let's just think of our cane as nothing more or less than a tool to accomplish a task, without any emotional attachment, like you might have for a screwdriver. Would you hate using a screwdriver to take out a screw?" She giggled pleasantly.

"Right. So, from now on, I don't want you to refer to your cane as a cane. Just call it your screwdriver." More giggles. "We're all just using our screwdrivers today."

By the end of the workshop, this girl expressed much more cheerfully that thinking of her cane as a screw driver really helped her feel more comfortable, as she indicated in a follow up email later on that same day, "I really think that today helped, and has changed me a lot. I've had to reevaluate the way people perceive me, and the way I perceive myself and I think that's been so useful" (Personal Communication, 2010).

Re-Integration and Social Engagement

Social engagement may be defined as a short or long term exchange between individuals or within groups. When this is mutual and equitable, it fosters mutual camaraderie and achievement among these individuals or groups. It is an active, generally equitable

engagement of and with others through mutual and respectful sharing of kindness, camaraderie, appreciation, and personhood, as well as a sharing of access to information and resources that each may offer. It is an active exchange of the active self.

A longitudinal study (known as the Millennium Cohort Survey) including nearly 14,000 children aged 7, 357 with sight impairment and 13,500 without has been conducted by Harris et al. in the UK. So far, four surveys of the children have been carried out at age 9 months, 3, 5 and, 7 years. The last survey was carried out in 2012.

Results of these surveys suggest that at age 7 the children with sight impairment have a “restricted range and variety of social experiences compared to those without sight impairment. This is particularly noticeable for children with sight impairment and another impairment” (Harris et al., 2012, p. 17). The results suggest that “sight impairment results in lower well-being for children as young as seven years of age” (p. 22).

Findings indicate that “children with visual impairments do not have equal opportunities to participate in physical activities and are therefore more sedentary than are sighted children” (Perkins,

Columna, Lieberman, & Bailey, 2013, p. 2). This lack of participation was found to be due to a lack of recreational activities, physical educator's lack of knowledge about curricular modification, lack of facilities, and lack of parental knowledge about facilities.

This lack of involvement in sports and other activities with sighted peers often resulted in children participating in sports with their parents. Doing activities with parents that are typically done with peers can lead to the children becoming too dependent on their parents. "Professionals should recognize that it is important to teach children with visual impairments to be independent, gradually decreasing their dependence on their parents" (Perkins et al., 2013, p. 8).

Another research study involving 385 sighted children and 54 blind or visually impaired children (aged 13-16) attending regular schools in Finland found that "adolescents with visual impairment did not differ significantly from the control group in depression or distress symptoms" (Huurre & Aro, 1998, p. 75). "However, some adolescents with visual impairment may be at increased risk of [vulnerability] and difficulties in their social development. Particularly there was a trend for girls with visual impairment to

have more difficulties in social relations compared with their normally sighted peers” (p. 77). The authors suggest that these findings may be due to difficulties in orientation and mobility. “Visual impairment may also cause functional restrictions, especially relating to mobility and orientation. Visually impaired persons find it therefore more difficult to participate in social events and maintain relationships with other people. These limitations may be more pronounced in adolescence, which is a period when social contacts, friends, and dating are very important” (p. 77). This observation further highlights the need for mobility and perceptual training for young people which, in turn, may lead to greater confidence and more participation in social activities.

WAFTB works to help the student who is blind re-integrate into the social and community system in which he lives. The family is the first model of community. Children develop their relationship with their community through their relationship with their family. If children are relegated to a role of passive recipient in their families, they will typically take on that same role in their community. All too often, blind children and even adults are isolated or marginalized from the normative functioning of their family and community. They are often restricted from freedom of play, not allowed to participate in community

programming or extra-curricular activities, and isolated from family functions and responsibilities. Consider the following examples. After Kish accompanied a 6-year-old child who was blind and her father in Austria to a Christmas festival, the father said, "I'm ashamed to say that we never brought her to one of these." In another example, a British family of an 8-year-old boy who was blind named Lucas was talking with another British family who had a similar aged boy who was also blind. Lucas' family was talking about some of the games he liked to play on his Wii. Boxing was one of his favorites. The second family also had a Wii which their older boys used regularly. Their response to learning about Lucas' interest in the Wii was, "We just assumed our son wouldn't get anything out of it." Family members who are blind are also often relegated to recipient roles, conditioned to wait until things are brought to them or managed around them.

Some people who are blind often refuse to reach out to touch or explore things unless the item is placed into their hands, or their hands are "puppeted" to the item. Moreover, many family members who are blind are treated or regarded in a manner different from their siblings or peers, thereby setting them apart. They are allowed to "slide", are disciplined differently or not at all, or are given special allowances. This

typically engenders resentment among peers and siblings and estranges them from the child who is blind.

Sometimes children who are blind are misperceived as more vulnerable, more delicate, or less capable of managing themselves in the face of a mishap. When a child who is blind gets hurt, falls down, runs into something, or just suffers a common mishap during casual play with other children, people tend to become more upset than they would if the child had been sighted. Such misconceptions also re-enforce the message that the child who is blind is different from others, that a lower standard should be set for him, and that he cannot or must not be expected to participate as an equal with his peers on his own merits. This can result in a self-concept of substandard worth, coupled with a highly demanding or inappropriate presentation to others.

Certainly, all of these misconceptions about children who are blind become true as a self-fulfilling prophecy when a child is conditioned accordingly, but none of these things need be true for a child who is blind who is prepared and expected to be robust and proactive.

WAFTB encourages active engagement of peer-based support where needed or desired. Social engagement

may at times be a crucial component of interaction with the physical environment for a person who is blind. Not only does social engagement often motivate interaction with the physical environment, social engagement is often facilitated by interaction with the physical environment through recreation and other interactive activities. Assistance can be mutually engaged to help bring the person who is blind into sync with the sighted world by fostering connectivity with the external environment through a sharing of vision. In essence, a partner who is sighted can help to bridge the perceptual gap that may, in certain situations, stand between the person who is blind and the environment. This can help the person who is blind function more effectively or conveniently in environments that may be difficult or impossible to access without vision. These may include environments that are highly dynamic, complex, unfamiliar, or potentially hazardous. Partnership with individuals who are sighted can also facilitate active participation in activities that might be difficult or impossible without support.

The absence of visual or self-directed physical activity can result in social isolation and disconnection. This can have a profound impact on healthy attachment and social relationships for young children. One distinct advantage of physical and social contact

between partners who are blind and sighted may be the restoration of connectivity with the social environment for the person who is blind, including movement and body language. For someone who is blind, physical contact may open pathways of awareness of how people move and how people express themselves physically. Thus, physical contact with peers who are sighted may help people who are blind come into sync with physical, nonverbal forms of social expression.

Unfortunately, it is very easy for the partner to take over in such a partnership. When this happens, students who are young or newly blind may be placed in passive recipient roles. The more a student is called upon to be responsible for determining his own actions, the more he will develop and apply all areas of self direction toward achievement. This is true even insofar as determining who he wishes to partner with, under what circumstances, and by what method. For this social exchange to work in a mutual manner, it is imperative that the person who is blind facilitates the social interaction so that he will have the social advantage. Just as a person who is sighted can assume a courteous role in facilitating the safe and effective interaction with the external environment of the person who is blind, the person who is blind can also assume a courteous role in supporting a positive

exchange toward a healthy, equitable, and mutually beneficial interaction.

Adults should not hover over children who are blind for several reasons. Doing so creates an expectation of dependency on adults that becomes deeply rooted and is difficult to break. It also interferes with development of peer relationships. For example, a high school student who is blind may have difficulty getting to some of his classes on his own, especially when he begins a new semester and has a new schedule. He may decide that he can get to some classes on his own, that he can get to some classes partly on his own, and that he can get to other classes not at all. Perhaps he needs help getting through the lunch line and finding a table. He should be supported in gaining the assistance he may need, for as long as he needs it, from his peers and classmates rather than having it imposed on him by adults. This is done by sharing and facilitating, not usurping the learner's experience.

Sighted support is often key to accessing the environment more smoothly, conveniently, efficiently, safely, and with greater autonomy. The issue is not whether assistance is engaged, but about how it's engaged and the manner in which it is delivered. Very often, the nature of the assistance is predetermined

without input from the person who is blind. Many young children who are blind are on the arm of an adult most of the time and look to the adult for all the answers. In this passive mode, a person may become incapable of learning not only to manage himself physically, but also to manage himself socially with peers. However, if assistance is engaged in a manner of equitable exchange, the person who is blind becomes an active participant in and contributor to the process. In this way, a person who is blind may engage all the assistance he needs to participate in every activity of interest, while still maintaining personal dignity and remaining self-directed. WAFTB has much less concern about children who are blind actively engaging assistance from their peers than it does with adults serving as caregivers. The former can actually help to develop a student's autonomy through active social engagement, whereas the latter almost invariably compromises a student's autonomy.

In this context, encourage your students to do whatever they can for themselves. When they may need help or support, encourage them to take charge of that process rather than being subservient or passive in the process. Try to discourage adult aides or care workers from following children around to babysit and supervise every move, a situation that occurs all too frequently. The concept could be useful, but the

implementation is disastrous. Adult support workers are most effective at fostering autonomy when they are transparent to both the student and his or her peers. They should be regarded as a classroom assistant, not little Jimmy's assistant; and they should remain well back and well out of reach. Our discussion about actively taking charge of one's network of support is a critical one because many people who are blind are taught, implicitly or explicitly, to assume a passive role when being supported.

The way human guide is introduced, taught, and largely regarded tends to relegate the person who is blind to the role of passive recipient rather than an active participant or contributor to the process of movement. Although some instructors will espouse the idea that the partner who is blind has an important role to play, the reality is that the "partner" is all too often told who is going to assist him, when this assistance will occur, where it will happen, under what circumstances it will happen, and even how the assistance will be rendered—and the recipient is expected to remain quietly compliant and even grateful! Personal choice and dignity have been meticulously removed from the process.

Enforced or resigned passivity erodes the process of self-direction more than the act of guiding itself.

WAFTB finds that when people who are blind assume and maintain active management over who is assisting, how the assistance will be rendered, when and to where, and whether or not they want the assistance at all—then the process of self-direction, freedom, and autonomy can be preserved and enhanced.

On the other hand, sometimes situations go too far in the other direction. If a student who is blind is expected to do everything on his own and if peers are admonished not to help him and even to keep away from him so that he can learn to manage by himself, a different kind of isolation can result. In this case, the student never quite develops the movement skills to keep up with his peers, but also never quite develops the social wherewithal to garner the sustained interest of his peers to support his inclusion in peer activities. The continuous use of human guide will eventually degrade the potency of the perceptual navigation system. There is no getting around that. Therefore, each person must strike the balance that makes the most sense to him in each situation. Although the continuous use of human guide is very problematic, the use of a human guide in and of itself can enhance rather than diminish one's freedom when it is engaged in an active manner.

Many children who are blind live in their heads and act in ways that are out of touch with or out of proportion to what is going on around them. Children who are blind perform these inappropriate actions often because they are kept apart from or not engaged in the same flow of social interactions enjoyed by children who are sighted. In the absence of external stimulation and active involvement, what goes on inside their heads may become highly stimulating. These students may exhibit autistic-like styles that may not be autism at all, but may actually be a way of seeking and obtaining stimulation. This is not to say that people who are blind can't also be autistic. However, the authors are careful not to make the assumption that autistic-like behaviors should only be attributed to blindness out of the expectations that blindness will impair development. The assumption of non-autism in a child who is blind who may, indeed, be on the autistic spectrum can be as damaging as the misplaced diagnosis of autism. Nonetheless, there are many sociological factors of isolation and differential treatment that can contribute to an autistic-like presentation in many students who are blind.

Responsibility and accountability are excellent ways to draw students out of their heads and idiosyncratic style of behavior and into more socially adaptive and normative modes of interactive functioning. When children are contributing in an age-appropriate way

to the family, they are regularly presented with the opportunity to learn how to engage the community in a more mutually contributory manner.

Daniel's mum, Paulette Kish said, "We must help parents to start teaching interdependence within the family unit early in life. By the age of two a child can help put their toys away. By three they can learn to help fold some clothes (At age 3 & 1/2 Daniel could help me fold Keith's diapers.) By four they can set the table, put their own clothes away and help feed the pets. By five they can make their own beds, pour their own cereal and milk, and make a sandwich" (Kish, 2000).

This approach quickly helps the student to become more grounded and connected to the external environment. "In order to make meaning of new information, the brain will connect new experiences to previous ones, activating consciousness. Assisting students in connecting learning experiences to their personal lives helps them learn in ways that are relevant (as cited in Merriam, 2001, p. 77). Conventional forms of social engagement, including holding a career, cannot happen without an understanding of and appreciation for active, mutual contribution.

Normative social engagements are critical to social development. Responsibilities held in the family prepare a child to take on responsibilities in the community. By involving the child who is blind in all aspects of family functioning as an equal and not a sub-equal, the role of passive recipient is transformed into a role of active contributor and participant in the family as well as in the community at large.

Finally, children who are blind must be encouraged to engage others socially in the same manner that sighted children do. Sighted children learn from an early age that they must direct their attention to engage others' attention. If the child does not do the work of giving attention, others' attention is not given fully to the child. In western culture, this usually means that the child must make and maintain eye contact and communicate with attentive body language. Children who are blind are often allowed to slide on this point because it is assumed that they cannot observe the way that others direct their attention and because others assume that children do not need to make eye contact if they cannot see. On one occasion while delivering a presentation to a team of professionals in Germany, one professional insisted, "but our students are blind. They cannot observe." While this comment did provoke counter argument from other professionals in attendance, it

does nonetheless reflect a still common misconception about people who are blind held among professionals even in the 21st century. This erroneous belief may not prepare children who are blind for realistic and effective interaction with the general public outside the family. In fact people who are blind can and must maintain a consistent level of situational awareness and need to meet the public more than half way to be given suitable attention. We do them no favors by failing to hold them accountable for directing their attention to others.

A simple way to do this is not to allow your attention to be engaged unless and until the child who is blind does the work of directing his attention to you. The child must have his head up, his face turned toward you, and his body poised and erect. He must hold his body still and stop any unnecessary movement he may have been making. He must have his hands out of his eyes and must look interested. This nonverbal indication of attention and interest can be explained and taught to children as young as six or seven, but reinforced by family and teachers even with toddlers. Consistent reinforcement by family and teachers can take the form of withholding attention until the child understands and enacts his role in social interaction. Now, when the child's attention is properly directed to you, you can happily give the child your entire

attention. The need to engage others is very strong for most children and will generally override other behavioral habits. Except for children on the autism spectrum who may benefit from a different approach, consistently giving your attention to the child only when he first shows that he is giving his attention to you generally results in a fairly rapid adoption of these new interactive behaviors. This approach also often results in the reduction of “blind” behaviors such as eye-poking, rocking, and head shaking.

When applying these strategies, you might make statements such as the following:

- “I don’t know who you’re talking to. You need to look at the person you’re talking to so I know who it is.”
- “Hmm? Did you ask a question? I can’t hear you with your head down like that. I can hear you better when you look at me.”
- “I’m sorry. What did you just say? I couldn’t hear you very well because you weren’t looking at me.”
- “I don’t know who you’re talking to when your hands are in your face like that. Ah, what beautiful eyes! I love to see your eyes when you

talk to me. Thank you for showing me your eyes. Now, what were you saying?"

- "I really like your voice, but I can't hear it when it isn't pointed at me."

This discussion of social engagement isn't just relevant to children who are blind. Adult students may not have learnt the lessons of social engagement as children. As adults, they may have more difficulty engaging their peers or members of the public. This can have far reaching consequences for employment, establishing relationships, or just getting someone's attention at a customer service counter. Kish had this exact discussion once with one of his students who had gone through extensive mobility training, but who still kept his gaze straight ahead and slightly lowered no matter what his situation. The matter came to a head when he was in need of some information while traveling outdoors, but was unable to catch anyone's attention for 10 minutes. At that point, Daniel began the discussion about social engagement.

On another occasion, one of Daniel's students was fairly engaged, but he was extremely tall and did not account for his height when addressing people. Consequently, he always spoke right over the head of whomever he was addressing. Daniel noticed that it

was more difficult for this student to engage others' attention or that others' attention to him wavered until he began adopting the habit of tilting his head slightly downward toward people when addressing them.

A Final Note

The preponderance of literature tends to focus on the developmental differences between children who are blind and children who are sighted and on the differences in mental processing and functional application between persons who are blind and those who are sighted of all ages. These differences usually showcase delays, deficiencies, or anomalies among the blind when compared to the sighted. When supernormal capacities are highlighted among the blind (e.g., supernormal hearing, touch, or verbal memory), they are often explained in terms of a perspective of compensation (e.g., "It is no wonder that certain mechanisms become over developed in some areas by way of compensation for the challenges that blind people face in so many other areas."). The absence of vision does present significant challenges, and these challenges do impact development, function, and mental processing, although some of the best-controlled, long term studies show less distinction between persons who are blind and sighted than is often found in less rigorous research. It may

be more productive and constructive to concentrate attention on the similarities that underlie development and functional capacity for all people. In this chapter, the following fundamental principles of human development, which apply equally to persons with and without vision, have been discussed:

- The thirst for freedom;
- Use it or lose it;
- Learning driven by need;
- What goes into development directly affects the product;
- Perception-based learning is most natural and effective; and
- Person-centered relationship with the environment promotes the most effective learning.

These principles are the very building blocks of development and learning, and they impact development in a similar manner for both persons who are blind and persons who are sighted. Maintaining this perspective supports the development of an

instructional approach that is suitable, effective, and expedient for just about anyone under just about any circumstance because this perspective taps directly into the fundamental human nature that drives who we are and what we do.

The next chapter explains how to teach FlashSonar skills including how to generate the most effective tongue click.

Chapter 4 – How do I Teach FlashSonar to Myself and Others?

This chapter is about how to teach FlashSonar skills. It includes information about how to generate and use the tongue click.

FlashSonar: A Principal Travel Method

When Daniel Kish and his team were conducting Echolocation workshops in South Africa, a would-be workshop participant who was blind asked the team about their heavy use of FlashSonar and their claims about its effectiveness. This very distinguished, well spoken, and extremely thoughtful gentleman had up to this point considered more traditional forms of echolocation to have their occasional uses, but considered echolocation to be distantly subordinate to a cane or guide. Daniel assured him that he and his team were avid cane users and maintained ready access to their canes at all times, but that the team rarely found the need for a guide, even in unfamiliar places. Intrigued, this gentleman asked, "If you could use only a cane or FlashSonar, which would you choose?" After a poignant silence, the team began stammering, noncommittally, hemming and hawing, offering pros and cons of each in various situations,

but reaching no definitive decision. With genuine fascination, the gentleman at length observed, "It's really that hard for you to choose."

There exist many methods and modalities for orientation and mobility including but not limited to the cane, electronic travel aids, orientation aids, travel preparation methods, dog guide, human guide, visual aids, and echolocation. According to tradition, mobility methods are categorized in terms of primary and secondary modalities. These categories are said to be defined by factors including the extent and type of information believed to be made available to the user, and the travel efficiency and safety that is believed to be afforded to the user. Essentially, a primary method would be defined as one which can stand alone in providing the user with a safe and effective travel experience without need for additional (secondary) methods, although it is generally accepted that methods considered secondary may be effective in enhancing travel experience. The single factor that fundamentally distinguishes primary from secondary methods is whether or not the method will reliably allow the user to detect and safely negotiate a step down, drop off, or some other break or irregularity in the terrain. Three mobility methods are traditionally designated as "primary"—the cane, human guide, and dog guide.

All the rest are traditionally considered secondary.

This primary-secondary distinction may reflect professional priorities regarding safety, but does not capture the significant impact that other methods, traditionally considered secondary, may have on the overall travel experience of a person who is blind. Any or all of these “secondary” methods may be applied by choice of the user according to a personal evaluation of safety and effectiveness, and these user-based evaluations should be respected and not dismissed. The detection of drop-offs is fundamental to safety, and any mobility process is well advised to include a method that satisfies this single requirement. However, this single factor need not overrule or overshadow the broad and diverse impact of a host of other factors such as navigation of the larger environment, speed and proficiency of interaction with items, awareness of surroundings, esthetic appreciation, and, perhaps most importantly, personal freedom and dignity. These and other factors are effectively addressed by other methods in a manner and quality that may be less achievable by any of the methods considered primary. Instead the term “principal” can be used to refer to the prevalence and preference of use by a given individual of any and all methods. Thus, a person may use a cane as a way to perceive terrain, but may find that

the bulk of information most pertinent under most circumstances is conveyed to him by GPS, residual vision, echolocation, or through his feet. In such a case, these methods serve the user as principal means to effective mobility. FlashSonar can be developed to a quality and scope that makes it viable as a principal means to mobility.

The effective use of sonar is a complex and sophisticated process as is the effective use of vision or any other sense. It is not incidental, random, or sporadic. Those who regard FlashSonar as principal in their mobility process use it skillfully, strategically, and often intentionally with a degree of attention and in a manner that may supersede (albeit not replace) the use of other modalities.

How to Teach

In keeping with a modern developmental psychology perspective, the authors don't fully subscribe to the sequenced approach. While rough developmental milestones and sequences may exist, they are heavily dependent on personal, social, and environmental factors. This is particularly true for individuals who are blind whose developmental sequencing is even looser than that of the general population, especially considering that a higher percentage of this population is faced with the challenge of additional

involvements. In practice, the application of a sequenced skills curriculum often misses the mark. Development and learning are only partly driven by developmental sequences that may be more or less hard-wired; they are also largely driven by what we may call “relevance.” Humans are driven to learn and grow by what is relevant to their interest, survival, and attainment of resources. For example, children understand fractions long before they are formally taught the arithmetic operations as demonstrated by their awareness of equity when it comes to cutting pie and pizza. They often understand money long before they are able to do percents, and all of us understand time (base 12 or base 24) before we are even introduced to the concept of bases. Children who are blind are often observed to excel well beyond their peers who are sighted at certain skills, such as swimming, climbing, music, roughhousing, and auditory processing, because these various skills may be more relevant to their style of exploring and understanding the world.

The FlashSonar program is based more on relevance than on sequence. The instructor should be warned not to try to impose this curriculum on a student in a sequenced, prescribed manner, but should first strive to understand the student’s perceptual and environmental interaction style.

As with any orientation and mobility training, it is important to know what skills the student is already using; therefore, an assessment of echolocation skills should be conducted. Before starting FlashSonar training, the teacher should take plenty of time to observe the student's existing sonar skills. For example, the teacher might ask the student to walk along a hallway or sidewalk using any skills he likes and observe whether the student can walk fairly straight without making contact with the walls or undue contact with other objects. The teacher can check whether the student is able to perceive when a wall or door is in front of him and observe whether the student stops independently or hesitates before contacting objects in the environment. If the student is able to do some of these things, he may be demonstrating some basic sonar skills. Some children demonstrate strong skills at an early age with no instruction, but knowledgeable instruction always helps to improve skills. As the parent of one child points out about her son "We have seen Justin using echolocation on his own as a toddler . . . I'm not sure how much Justin knew what he was doing or how much further he would have taken it. I know that I have heard a lot of blind adults say they use echolocation to some degree . . . But in Justin's case, with structured learning his potential in this area is being drawn out and he is learning to use echolocation

more effectively than he would have otherwise” (as cited in Kish, 2011). (For training exercises, please see Chapter Five.)

Some students who use echoes are unaware that they are doing so. “However, conscious awareness is not mandatory for successful echolocation” (Rosenblum et al., 2000, p. 202). Moreover, it is helpful to assess a student’s situation and behavior to infer which parts of the brain are being accessed and activated, or not activated, as the case may be. For example, when directions or prompts are given to a student, the action portion of the student’s brain is usually activated. The thinking and perceiving parts of the brain may be little involved if all the student does is respond to given directions. An approach more effective at involving the thinking portion of the brain is for the teacher to ask questions of the student instead of giving him directives. So instead of telling the student which direction to travel in, ask the student if he knows in which direction he should be going or what clue in the environment he is searching for. The more the student can direct himself and the situation, the more the student’s perceptual portion of his brain is involved and stimulated. This approach respects what the student has going on in his head, and respects and nurtures his capacity to learn and grow in all areas of self direction.

One approach that is found to be effective to facilitate rapid development of self-direction is to conduct a majority (or sizeable percentage) of lessons in age- and situationally-appropriate environments that are not known to the student. Familiar environments may induce a sense of security, but they also may induce a sense of complacency. Motivation and attention seem to drop precipitously in familiar surroundings. Therefore, the most rapid learning occurs consistently in unfamiliar surroundings. The percentage of exposure to unfamiliar settings or situations will vary somewhat according to student needs. For instance, very young children generally do better in the beginning of instruction in familiar surroundings. For some students familiar surroundings may support the development of student-teacher rapport in the initial stages of instruction—especially for very young or highly anxious students. In familiar surroundings, the teacher can get a baseline of how a student functions when at ease. However, the aim is toward moving into less familiar surroundings to ramp up the attentional systems and motivation.

The list of exercises in Chapter Five of this book is adaptable and is designed to fit around the learner and the available environments. From a teaching point of view, the aim is to help the learner become more actively aware of FlashSonar and how he can further

develop his knowledge of the environment by using his hearing. Van der Poel (1997) explains that “in the case of a visually impaired person, it [hearing] brings the environment closer, mostly in an abstract form, and it needs to be supported by haptic experiences if it is to form a meaningful whole” (p51). Learning about FlashSonar allows the echo signals to be used strategically to interpret and understand more quickly and more easily simple and complex environments in greater detail, at greater distances, and under a broader range of circumstances and activities, reducing the need for haptic, tactual and verbal information.

The FlashSonar program in Chapter Five is in no way intended to constitute a complete set of activities or skills that may be learned. The activities included are selected to represent broadly the principal types of interactions that people may have with the environment. They are also intended to provide focused opportunities to practice developing certain specific skills which represent skill sets. They can be generalized by the learner to address any of life’s requirements. These activities must be adjusted or modified according to student need and environmental determinants. Activities can be modified or added according to need. The sequence suggested in Chapter Five is only a very general guide, and will not apply to

every student in all situations. For students who are cognitively delayed, a more experiential approach will be needed, with less drill and less verbal explanation.

The process of learning FlashSonar skills should be thought of as honing and enhancing an existing skill because many people who are blind already use some form of echolocation, even if they are unconscious of it. Schwitzgebel and Gordon (2000) “contend that human beings not only can echolocate if trained but actually do echolocate in their daily lives” (p. 17). Many people who are blind and have received no formal echolocation training are still able to detect objects and work out some environmental clues using reflected sound. They may be able to locate and recognize large objects such as buildings or walls. Griffin (1958) observed that “the most skilled blind men do equally well without artificial aid of any sort—basing their echolocation on footsteps, finger snaps, or other sounds which are available without artificial generating devices” (p. 313).

How Brains Learn to See

It is believed the brain learns to see by using systematic stimulus differentiation. This natural process may be sped up with formal instruction. The process of helping someone to learn FlashSonar, or any other perceptual skill for that matter, involves

helping the student to move through a process of unconsciousness to consciousness to second nature. We often conduct many activities unconsciously with a lack of awareness of how we do what we do. Often, we are also unaware of how our performance falls short of where it could be. In training, the teacher starts by making the unconscious conscious in the student. Perception becomes deliberate and conscious. Once the process is made conscious, the student can deliberately and with awareness target skill areas needing refinement and set about refining them through this process of self-monitoring. Once this is done, the skills being applied become second nature, but this is not the same as unconscious. They are second nature because they are so easy that they require little attention to execute them. The student is still very much connected to what he is doing, he just doesn't need to concern himself with maintaining vigilance to that process. Lack of consciousness or awareness, on the other hand, means a lack of connection to what we are doing, and how. Without this connection, we cannot intentionally manipulate and effect our own experiences and interactions. With very young children, the student can move from unconsciousness to second nature, without necessarily passing through the conscious phase—or, if the child does pass through that phase, it may be brief.

This whole progression starts by tickling the brain into registering and processing subtle stimuli that may be beyond the conscious experience of the student. These stimuli often flow through perception without conscious awareness, and the neural system may not have developed the full capacity to register or react to these stimuli. As instructors, we must help the student to “hook in” to these stimuli so that channels of processing these stimuli can be opened and made alive. The opening of these channels is often accompanied by a spontaneous sense or expression of excitement or sudden realization—the “aha!” experience. This involves helping students to register and process stronger or more intense stimuli so that the brain may then open to process subtler and finer stimuli. Perception of and reaction to the stimuli is key. For this to happen, the instructor helps the student to develop a relationship with the stimuli on their own terms. This relationship is not governed or even guided by the instructor. It is supported into development through a self-directed discovery process, which is articulated in Chapters Two and Three of this text.

Neural Activation of External Mapping

A question often asked is when is it best to begin perceptual development training? Infants who are sighted begin their perceptual development training

(learning to see) at birth, and children who are blind learning to “see”, to perceive and move freely should be regarded no differently. A good motto is, “The earlier the easier, but it’s never too late”, as recent studies of neural plasticity suggest.

A study on three people whose sight was restored after a number of years of having no useful vision, but were successfully able to start identifying images, especially moving images, suggests “that the idea of a critical period should not be applied too strictly to visual learning, and . . . [provides] cause for optimism for the many blind individuals who are candidates for treatment. The human brain, it appears, retains at least some measure of its ability to launch programs of visual learning even after extended periods of visual deprivation” (Ostrovsky, Meyers, Ganesh, Mathur, & Sinha, 2009, p. 1490). This also applies to people who have previously been thought not to benefit from restorative surgery. The “complex task of image parsing can be acquired even after a prolonged delay, although the rate of acquisition slows down with age, possibly because of decreases in plasticity” (Ostrovsky et al., 2009, p. 1490).

The above discussion suggests positive implications for activating the imaging system of individuals even after years of immobility, passivity, and dependency

conditioning wherein the imaging system would have atrophied or remained dormant. Present throughout all these strategies, exercises, and activities is a view toward encouraging the student to interact with accuracy and precision with the external environment. This means directed reaching for stimuli, and moving toward, among, and around stimuli with precision. Try to discourage groping or fishing for what may be there, encouraging instead a direct reaching for what is perceived to be there. This isn't to say that you should discourage discovery exploration. Exploration is encouraged, but when we have opportunity to know what is there before reaching, we encourage active, directed reaching and precision movement.

It is important to encourage the student to reach for the item directly. Directed reaching is one of the most important developmental milestones for infants who are sighted (Adelson & Fraiberg, 1974). This process connects the imaging system to movement. Encouraging directed reaching in students who are blind facilitates the same connection between the imaging system and movement. It has been shown from recent brain scan research (covered in earlier chapters) that active echolocators are, indeed, using the visual system to process and respond to echo stimuli. The activation of the imaging system needs to be fostered by self-directed movement. Later in

the training, the instructor should encourage students to refine this process by precision of movement—for instance reaching directly for poles or tree trunks, and moving among obstacles without touching them.

This seems to activate the externalized mapping process. How this is best done is a matter for speculation, and will remain so until we understand the neural mechanisms better, and can cross reference neural development with behavioral development. In the meantime, we may use what we know and what we have observed and experienced to draw some inferences and make some educated guesses about how to activate the perceptual imaging system. Among other things, we take our cue from infants, who are perhaps our predominant teachers. Infants have to teach themselves how to externalize and interact with their environment. Adults are both helpful and disruptive to this process. It's really up to the infants ultimately to figure it all out, and they generally do a reasonable job despite the well-intentioned meddling. Infants who are sighted engage in two critical developmental milestone behaviors that strongly activate this external spatial mapping process at an early age: They engage in directed reaching, and they recognize faces.

Children usually learn to crawl between 5 and 10 months of age. The action of crawling gives the infant choices about who and what to approach or move away from and is a significant self-directed movement. "The acquisition of self-produced locomotion—specifically forward movement on all four limbs—is such an epigenetic event and that its emergence is fundamentally linked to many of the developmental changes taking place between 6 and 9 months of age" (Bertenthal, Campos, & Barret, 1984, p. 177). It is also understood that "self-produced locomotion may facilitate brain development" (p. 177) as the act of crawling gives the infant more self determination about what to do and how to interact with his environment. This may be particularly important in the development of the visual system as "when transported infants tend to be visually inattentive" (p. 193). It is only when infants learn to crawl that they learn to understand visual perspectives and depth perception.

A delay in crawling, which is common in children with a visual impairment, may also then lead to delay in exploring the environment and understanding how objects relate to each other. On average there is a 7 month delay in a child with a visual impairment walking independently across a room compared to a child with normal vision (Adelson & Fraiberg, 1974).

“Blindness does not affect gross motor development in some uniform fashion. Blindness has relatively little impact on postural achievements in the otherwise normal and self-stimulated infant who is blind. However, blindness is associated with a marked delay in the achievement of mobility skills” (Adelson & Fraiberg, 1974, p. 119). This may be partly due to the fact that a child with a visual impairment will lack the visual lure of objects, so has no incentive to move towards an appealing object. At about the age of 1 year a child will start to move towards a sound even if she cannot see the object (Adelson & Fraiberg, 1974). The delay in independent movement may also be explained by the fact that many children who are visually impaired are discouraged from moving independently as parents and other caregivers are overly concerned that movement may lead to injury. This appears to be especially true for infants who are blind and are medically fragile or who are recovering from trauma or injury, as is the case for many. The increased nurturing that infants with medical needs require may inadvertently lead to the establishment of long term patterns of over-assistance and dependency conditioning. Adelson and Fraiberg (1974) reduced the average age when children who are visually impaired moved independently but stated that it is “unlikely that the delay can be completely eliminated, since sound does not provide the same adaptive advantages as sight” (p. 126).

Recent research has shown that motion has a key role in humans learning to visually recognize objects. Initially infants learn to segregate objects from the environment only when they are moving; this process takes place approximately two months before they can do the same with static cues (Ostrovsky et al., 2009). "During the early stages of visual learning, motion appears to be instrumental both in segregating objects and in binding their constituents into representations for recognition" (p. 1489). "The most effective visual cue for eliciting an orienting response from even very young infants is motion. Infants tend to preferentially look at regions of the visual field that contain motion, over those that do not" (Sinha et al., 2009, p. 8).

This is important because, to stimulate the visual system in children with a visual impairment, a parent or caregiver will have to move objects for the child, even though the parent may think the child cannot see objects that well. The delay in the child moving objects for themselves means that the parent or caregivers intervention may be necessary to prevent further developmental delay. This raises questions about how object recognition occurs for those children with no vision.

Whether or not children who are blind generally engage in directed reaching and under what circumstances is a subject of debate. Suffice it to say that some children who are blind do engage in reaching, but the degree of directedness even among those who do actively reach is highly variable. It is more common for children who are blind to engage in what we call discovery reaching, wherein the hands, arms, and whole body become tools for canvassing ones surroundings, just as the eyes of a child who is sighted do. At the same time, many children who are blind tend not to engage in directed reaching with precision toward desired items of chosen interest. Patterns of passive reception are often engendered by items being consistently placed directly into the child's hands without the child being stimulated to reach for a given item. A child's hands are often physically directed to objects by others, or the child is expected to just fish haphazardly for objects. We hypothesize that these common scenarios can disrupt the development of a process by which the child establishes a dynamic relationship with the environment by mapping its elements relative to himself, and directing his interaction with these elements with precision. It is through the self-directed interactive relationship that both the externalized mapping and executive function (managing one's affairs through personal choice) occurs. As this

directed reaching phase is often missed by children who are blind, and is not necessarily re-established non-visually as they grow older, FlashSonar has continuous opportunities to engage directed reaching for items and stimuli, as well as precision interaction with said stimuli. As students are called upon to interact with the world—negotiating, retrieving, approaching, or circumventing, the teacher looks for increasing levels of precision movement with grace, speed, and confidence.

Scanning

The use of auditory scanning “consisting essentially of object detection with head movement” (Rowan et al., 2013, p. 56) in humans who are blind using echolocation was noticed by Kellogg (1962). It is an important skill also used by bats that “shows parallels with saccadic eye movements” (Surlykke, Ghose, & Moss, 2009, p. 1016). “The sequential scanning of the echolocating bat resembles results from vision studies showing that humans and other primates sample information from a complex display by a series of fixations, interrupted by saccadic eye movements” (Surlykke et al., 2009, p. 1019).

It is the ability to focus on and pick out particular acoustic and spatial characteristics of the returning echoes that is required for echolocation. Taken a

step further, it is the active and strategic use of echo signals to ‘query’ the environment much like scanning with a flashlight. Just as someone cannot take in an entire scene visually at a single glance, but scans the scene and picks out the features they feel are important, so in FlashSonar the learner will quickly concentrate on specific sounds and echoes in rapid succession. Dr Steve Charles (2004) explains, “Head motion is analogous to motion parallax and saccades in the visual system and should help resolve ambiguities and improve the precision of sound localization” (Charles, 2004). This is also true of bats when they echolocate. “The bat did not sample all elements of the auditory scene simultaneously, but shifted its focus from object to object sequentially” (Surlykke et al., 2009, p. 1015). A bat samples the environment “in a manner analogous to sequential visual fixation of objects within a complex visual scene” (Surlykke et al., 2009, p. 1018).

A recent study found that “expert echolocators were remarkably accurate at identifying shapes when they were allowed to freely move and explore the objects as they would naturally; when they were required to remain still, however, their performance declined dramatically” (Milne, Arnott, Kish, Goodale, & Thaler, 2014, p. 1829). In the same study neither of the control groups (echolocators who were blindfolded and

sighted as well as those who were blind) showed this movement advantage.

Children who have a visual impairment often turn their heads so that one of their ears faces the noise or voice that they hear. This means they may turn their heads away from the person speaking to them. “This response is often misinterpreted in clinical settings as an indicator of refusal or lack of interest of the blind child” (Hug, Arias, Tommasini, & Ramos, 2014, p. 2023). It is important to note that this may not be the same as wild or rhythmic head waving, nor is head waving necessary to establish orientation as some believe. Discrete scanning is sufficient for auditory localization.

Stimulus Sensitization

The FlashSonar program taught by WAFTB starts by sensitizing the student to echo stimuli. Usually the teacher will have them detect and locate easy targets such as large plastic panels or bowls. Many students will pass through the earlier, more obvious stimuli very quickly, while others will need more time. The idea is to help the student get a sense of how echoes sound and to direct their response accordingly. This is called a “hook stimulus” (as discussed in Chapter Two) because it hooks the brain’s attention to a stimulus that it might otherwise ignore. The teacher

keeps increasing the clarity of the stimulus until the student evidences awareness of the stimulus. Then the teacher has “hooked” the brain. Once this is done, students can often go immediately back to the stimulus that they couldn’t detect just 5 minutes prior, and more often than not, the brain has already adapted to detecting the stimulus clearly. A more detailed explanation of how to conduct these exercises is provided in Chapter Five.

Stimulus Clarification

If a student is unable to register or describe a stimulus consistently, it may be that the stimulus needs to be clarified. There are generally three ways to do this.

First, by representation: A similar but more detectable stimulus may be used. For example, if a student cannot detect an opening in a wall such as an open door, the teacher should find a room that is highly reverberant (larger or less furnished) so that the student will hear more clearly as he passes the opening. If a student has difficulty locating interior corners, he will likely be better able to find a large alcove. The teacher can discuss the sound of an alcove, and relate it to the similar but less “hollow” sound of a corner. Alcoves and corners tend to be easy to detect and locate because they throw back most of the acoustic energy to the sonar user.

Second, by intensification: Bring the student closer to the stimulus, or use a larger version of the stimulus, such as increasing the size of the open door or branching corridor. This serves to intensify the stimulus under investigation, making it easier to detect.

Third, by illumination: Use a different sonar signal for that exercise. If the student can't detect the stimulus with a pulsed signal, such as a click, perhaps they can with the sound of a radio or hand clap. This strategy sheds a different "light" on the stimulus that may cause it to stand out so the student can detect it more easily. Then, go back to using a tongue click.

Bats also seem to do something similar as they sometimes use a different type of sonar which is higher or lower in frequency (than their usual sound) to detect objects. "When the echolocating bat shifts the direction of its sonar beam from obstacle to obstacle it also makes range-dependent adjustments in the duration of sonar calls to avoid pulse-echo overlap, suggesting accommodation to objects at different distances" (Surlykke et al., 2009, p. 1019).

Stimulus Comparison

It may help a student to directly compare one stimulus with another. This is particularly useful when

teaching aspects of feature characteristics such as the dimension of an object, its location or density. It may help the student to register these signature types when they have a basis for immediate comparison. For example, if a student is having difficulty registering foliage, confusing it with various types of fencing, it may help to find a location where both types of stimuli are immediately available. The teacher would need to source an area where there are trees and poles, retaining walls and hedges, a wrought iron fence and chain link fence, etc.

Research shows that “subjects [can] reliably detect relatively small changes in range of an ensonified reflector positioned in virtual echo-acoustic space” (Schornich, Nagy, & Wiegrebe, 2012, p. 681). “At a reference range of 1.7 m most subjects could detect a change in target range of only 30-40 cm” (Schornich et al., 2012, p. 677). This demonstrates that the participants could detect a change in distance of less than 30 cm (approximately 12 inches) for a reflective surface 1.7 meters (approximately 1.9 yards) in front of them when using echolocation.

Stimulus Association

Stimulus association is the conceptual version of stimulus comparison. Instead of comparing elements in the environment, they are compared in the mind

whilst drawing upon mental references. For example, when facing a hedge, a student might say, "It sounds solid?" the teacher might reply, "as solid as the wall to your house?" "No, not that solid," she might reply. "As sparse as the fence of your yard?" "No, more solid than that," she might answer. Now we have a range of relativity to work with. "Does it remind you of anything else near your house, maybe in the side yard?" "Bushes?" she might query. "But what seems different from those bushes?" "These are sort of flat like a fence." If she can't put the word to it, the teacher may ask her to touch to determine that it's a hedge, and then they may discuss why it sounds the way it does. This strategy is often used in discussing and describing stimuli. As students build up more of a repertoire of experience and understanding of acoustic imaging concepts under their own direction, they can draw on this experiential base to understand and work out new stimuli.

For example, when a student is having difficulty identifying or describing a feature, such as a palm tree (because of its seemingly solid, flat branches), the teacher might ask "what does it remind you of? What are its characteristics?" They might discuss other trees the student has encountered, and talk about how this one seems similar and how it appears to be different. When teaching a student to find entrances

to buildings, the teacher may want to discuss what alcoves sound like. The teacher may find it helpful to refer back to some of the beginning exercises when helping the student to understand the more advanced ones.

Stimulus Shift

The stimulus shift paradigm is used by psychophysicists to teach a student to register and respond to one stimulus by substituting another, more powerful stimulus, then fading that stimulus gradually so that perception of the subtler stimulus builds. For example, a student may have difficulty finding and approaching a tree trunk. The canopy of the branches can obscure the trunk. It may help to place a loud radio (set to produce only static or white noise) at the trunk, and have the student approach that at first. The student gains experience orienting toward and approaching a sound source. At first, the student is reliant on the sound source. The sound source is then reduced gradually in volume. Without realizing it, as if by magic, the nervous system gradually keys into the echo stimulus as if the radio were still on. It's a kind of neurological bait and switch, a way of tricking the brain into thinking it's responding to one stimulus, when it has really learned to adapt to, register and respond to another.

Attention Stabilization

Due to over use of passive forms of external guidance and direction, many students may not be accustomed to placing their motor system under the self-directed guidance of their auditory system. Also, congenitally blind children often tend to focus their attention into their heads, or on to matters of cognition other than the physical environment, such as the social environment. They often focus on what we call “in the head” environment, or focus on social engagement with a high degree of linguistic rather than spatial processing.

For example, when asked to locate an object or to move in a circle around one, students may begin to meander near or around the object, eventually wandering away from it without realizing it. They may do this even when they know where the object is. It often helps simply to bring the student’s attention back by asking, “where is that pole?” Or, it may help to instruct them to “stop, face it, now go for it.” A teacher helping the student stop and refocus before they get too far off track can actually help them to adopt good perceptual habits of presence of mind, attentiveness, maintenance of conscious awareness, and self-trust. Usually, this is best achieved by asking strategic questions or dropping thought provoking

hints, rather than by giving directives, descriptions, or explanations.

Another possible approach is to place a bean bag on each shoulder of the student or perhaps the top of their head. This often facilitates students' ability to slow down and focus more intently. Rather than pose a distraction, the process of keeping the bean bags from falling seems to heighten attention globally perhaps by causing an automatic bio-feedback loop, which gently encourages attention. It may also keep those bouncy, jiggly children from bouncing and jiggling too much. Placing the bean bags in spare plastic produce bags may increase the affect, because it's easier to hear the bag when it falls. For students who are reluctant to do this, it could be made into a kind of game with the teacher wearing the bean bags as well and competing to see who can balance them for the longest time. Sometimes a teacher needs to show the student that he is willing to engage in whatever task or activity he is posing for the student to make it more of a shared task.

From Easy to More Challenging Tasks

Generally speaking, in terms of learning FlashSonar skills, it is easier to learn to perceive one target before many targets, simple targets before complex targets, and targets from a stationary perspective

before moving. Some students though may need to experience a real environment before being able to understand some of the stationary exercises.

In 2001, Hughes conducted research with people who were sighted under blindfold using an artificial sonar system. The participants had never seen or used the device before. The experiments were conducted in a room with spatial layouts the participants had not previously encountered. They were given no instruction on how to interpret the sounds and no objective feedback on their performance. The participants were asked to approach various apertures to judge whether the gap was sufficient for them to pass through or not. They could then approach the aperture and discover if they were able to pass through it.

These experiments demonstrated that “even naive participants are capable of utilization of important aspects of echoic stimulation for perceptual descriptions of spatial layout and locomotor guidance” (Hughes, 2001, p. 395). However the “oblique approaches to the apertures, separations in depth of the panels and panel rotations each had the effect of reducing the accuracy with which the passability judgments were made” (p. 395). This finding suggests that it would be easier for the learners

to determine the distance they could pass through without the added complicating factors until they were more developed in their echolocation skills.

In Hughes' research the participants "frequently judged apertures slightly smaller than themselves 50% of the time" (Hughes, 2001, p. 395) but they were given no training before taking part in the experiment. It may be that with more training they would have been able to interpret the echoes more accurately. It would be interesting to conduct this research again but with training added to monitor any possible advantages that FlashSonar training might provide.

Passing Through Gaps and Hearing Walls

Perhaps one of the most useful applications for FlashSonar is to judge whether a gap is wide enough for the individual to pass through or if an obstacle can be avoided, so that the individual who is blind can negotiate cluttered environments easily and gracefully. "The potential of structured echoic sound to be comparatively informative regarding object identities, location sizes and orientations in 3D space was suggested by Griffin's pioneering work" (Hughes, 2001, p. 372).

The skill seems to be acquired fairly quickly, especially when the obstacle to pass between is a wall, according to research by Russell (1999) and Hughes (2001). "The point at which participants judged the apertures passable and unpassable equally often was at intermediate values, close to actual body width" (Hughes, 2001, p. 387). The research showed that the participants found it easier to judge the width of the gap if they faced it straight on, than when they came at it from an angle. "The actual aperture size needed to be approximately 20 cm larger when one panel was rotated away for it to be judged equally passable as one rotated by the same amount toward the perceiver" (Hughes, 2001, p. 394). In terms of training it would be preferable to start the student with fairly large gaps and ones that they can directly face. The participants in Hughes' study used echolocation for just a few hours; yet they were able within that short time frame to start judging distances accurately.

In a study by Rojas et al. (2010) using sighted participants, "most of the participants were able to detect walls after two sessions of training of one hour of duration each or less. After two hours of training all the participants were able to detect the walls and were able to stop just 0.5 [meters] away from them" (p. 1073).

When crossing a room diagonally, individuals who are blind may describe being able to hear both walls simultaneously—the one receding behind them and the one approaching in front of them. Hughes (2001) discovered that “a clear shift in frequency can be observed as echoes returning from the nearer wall are replaced by those from the further wall, and for a brief period, echoes at these separate frequencies are both present” (p. 380). This information enables an individual using echolocation to manage more advanced activities, such as traveling from one corner to the other in a room or larger space, across the diagonal (see Chapter Five for a training exercise).

Generating the Click

The ability to use a natural echo signal in echolocation is important because it is always readily available, does not use batteries and does not use distracting noises that would draw attention to the person (Carlson-Smith & Wiener, 1996).

Begin by informing the student that the signal used will be dictated by the environment and activity. It need not be produced any louder or more rapidly than necessary. Ask the student to make the softest click she can, then the loudest. Throughout the training you may need to remind the student to adjust her click according to need. Many students will

find themselves clicking more rapidly than needed. Remind the student that we want “relaxed clicking”, to “breathe between clicks.”

Ask the student to make a clicking noise; many students can make a suitable click without much training. If a student struggles, it is worth the teacher demonstrating the signal to see if the student can copy by example. For a child, the teacher can teach parents and siblings how to make the sound if the student can’t, and again the student may learn from the example. It may help to use a popsicle stick, tongue depressor, or spoon to show the students where to place their tongue. Enlisting the help of a speech and language therapist may also help, if one is available.

A click to avoid is what is referred to as the “cluck click.” This is a double click in which the tip of the tongue slaps against the bottom of the mouth. This muddies up the signal and extends the signal so that it masks the returning echo. The most effective click is a sharp, single click similar to a finger snap or the pop of chewing gum. For students who struggle to make a click, the teacher can educate the student about tongue awareness. There are two parts of the tongue—the tip (the forward part used to make sounds like “t,” “d,” and “l”, and the blade of the

tongue, used to make sounds like “k”, “g,” and “ng” combination. The teacher asks the student to make these sounds. The teacher could also have the student try to make a click sound while the student very gently presses a spoon beneath the tip of the tongue, just to provide some feedback to remind the tongue not to drop. Sometimes, this alone helps the student make a useful click.

It may help the student to imagine that a blob of peanut butter is stuck on the roof of the mouth, and he must use the blade of the tongue to pull the peanut butter away. The center of the tongue should be pressed to the roof of the mouth to create pressure, then pulled away quickly and forcefully, producing a distinct click. If a click is juicy or “sloppy” to begin with, it will usually tighten up or sharpen with a little time. If the student just can’t make any suitable click at first, have them produce a “ch ch” sound.

For the sake of simplicity, you can divide the clicks that students may use into two categories—back clicks (produced near the back of the mouth), and forward clicks (produced with the tip of the tongue near the front of the mouth). You can help the student position her tongue for back clicks by having them produce a “k” sound, as in “kite”, or a “g” sound, as in “go”, or a

“ng” sound, as in “kong”. Having the student repeat “king-kong” while keeping the tip of the tongue from dropping is often enough for them to discover a useful click. For those students inclined more toward a forward click, the tongue may similarly be brought into position with the words “judge” or “church”.

You may also ask students to smile when they click, as smiling helps to focus the acoustic energy outward, keeping it from being swallowed up or trapped within the mouth, and the result is a pleasantly bright click.

Developing a sharp, strong clap is also of use. In general, the clap should sound like a pop, not a slap or a hollow thud. An effective clap is produced by misaligning the hands slightly as they are slammed together - striking the fingers of one hand against the palm of the other, rather than bringing the two palms together. Children as young as six can produce very sharp claps. Some children will complain of discomfort in the hands, but this usually results from lack of use of the hands due to others over-catering to the child who is blind or isolating him from age appropriate tasks and activities. The child who is blind also may not engage in rigorous activities which develop hand strength.

The click mirror exercise or click shaping

This exercise helps students to shape their click to become stronger and sharper. Again, the more clearly and distinctly the student speaks to the environment, the more clearly it responds. You will need a large, blank wall with at least 30 to 50 meters of open space around it. It is okay if the wall has windows or other ornamentation, but it is best, if manageable, that there be little or nothing else in the space between the student and the wall. It starts with the student clicking at the wall from about 16 feet away. Have the student listen to the wall's reflection of his click. You want the click to be reflected back clearly and distinctly so that the student is very sure he can hear it. Sometimes, it may help to move further away until the student says he can hear it clearly. Once he can hear the reflection clearly, then have the student move 2 or 3 yards further away, resume clicking at the wall, and concentrate on "inviting" the wall to speak back clearly and distinctly. Once student and instructor are satisfied, a few more yards are added to the distance between student and wall, while the student concentrates on keeping the wall's answers clear and distinct. The distance is increased until the student can no longer hear the wall. This distance is marked as the signal distance threshold, and may be revisited later to increase the distance still further. In this manner, the wall serves as a "mirror" to help the

student shape his click, just as a conventional mirror is used to reflect what we are doing back to us. Men may use a mirror to shave. Women may use a mirror to apply makeup. A student who is blind may similarly use an acoustically reflective surface to “mirror back” the sound of his click, so that he may refine it. This exercise can also be used to hone one’s clap in a similar way, but the distances may be increased ten-fold.

Learning the Click

Many students will complain of dry mouth or tongue soreness in the beginning stages of clicking. Adults, for whatever reason, are much more likely to express discomfort than children. It is useful to keep the mouth hydrated. However this discomfort passes quickly, usually within a day of regular use. The tongue is one of the strongest muscles in the human body. As clicking becomes a regular practice, the tongue is no more likely to tire from it than it would from talking or eating.

Also, some students complain that they struggle to maintain click sharpness or consistency. Again, this usually passes quickly with regular practice, and can be assisted with the click mirror exercise discussed above.

Research where novices generated tongue clicks and then listened to the echoes showed that the “subjects improved during training not only in terms of the temporal precision of their auditory analysis, but more importantly in terms of shaping their tongue click to optimally serve the echo-acoustic task” (Schornich et al., 2012, p. 677). This demonstrates that the tongue click can be self-modified by the learner to improve echolocation performance. “Most subjects produced relatively loud, short, broadband tongue clicks” (p. 681) with “durations between 3 and 15ms and sound levels between 60 and 108 dB” (p. 679).

Ultimately, all science aside, the best sonar signal is one that a student will use and which does not cause undue disturbance to others. Also, certain signals may be more suitable for certain applications. Finger snaps may work for some students who struggle with clicking. There may be no general advantages over clicking, unless a student’s finger snap is more powerful or versatile than his click. However, it does require the use of one hand, and it is less directional than clicking, so it may not be so easily focused.

Cane taps may also be used. However, like finger snaps, they are less directional, and therefore less focusable. Also, the acoustic energy is not well aligned with the ears, and is partly absorbed or scattered by

the ground's surface. Of greater concern though is the fact that cane taps are not consistent. The power of a self-produced signal is its consistency, which lends itself to allowing the brain to attune to that signal. The acoustics of cane taps is dependent on the surfaces beneath the cane, which introduce variables outside the control of the user. Grass, carpet, rubber, and soil produce almost no usable signal. Wood or linoleum may produce a marginal, thudding kind of signal. And, in any event, not everyone uses a tap-style cane technique. If a cane is to be used in this way Schenkman and Jansson (1986) discovered that canes giving the most acoustical information (about surfaces of concrete, sand, linoleum, and asphalt) were those constructed of fewer pieces and were longer. Using a cane to produce an echo signal is not a technique that WAFTB teaches, as they have found it generally inadequate and inefficient.

Footsteps have the advantage of always being present in some form, assuming that shoes of some sort are worn. Some blind people have been known to wear taps on their shoes or shoes with hard soles to produce clearer signals with each step. However, footsteps share all the same drawbacks as cane taps, with the possible exception of some flip-flop sandals. The use of the rhythmic and steady slapping of flip-flops against the heels has been observed, and is

independent of surface type. However, flip-flops may not serve as the shoe of choice for all circumstances.

Handheld clickers may be used for certain circumstances. The clicker should be cupped in the hand, button facing outward and forward, and activated by the thumb. Clickers should be sounded either at waist level or above the head, never near the ears. At least 1 second should span between press and release of the button. Clickers should never be activated rapidly, and should only be used out of doors or in open environments.

For very beginning exercises, some students may benefit from making a continuous “shhhh” sound, or just using their voice. Some students may not have the breath support to make long “shhhh” sounds. If this is the case, a transistor radio tuned off station may help. This should be held just below the student’s chin.

One of the easiest demonstrations of echolocation is based on the ripple-noise pitch change. For objects that are closer to the student than approximately 2.2 yards (2 meters), an approaching surface will have a noticeable change in pitch as moves away or towards the student. The student can make a ‘shush’ noise and then use their hand (or object such as a magazine) as

an approaching and retreating surface and listen for the change in pitch.

Some people have raised concerns that the click may be difficult to learn, but these authors have not observed this. Out of six workshops conducted at Birmingham City University involving a total of ten teenaged and adult students who were blind, every student was able to produce a satisfactory click with little or no training. Out of over 1,000 students who were blind with whom Daniel Kish and his associates have worked, less than half a dozen above nursery school age were unable to produce a satisfactory click during the training period. In one such case, a speech therapist among the workshop attendees began working with the student, and expressed that she felt she could help him. On another occasion, the boy took to using a handheld multi-clicker, which allows adjustment of the click volume. On a third occasion, the student had a palatal deformity, but he compensated by producing a loud "k" sound.

By way of example of how simple it is for most students, on one occasion, Daniel was working with three high school students in Australia. One of the students exhibited some abnormalities in his articulation, and also evidenced some learning disabilities that required additional time and attention.

Daniel had introduced the click and tongue awareness, but the boy continued to struggle with a juicy, sloppy, cluck click. Daniel presented him with a spoon to help him train the tip of his tongue not to drop, but progress was slow. Daniel resolved to move on to the other two students, and return to the boy as time permitted with other exercises. While Daniel worked with the others, the boy took initiative to continue practicing on his own with the spoon. About 5 minutes later, as Daniel was wrapping up with the other two, the boy exclaimed "I got it! Listen!" Sure enough, the boy was producing a brilliantly sharp click.

Using the Click

The amount of time between self-generated clicks is important. The second click must not be within a few milliseconds of the first otherwise it is perceptually integrated with the first and can mask returning echoes. However "when the object to be echolocated is a distant one there may be some advantage to having a slow repetition rate so that the range determination might more easily be accomplished" (Welch, 1964, p. 6). To locate a building in a large shopping mall parking lot, a student may want to try clapping his hands but with a few seconds break between the claps. This compares interestingly with bats as they use two types of echolocation; frequency pulses and

frequency modulated pulses. Some bats use both types and some can alter their strategy dependent on their task (Long, 2009). Similarly, human echolocators may vary the repetition rate and volume of their clicks depending on the circumstances. Fast movement or movement in congested places where there is a lot of motion may necessitate more frequent clicking in order to maintain spatial updating. Quiet environments, such as a work place or library are best addressed with quiet clicks, as loud clicks may be disturbing, but more to the point, may over-saturate the user with more information than is necessary or desired. In contrast, noisy environments, such as transit stations, shopping centers, or urban environments, may necessitate louder clicks so as to “pierce” the noise with an echo signal that is sufficiently strong to elicit the echo information that is needed. By this method and with proper scanning, an echolocator can maintain awareness of objects and features in almost any condition.

An analysis of the tongue click used by two expert echolocators showed that the expert who had a greater sensitivity to echoes had a different frequency range (and more distinct tones) in his click. The researchers speculate that his ability to differentiate echoes more effectively may be due to “his greater control of the spectral content of his click” (Smith

& Baker, 2012, p. 103). The sound pattern of the tongue clicks is very different from conventional radar waveforms, "and it might be safely concluded that it is likely that the brain is processing the data in a very different way from a conventional radar system. Given the structure of the auditory tract, the 'borrowing' of parts of the brain normally used for visual processing and the multiple parallel processing paths often employed in the mammalian brain and the ability of humans to discriminate, it comes as no surprise that additional processing is at play" (Smith & Baker, 2012, p. 103).

During an echolocation experiment, all six subjects who were sighted were "allowed to choose any kind of vocalization, as long as they produced it with the mouth" (Wallmeier & Wiegrebe, 2014, p. 3). "During training, subjects improved both the precision of their auditory analysis and, in the echolocation experiment, optimized their vocalization for the echo-acoustic task. Analyzing changes of call parameters over time revealed that after less than five training sessions, all subjects ended up emitting short broadband clicks and continued to do so during the whole acquisition" (p. 4). Feedback was given by way of an audio sound. This research demonstrates that a tongue click can be evolved, refined and used effectively by sighted adults to echolocate objects.

Hand claps, for example, may elicit echoes from distances ten times that of a tongue click, although they tend to yield little detail, and they require use of both hands. Still, one can use them to get a big picture layout of large surfaces and structures all around a large environment, such as a park, school campus, city square, or courtyard. One can also use them to isolate and then direct one's course toward a specific structure or surface of interest across hundreds of meters. It is worth developing a clear, sharp clap for this purpose.

Shape/Texture Differentiation

DeLong, Au, Harley, and Roitblat (2007a) wanted to try and find out more about how dolphins echolocated; because the dolphins could not communicate how they used echolocation, these researchers used human participants and asked them how they echolocated. "The cue reported most frequently by the participants . . . was the pattern of change in loudness, pitch and timbre across the echo train" (p. 311). A very rough guide seems to be that objects that varied in size used overall loudness, those that varied in material and texture used timbre, loudness and pitch, and a change in loudness or pitch determined the object shape. "Human listeners report pitch and timbre and to a lesser extent duration and amplitude as material discrimination cues" (DeLong, Au, & Stamper, 2007, p. 616).

Kunkler-Peck and Turvey (2000) demonstrated that suspended thin plates hit with a steel pendulum in circular, triangular and rectangular form are distinguishable by individuals with normal hearing. Individuals in their study were also able to distinguish among materials including steel, Plexiglas® acrylic sheet, and wood using echolocation. They “found that listeners were able to identify the shapes of thin plates—circular versus triangular versus rectangular— independent of their material composition” (p. 292).

More recently, DeLong et al. (2007) have demonstrated that humans can discriminate between hollow cylinders and spheres made of steel, aluminum, brass, nylon, and glass based on reflected echoes. They suggest that the timbral characteristics, duration of echo and pitch give sufficient information to allow for determination of type of material and shape. “Distance changes these acoustic dimensions because as sound travels through air it: a) loses overall energy; b) loses energy selectively across the frequency spectrum; and c) travels at a finite speed” (Rosenblum et al., 2000, p. 4).

Interpretation and use of sound patterns determines the effectiveness of echolocation for the user, as well as its suitability to a broad range of applications. An experiment using artificial networks to investigate

sound cues for echolocation discovered that “frequency, amplitude and combinations of those features within an echo train can distinguish some objects” (Wisniewski, DeLong, Heberle, & Mercado, 2013, p. 8). “As a target with a coarse surface reflects less energy than a target with a finer surface, differences in intensity could be a simple cue allowing structure discrimination” (Simon et al., 2014, p. 6).

Rojas et al. (2012) were interested to find out whether it was possible for a human echolocator to be able to identify three different wood veneers of maple, chestnut, and sycamore from each other. The research demonstrated that “a priori human beings would have enough acoustical clues to distinguish several different wood surfaces by means of echolocation, mainly by timbral differences below 3000Hz” (p. 5). However, the researchers do acknowledge that to do so in practice may be very difficult and require a lot of training. What may be possible under controlled conditions may not be practical under real life, day to day conditions. However, it is useful to know what the possibilities are, so that the practicalities can be better understood.

Garcia, Roozen, and Glorieux (2013) used a spherical model of a human head and simulated how one’s own voice travelled from the mouth to a reflected

object then to the ears. The frequencies studied were between 100Hz to 8Hz. "Frequencies above 2Hz provide information for localization of an object" (p. 253) whereas the "low frequency range (below 2Hz) does not provide any useful cues for object detection-even though the absence of energy in this frequency range might be a cue in itself for object identification" (p. 258).

Rowan et al. (2013) have carried out research using participants who were sighted and blinded with a virtual auditory space to try to clarify the effect of distance and orientation of the virtual object when it is found using echolocation. The research focused on the information in the echo rather than head movement. Even though this research used a virtual environment as opposed to a real environment, the researchers state "there is reassuring consistency between the results of our studies using virtual objects with those of previous studies using 'real' objects in similar conditions" (p. 63). When objects were presented to the listener in flat orientation, the participants could only locate the object at around a distance of approximately 2 yards (1.8 meters), whereas if the object was presented at an angle the majority of participants could locate the object from about 3.3 yards (3 meters). This is consistent with the fact that some echolocators can find objects at greater distances

while head scanning. "It may be that a composite strategy comprising different phases could be applied to human echolocation, reminiscent of the search and approach phases encountered in the rich repertoire of the bat echolocation strategies" (p. 63). Rowan et al. (2013) suggest that echolocation may be more effective when the listener uses emissions that they were familiar with or had more control over, which would happen in real environments but not in the virtual reality used in their experiments.

Language and Communication

Teachers may need to work with students on developing a language to express and convey their experiences both to themselves and to others. People who are sighted love to talk about what they see. A rich, visual language has developed that people who can see use to communicate. Thus, people who are sighted can convey their own images to others by this rich, visual language. Persons who are blind are often left out of this communication process. Society tends not to support development and use of nonvisual descriptors. Nonvisual descriptors may mystify people who are sighted or may be misunderstood. For example, when one of our Scottish teenaged students was asked if he was aware of using echolocation (after we had explained what this was), he said (in a delightful Scottish accent we cannot

represent here, “Well, I sometimes think I can hear walls, but my mum says that’s stupid.” We often hear similar stories. So, part of our approach is to help students develop a vocabulary which they can use to communicate their experiences to others in a manner that may be better accepted and understood.

Considerations

Cane users

For cane users, it is the authors’ experience that the FlashSonar program is most effective when conducted with the student using a cane. It is true that some students may find some of the exercises easier without the cane, but it seems that for most students the payoff is usually greater and speedier if the cane is used from the beginning. It can be quite frustrating for both student and teacher to have students perform the exercises well without the cane, only to have their hard earned performance fall apart when the cane is re-introduced. Use of the cane facilitates self directed discovery and, for most students, there is much to be said about the stimulating affects of self directed discovery on perceptual development. Some students after receiving FlashSonar training actually begin to appreciate their cane more as they understand how the cane will protect their lower body while above knee height obstacles can be detected by using echolocation.

Dog guide handlers

FlashSonar can greatly complement and facilitate work with a dog guide. One of the advantages of a dog guide is that the dog may be able to guide the team very quickly and efficiently along familiar routes while generally maintaining the handler's safety. One disadvantage is that the dog, by virtue of its job to keep the handler safe, actively isolates the handler from most tactual information, leaving the handler potentially quite disconnected from the environment. FlashSonar can reestablish this connection by making information from the environment available to the handler. Using this information, a handler may explore and train the dog in new territory, or better direct the dog through known territory.

There is a distinction between guiding and leading. A dog has neither the brain structure nor the requisite knowledge of human culture and society to be an effective leader of a human being, blind or otherwise. He may have the perceptual faculties to guide a person who is blind safely and quickly through an environment, but the job of leader must fall to the human.

Canine psychology is instinctively based on a culture of firmly established pack hierarchy. The dog must either defer to a leader or assume the role of leader.

Some people who are blind may be ill-prepared for this leadership position in their personality, knowledge, and/or their mobility capacity. FlashSonar is a perceptual strategy that can help restore the human to his rightful and necessary role as leader, thus maintaining the effective functioning and integrity of a guide team.

Hearing loss

It is not necessary to have normal hearing to be able to benefit from using FlashSonar. In fact, FlashSonar may be even more important for those with hearing loss because the use of active echo signals increases echo detection, especially under noisy conditions to which people with hearing loss may be particularly susceptible. Ashmead et al. (1998) caution that "O&M instructors should not discount the residual hearing abilities of persons with hearing losses" (p. 8) as much of hearing loss occurs in the high frequency range yet it is the low frequency sounds that may be sufficient to enable someone to walk parallel to a wall, find corners, or to locate an opening in a corridor. Wiener et al. (2010) agree, stating that "for purpose of orientation using ambient sound, the lower frequencies take on more importance" (p. 136). From their research Carlson-Smith & Wiener (1996) found that "the hearing abilities and sound cues in the lower frequency range are sufficient for echolocation

and that high-frequency hearing and sound cues in the range of 10,000 -12,000 Hz are not necessary for this perception” (p. 28). They suggest that those with hearing loss could use echolocation if “at least some portion of the lower and middle frequency range, from approximately 200 to 2,000Hz is sufficiently audible and small changes in frequency and intensity can be detected” (p. 28). This comment is then justified by the explanation that the higher range of frequencies may be useful for echolocation but were “not required for echolocation to be accomplished—at least they were not in this test environment” (p. 28). In this research the tasks were both related to locating large objects (either a 4 foot by 7 foot board or a doorway). Therefore, it is possible that high frequency hearing is not required to locate large obstacles or internal doorways.

Mills (1958) demonstrated that precision for identifying sound location was best for frequencies between 200 and 1000Hz. Kohler (1964) concluded that an individual’s ability to detect variation in sound was more important than his or her absolute threshold of hearing. Carlson-Smith and Wiener (1996) acknowledge that “some people with hearing loss may be successful in some environments but not in others” (p. 28). It is likely that there may however be tasks and functions with someone with high

frequency loss will find more difficult (or impossible) such as distinguishing between a hedge and a fence, or locating small objects.

Even if an individual has severe hearing loss in one ear, FlashSonar may still be useful. Although binaural hearing is preferential to judge the direction and distance of sound (Whetnall, 1964), monaural hearing still provides some localization information. Wright & Carhart (1960) found that some individuals were able to localize sound monaurally. Indeed Supa, Cotzin, & Dallenback (1944) concluded that “monaural stimulation is a sufficient condition for the perception of obstacles” (p. 180). Perrott and Elfner (1968) agreed, although they noted that sound localization is primarily binaural, monaural localization is possible especially if the sound source is persistent and the head can be moved. Miura et al. (2008) found that “binaural hearing tends to be higher in the localization certainty at 10cm (approximately 4 inches) in obstacle width than monaural hearing under the condition with head rotation, whereas, under the condition without head rotation, variation of localization is more considerable in monaural hearing” (p. 5755). “There is some evidence that people with long-term blindness can learn to use monaural clues more effectively than sighted listeners for horizontal sound-source localization, and thus possibly for object localization” (Rowan, Papadopoulos, Edwards, & Allen, 2015, p. 38).

The reference to head movement can be directly related to bats who were shown to use “sequential scanning of obstacles (right and left of the net hole) and prey in all trials” (Surlykke et al., 2009, p. 1015) which has parallels with saccadic eye movements used to scan a scene by persons who can see. “The big brown bat sequentially samples the environment with its sonar vocalizations, adjusting the direction and distance of its acoustic gaze, in a manner analogous to sequential visual fixations of objects within a complex visual scene” (Surlykke et al., 2009, p. 1018). When examining bats ability to hear with one ear occluded, Griffin discovered “one ear suffices to warn a bat of the proximity of a large obstacle, but accurate judgment of the space between two wires requires binaural localization of the sound reflected from the obstacles” (Griffin, 1958, p. 73). This suggests that bats could perform some echolocation tasks with monaural hearing but require binaural hearing for more complex tasks.

“There has been no research that relates categories of hearing loss with the ability to interpret environmental sounds for orientation and mobility” (Wiener et al., 2010, part I, p. 103). However the teacher may need to take into account that those with conductive hearing loss are more likely to be free from noise distortion. Those with sensorineural loss

are prone to distortion even with amplification. If a student has a hearing loss, the teacher should involve their audiologist so that the type of loss can be fully understood. It may also be necessary for the teacher to educate the audiologist (if there is one involved) on the need for spatial hearing in blind clients, as most audiologists focus primarily on speech discrimination, with little attention to or understanding of the use of spatial hearing by blind people. Such education delivered to the audiologist will help ensure that prescription of hearing aids where necessary will properly take into account the use of spatial hearing. Otherwise, the hearing aids could be designed or programmed in such a fashion to suppress or complicate spatial information. It is also important to note that some people with hearing aids can use FlashSonar very effectively, provided that the hearing aids are prescribed and adjusted with spatial hearing in mind.

Weather and climate

Weather can strongly effect how sounds travel in the environment. Wind and temperature can affect how far a sound carries. Wiener et al. (2010) suggest that with regards to temperature “one may be able to hear sounds at greater distances when crossing streets in the morning than when crossing streets at midday” (Part I, p. 92). It is therefore important that the

student is exposed to different weather conditions during his FlashSonar training, but the more difficult conditions (such as high winds and heavy rain) may be more appropriate once the student is more advanced in his learning. High wind can mask echoes so that they can be difficult to hear, requiring louder self-generated sounds and more scanning.

It is also important to remember to refrain as much as possible from smothering a student's hearing ability in cold weather with excessive head or ear coverings. Anything covering or hanging over the ears will diminish or distort hearing capacity. It is possible to adapt to this to a degree, but this will require experience. Also, wide brimmed hats or caps commonly worn in sunny climates will cause a distorting affect to the use of echoes. The hat brim should be oriented upward as much as possible so as not to cover the face. These distortions are not subtle or inconsequential, even though new students may not be aware of how much hats or other protective garments may occlude hearing. A very useful trick for protecting the ears in the cold is to cover just the upper tips. It is these that are most exposed to and susceptible to the cold. If these are covered, hearing is not much occluded and the ear can survive a much lower temperature. It is worth keeping in mind that, no matter how low the temperature, we would never

imagine occluding the eyes by covering them. Why cover the ears?

It has also been our experience that FlashSonar can be used to improve orientation in inclement weather. While it is true that snow can muffle sounds and has been referred to it as “the blind man’s fog” (Sullivan & Gill, 1989), hard or solid surfaces become that much more pronounced or accented by FlashSonar in the snow. Any solid surfaces—trees, buildings, posts, or parked vehicles—stand out as points of reference to establish and maintain orientation. For example, if the sidewalk or footpath is covered in snow such that it becomes difficult to determine where the footpath is, one can use FlashSonar to detect tree lines, building lines, and open spaces clearly to maintain one’s direction.

Persons with low vision

With regard to low vision, WAFTB does not make a regular practice of blindfolding children. Low vision, as a component of the perceptual system, deserves and warrants attention, often very specific attention. There are often situations when degrees or quality of vision simply require integration of nonvisual skills and perceptions in order to recover and enhance a quality of self directed achievement comparable to one’s peers. What is called the “visual system”

occupies about 40% of the brain, and seems to be the default system for spatial processing. What we call the “visual system” is really an imaging system that can be recruited to construct dynamic, operational images from nonvisual inputs. This can happen naturally without specialized instruction or therapy, but for many reasons, it often does require assistance and support to do so. Even though the imaging system can and does integrate multisensory input for image construction, the nature of its neurology tends to favor visual input, and that is usually where the imaging system defaults. This may not be a problem for standard, day to day functioning for persons who can see, but it can be a real problem for one whose degree or quality of visual input isn’t up to the task, isn’t quite enough to make the wheels turn properly, does not provide quite enough data to allow the computer to process properly. Now, the imaging system may really need some help to construct these images, and this help will probably come from increasing support from nonvisual perception and skill.

However, since the imaging system tends to default to visual input, it may be necessary to isolate some or all of the nonvisual skills and perceptual training from visual input. FlashSonar is one example of a perceptual process that needs to be isolated

from visual input in order to give it any chance of developing. Students simply do not develop FlashSonar when they have the visual system grabbing at visual information, often erroneously, thereby usurping, short-circuiting, or disrupting the development of other areas of integrated perception. It may and often does become prudent to offer experiences of visual occlusion during portions of the perceptual training. These spans of visual occlusion may provide opportunities for nonvisual perceptual capacities to take hold and grow, where they might otherwise not.

Visual functioning generally interferes with sonar information as it tends to dominate perceptual attention (for better or worse). However, it is surprising how motivated many students who are partially sighted can be to learn FlashSonar. They often know just how dependent they are on the little vision they have and how fragile that dependency is. When the lights go down, they go down hard on these students.

FlashSonar seems to be particularly helpful to students who have visual field loss, as students can learn to use it to fill in these gaps. For these students, FlashSonar will often serve to allow the students to register objects or features outside their visual field.

Then, they may bring their vision to bear on the target to gather more information. This method can reduce the need for constant visual scanning.

For students who are partially sighted, we find that it seems more effective to isolate, and then give specific attention to integrating. During auditory image training, the visual system is literally adapting to process nonvisual information to extract spatial images. For this to happen, the visual system seems to need a period of disconnect from the eyes. It seems to be hard wired to receive and process information from the eyes by default, so it needs to be insulated from the eyes in order to foster new connections and operative pathways for nonvisual integration and image construction.

Since students who are partially sighted are using their vision most of the time between lessons, they tend to learn auditory imaging more slowly. However, they sometimes have an advantage in that they may have visual images to draw upon in learning how to image nonvisually. In other words, the imaging system seems to be able to apply previous visual experience to developing a nonvisual imaging process.

Consider the following example. Daniel Kish was working with a 14-year-old boy named Brian who

had been blind for about one year. Daniel began by having Brian show Daniel around his neighborhood in which he'd grown up. Daniel instructed Brian to call to mind everything around him as vividly as he could remember. "Take me on a tour, and describe everything as if you were seeing it." This process seemed to stimulate his receptivity to the opening of nonvisual channels, and the authors posit that this may be true for many others.

Students with light perception or visual memories often confuse sonar images with visual images. They seem to "see" what they hear. They may say: "I can still see the wall," even under a blindfold. The brain can interpret sonar sensation in a visual reference—causing crosstalk between the sensory channels. This is called cross modal processing, and may also be referred to as synesthesia. With the exception of very young children, it may be helpful to students to explain to them the difference between what they see and what they hear. The strategic use of blindfolds and isolating headphones or earplugs can be helpful here.

For example, 12-year-old Juan, one of Daniel's first students, retained a small amount of residual vision. The instructional materials in those days consisted of transparent Plexiglas® panels which could not

be reliably seen by students with small amounts of residual vision. However, Juan insisted he could still see the panels, even under blindfold, and concluded that the FlashSonar lessons were not of use to him. Then, Daniel placed him in headphones, and piped in white noise at a moderate volume. At was at that point Juan was startled to notice that he now saw nothing. He became aware that his vision was not the primary source of information for him and redoubled his efforts to complete his FlashSonar training.

Some people with partial vision will strain their eyes. But when their use of echoes is brought to their attention and refined, they may find it less necessary to strain. This is especially beneficial to those with fragile eye conditions.

Our practice under such circumstances is to offer occlusion about 75% of the time, more or less, depending on many factors. The isolation phases allow nonvisual skills to take root; and the integration phases allow opportunity for multi-sensory processing to develop into truly integrated perception. If the isolation phases are denied the student, the nonvisual capacities that may indeed be necessary to support self directed achievement may not take root and grow. Likewise, if the integration phases are denied the student, then the integration process may not

reach critical mass, as it were, and never quite come together.

WAFTB does not force occlusion on students. If you force occlusion on children (or adults), you will lose all hope of developing rapport, and instructional efficacy goes out the window. However, you can offer the student occlusion opportunities as a potentially invaluable benefit to perceptual development. WAFTB has developed many ways to support students to at least give occlusion training a fair try. Many older children like it, and younger children generally adapt to it quickly.

WAFTB tends to use sunglasses blocked off in various ways because students often like them and will accept them, and because they are generally more comfortable than blindfolds. Blindfolds can feel quite stifling and can be uncomfortable in the heat and humidity. Although wrap-around sunglasses may be used, a bit of extraneous light sifting occasionally in from the sides is not usually an issue. There is no reason to turn the lights completely out for all students all the time, especially when the likelihood of any given student going totally blind is remote. Should this be a likely prognosis for a student, then encourage wrap-around sunglasses or even industrial safety goggles. Consider providing several options for

the student to choose from, or turn it into a lesson to go out and find a pair that the student likes.

WAFTB offers the following suggestions for using occlusion:

- A. Diffused Occlusion: This is the most common method that WAFTB uses. There are several pairs of sunglasses and the student chooses which one they like. Often, offering a choice just makes the whole experience more intriguing and palatable, and perhaps the student places some stock in fashion. The most efficient for occlusion purpose are the ones with big lenses or the wrap around kind. The back is blocked with criss-crossed, thin strips of tape to allow light into the student's eyes, but to break up the image enough so that it can't be useful. This may take a little trial and error, since many students with very low vision are quite good at processing visual fragments. What may be incomprehensible to a person who is fully sighted looking through diffused occlusion may still make some sense to someone accustomed to using very little vision. As long as there is some light coming in, the student, even very young students, will often accept occlusion, and even consider it a game.

Students with very low vision often hardly seem to notice that they now can't use their vision anymore and may adapt very quickly to nonvisual development. Some will say that it's less confusing and more relaxing to operate this way. Over time, add a little more tape here and there, until eventually the glasses are completely blocked out, and the student hardly even notices or cares. Again, this can be done in combination with nonoccluded training for integration purposes.

- B. A World of Color: Sunglasses are used again, perhaps totally blocked off, but with colored tape to make the world a little more interesting. You may call it "the world of pink", for children who like pink. Or, maybe have different glasses with different colors that the student may choose from for that day. Use solid colors, not patterns or anything busy.
- C. Occlude the Instructor: Students will often accept occlusion if the instructor is also willing to wear occlusion. As a rule, generally do not try to encourage students to do anything that you as an instructor would not be willing to do, or at least try yourself. For example, if you use bean bags to help support better posture,

then also carry the bean bags yourself. If the student feels better when the instructor wears occlusion along with him, why not, at least to start with. Boys like to play pirates, and the blindfold becomes an eye patch, except we use two eye patches, or we patch the eye that sees better.

- D. Darkened Environments: Conduct some lessons in a dark room, such as a gym, auditorium, or multipurpose room, but with all the lights turned off and windows shaded; or conduct lessons at night in a dark area. Obviously, lesson options may be limited under such conditions, but there's still much that can be done.

Children who are congenitally blind

When working with children who are congenitally blind, do not spend much time specifically on body concepts, backwards chaining (tactile landmarking), or focusing on the minutia of things like doors, chairs, or whatever else you might assume the child doesn't know "because they can't see it." Focus on child-directed (adult-facilitated) discovery.

Daniel writes: "My spatial movement skills as a boy were nearly impeccable, as were most of my gross

and fine motor skills. I could find my way around anywhere, and take anything apart and put it back together. Yet, I probably would have scored low on things like body concept, had there been anyone to assess such a thing. When I swung my arms hard enough as a five year old, my hands touched something behind me. I don't know how long it took me to figure out that my hands were just touching each other. Until the age of about six, I was absolutely convinced that the deep end of the pool had no bottom at all, and would have screaming fits if they tried to make me go there. I didn't know my right from my left till I was eight, and only then because I'd broken my right ring finger and had it splinted for a month. I couldn't tie my shoes till I was nine. I believed that there was a hill at every stop light. (Ever notice the car seems to pitch forward when you put on the brakes?) Yet, my travel and orientation skills were top notch even at three years old. In time, I just figured out through natural consequence how the world worked. Sure, there were things explained to me from time to time, but there was little in the way of formal concept instruction. I mostly figured things out by my own self-directed discovery, which I was highly encouraged and supported to do."

It often seems to be assumed a priori that children who are congenitally blind will have problems with

body and other spatial concepts. This is not so when the child who is blind has plenty of opportunity to explore and discover through his own self direction.

There are certain issues of a social nature that do tend to pertain to children who are congenitally blind which deserve discussion, together with some perception based, discovery strategies:

- A. Directed Reaching: For infants who are sighted, vision provides a feed forward sensory mechanism that allows the infant to anticipate what may be around it. Directed reaching occurs in response to visual input. It serves to allow the infant to investigate and better understand the visual stimuli. The visual stimuli also give the infant a sense of what to expect when reaching occurs, although what to expect needs to be learned and it is learned in part incidentally by watching others even before the infant actually succeeds in reaching. Vision, then, provides an anticipatory sense of what is to be reached, even before contact is made with the items being reached for.

With infants who are blind, vision is not present to serve as a feed forward sense allowing for anticipation and self direction.

Directed reaching or discovery reaching occurs quite variably among infants who are congenitally blind. Auditory stimuli and incidental, tactile encouragement can stimulate reaching for many blind infants, rather directed or discovery in nature. Both are useful in helping the infant develop his relationship with his world. Some infants who are blind can remain fiercely fearless and unwaveringly inquisitive.

However, for many other infants who are blind, auditory stimulation may not be enough to stimulate directed reaching. The lack of visual stimuli may cause many infants who are blind not to be motivated to reach for items in their surroundings. "The human spirit needs both encouragement and reinforcement to work and to play. For the young child, it is important that the efforts associated with movement be met with inner delight of intrinsic reward" (Anthony, 2010, para. 21). Also, a certain anxiety may be present about taking the initiative to reach into unknown space. Perhaps the infant just has an anxious personality, or perhaps he attempted to reach or move, only to be met with shocking or otherwise negative consequences, such as an unexpected

head bump, or coming abruptly into contact with an unpleasant stimulus that was not anticipated due to lack of visual preview. In such cases, some blind infants may learn to remain immobile, lest their hand, foot, or any other part of their body become implicated into unpleasant and up-setting circumstances. In such cases, many blind infants may simply remain quite still, just listening intently to what is around them, or retreating into their own head.

Some caregivers will manipulate the infant's body to interact with the environment. In essence, they are guiding the infant's reaching and exploration in the hopes of engaging him in the world. However, this process can quickly degenerate into a dependency of the infant on others to govern its movements through space, and can serve to establish anxious feelings about self directed reaching and movement. As discussed in Chapter Three, early cane training provides infants who are blind with a sense of being able to probe the environment around them. It serves a similar purpose of feed-forward anticipation as vision does for infants who are sighted.

To support directed reaching, it is helpful initially when bringing items to the infant to lightly touch the item to the infant's hand. This is just to stimulate interest in the item. Once the infant realizes that the item is approaching him, stop short of the infant so he will be encouraged to reach for it. Over time, one can hold the item further away to encourage a full reach. With items such as a pacifier or drinking cup, one can tap on the item, causing it to make a sound that will come to characterize the item, or one can attach a bell to the item.

- B. Walking and Cruising: Nearly all children cruise along furniture and other surfaces in the development of walking. Infants who are sighted hold on for support for as long as they need to, yet always striving to move away from support. Before long, they are walking unsupported. Infants who are blind cruise as a means of physical support, but this physical support may also come to serve to form the parameters that define their world. They may come to depend on physical surface as a means of maintaining a sense of direction and purpose, and this becomes their comfort and their understanding of the world. In such cases, movement through space becomes

linked to contact with physical surfaces, and the prospect of self guided movement apart from physical space may become unimaginable for many children who are congenitally blind.

As discussed in Chapter Three, one convention the authors would avoid is encouragement to trail, square off, or to rely heavily on tactile landmarking for navigation purposes. As noted, the infant who is blind is already in danger of developing a strong dependency on physical surfaces for his mobility. To further encourage this process is to establish it into a fixed pattern of dependency that becomes almost impossible to break. Instead encourage the infant to hear and respond to the echoes from large surfaces and features, such as walls, inside and outside corners, and openings. These are usually easy for the toddler who is blind to learn to hear, and doing so can quickly stimulate confidence of movement in free space. Encourage touch for exploration but not for navigation. This is discussed in more depth in Chapter Three.

- C. Infant Scaffolding: Infants who are sighted are generally scaffolded, supported, nurtured, encouraged, and celebrated to move through

their development into greater and greater competence and self efficacy. Parents note their first reach, first step, first jump, first throw. As the infant's competence improves, scaffolding is withdrawn, or modified to encourage more and more self efficacy.

Infants who are blind are also scaffolded, but the ongoing nature of it often progresses differently. The infant who is blind may not be driven in the same way to extend and expand competence and self efficacy. For an infant who is blind, scaffolding may easily become enabling to the extent that the infant comes to depend more, not less, on the scaffolding process. The infant's capacity to engage the environment becomes predicated on the facilitation by others. In this case, scaffolding is not withdrawn reciprocally to developing competence, so competence may not be driven to develop. The result is a cycle of dependency conditioning or learned helplessness in which the child who is blind becomes ever more dependent on others to govern his relationship with the world around him.

This process of conditioned dependency may be exacerbated in the case of medical fragility

common among infants who are congenitally blind. In this case, the infant really does require considerable care and nurturing, but the pattern of nurturing may become fixed and may not allow the infant to develop self efficacy. What started out as a genuine requirement of care lapses into a habit of enabling and dependency.

Here, the family may simply need some gentle, understanding counseling to ease up on the amount of scaffolding being given. The philosophy and approach outlined here tends to show immediate impact. It isn't a situation of "if you do these things in just this way, someday, you'll get results." The approach is very relaxed and flexible, and the results are often immediate. This provides the family sound impetus and encouragement to take a more progressively developmental approach with the child.

Working with very young children

The authors are not advocates of a strict training program that all students must follow. The teaching approach is much more focused upon perception or self discovery for the student, rather than a skills-based approach. Daniel Kish and his associates have

worked with infants as young as 7 months on cane and FlashSonar development. Scott (2008) reports children in Western Australia being introduced to the long cane from 14-18 months of age. Experiential lessons in discovery are most effective with children.

Dr. Steve Charles, Pediatric ophthalmologist and Director of the Charles Retina Institute, has noted evidence of echolocation development in totally blind infants with stage five retinal detachment. "I frequently observed that the patients made high pitched, chirping sounds while moving their heads back and forth in a rhythmic fashion while walking or crawling. This behavior was not observed when the patients were seated or lying down. Some observers believe that the high pitched sounds are a result of laryngeal scarring secondary to long-term endotracheal intubation in the neonatal care units. This explanation may explain the high pitch but fails to explain the chirping. The rhythmic, back and forth head motion noted in many patients blind at birth or as infants has been referred to as a "blindism" and attributed to fruitless visual searching, analogous to nystagmus. The author has a long-standing interest in neurobiology and neural plasticity stemming from a background in medicine, engineering and retinal electro-physiology. . . . It is the author's opinion that blind, young children adaptively learn to chirp

high pitch sounds and make head movements for navigational purposes. . . . It is likely that chirping combined with head motion can be taught to children and even adults to augment spontaneous learning of acoustic navigation” (Charles, 2004).

Asking children under the age of 6 or 7 to “listen for silent objects” may confuse them. If you approach the session as a “listening game” the children rarely challenge you. Eventually, they get the idea.

When introducing the clicking, many young children can already click even as young as 6 months. For those who cannot, young children will obviously not respond to explanations and didactic instruction. But they will emulate others. So, you can teach parents and perhaps older siblings how to click, and how to model the use of the click to locate objects. “We click, and we turn our heads to look for things.” Often, if the teacher clicks at an object, that can be sufficient stimulus to motivate a child to approach the object without any further instruction. Ultimately, the articulation of the click and its manner of application are learned much as a language is learned—through observation, emulation, and application.

Young children are more inclined to touch everything and have difficulty maintaining necessary

concentration. While touching is not a bad thing, remind children that they're doing "listening" games right now. Tell the children that when they talk to things around them by clicking, the objects will answer back.

Asking young students for verbal responses is generally much less effective than requiring a specific action from them. For example, rather than asking them to say where the target is, tell them to go to the target, or reach for it.

The teacher needs to engage children in what they like to do, which is usually play. "The quickest way to a child's heart is through fun" (Kish et al., 1998, p. 3) Work FlashSonar into these fun experiences. Essentially, you are stimulating the blind child's interest in the acoustic environment, and developing the idea that different sounds correspond to different qualities in the environment. Some examples of games to play are below.

- A. Find the Box: Very young toddlers or infants often like to crawl into or under things. Find a large container, maybe a storage container or an open cardboard box, and position the child near it. Entice the child by talking or making funny noises into it to get his attention. "See

how boomy it sounds. Rrrrummmm.” Then, see if you can get the child to find it himself. The first time should be easy because the child heard you talk into the box. But then, place the child at different distances and different angles, and encourage him to find it.

Stimulate the child’s interest in container play. Bring out several containers of different sizes and made of different materials. Play with him. Encourage him to drop different things into the containers to see what kinds of sounds they make. Drop the containers to hear what sounds they make. Sing or make noises into the containers. Such activities can serve to stimulate further interest in the auditory environment, just as visual games and bright colors can help stimulate visual development for sighted children. The child may develop favorites among the containers. Encourage him to give names to the containers. When he develops interest, hold a container near him, open side toward him, and encourage him to find it by making noises. In time, he will learn to find it by clicking.

- B. Auditory Space Recognition: Carry the child from room to room in his house, and encourage

him to learn what room he's in based on its sound characteristics. This is best done from the center of the room. Have him name the room. It doesn't necessarily matter what term he uses as long as it's consistent. But, it could be a good way to develop vocabulary.

Stimulate interest in crawling into or under things—under a table, into a cupboard, into very large boxes. You can make this into a sort of hide and seek game. Make noises with him. See if he takes interest in the auditory environment in or under these things. You can do this same thing when you enter various environments that have different sound characteristics, such as the elevator, an echoey hallway, or a large cathedral.

- C. Hide and Seek: For older children the teacher could set up a game of hide and seek. This works well for groups of children who are blind. The rules are that one child counts to a set number while the others hide. They must hide near, under, or behind something that is at least as big as they are. This means that they have to scan and search to find such objects. They may need some coaching at first to get the hang of it, but coaching should taper off as quickly as possible. Then, the seeker has

to “look” for objects of a certain size, and check if anyone is there. If the seeker has trouble, he can ask for a hint. The hiders must clap their hands once, and the seeker needs to keep track of where he heard the signals coming from. You can set a limit on how many hints the seeker can ask for.

- D. Ball Play: You can make a ball easily into an audible ball by placing it into a spare plastic grocery bag, and tying the handles together loosely around the ball. Then bounce the ball against the wall, and intercept it as it comes back. If the student has to chase after the ball, he must maintain echo awareness to return to a point within tossing distance from the wall, and square himself so the wall is in front. Otherwise, the ball will just continue to bounce away askew.
- E. Explorer: Here, the real goal to the lesson is to explore. The teacher must find an area or large building that he thinks will be of interest to the child. Children often like large buildings with lots of corridors, stairways, elevators, and rooms of different types. The student is to listen for differences in his surroundings and keep track of whether things sound familiar or

different. This exercise can also be performed in an intriguing outdoor area with a rich environment such as a park. If this park has a playground or nice trees to climb, so much the better.

- F. Hobbies: The teacher should find out the child's hobbies and integrate them into a lesson. For instance, if a student likes ice-skating, get him to ice skate around the rink while keeping track of the outer railing and listening for others around him. If he rides a bike or trike, the teacher can find a location with a very long wall that has some twists and turns in it. The teacher can then ask the student to cycle certain distances from the wall or away from it and then find it again.
- G. Counting: Many students like to count things. By using FlashSonar, students can count poles, parked cars, trees, bushes, or open doorways. To do this, they need to be able to detect and discriminate what the objects are. If they have a particular interests such as dinosaurs ask them to count the 'dinosaurs' they find.

Working with students with multiple challenges

The human brain fundamentally wants to learn and develop a relationship with its environment based on self-direction and comprehension. So fundamental is this drive that the brain must be extremely damaged or injured for this basic drive to be rendered inoperative. Consequently, it seems that no one is immune to learning self-direction. Ferrell (2007) states that not teaching orientation and mobility skills to a young child who is visually impaired with additional disabilities could “sentence a child with visual impairment to a lifetime of dependency”. Of primary importance to remember here is that, while there is overlap among the various systems in the brain – language, cognitive, perceptual, navigation, action, emotional, memory, social, etc.—these systems also operate distinctively from one another. Someone with specific language impairment, for example, can still evidence normal or extra-normal intelligence. Likewise, someone with a cognitive impairment can still develop and apply fully operative powers of perception, action, and navigation. Cognition isn’t the single key to learning. Learning is as much about all of the other brain systems—all fueled by motivation. Some students who are the most cognitively-impaired may be the most perceptive. Some students who are the most motor-impaired may be the ones who strive most toward purposeful action. Teachers will find it

necessary to step away from concepts about complex decisions or explanatory instruction or Socratic questioning. The activation in these situations occurs most from supported and motivated discovery.

Effective perception and navigation stand quite apart from effective judgment and responsibility. However the right to self direction and freedom comes first. So, the teacher must endeavor to provide all of the means, tools, and opportunities for students of any background or profile to gain their freedom. Then, deal with the behavioral and judgment factors as needed and appropriate.

The only type of disorder WAFTB has found so far to pose significant challenges to perceptual development and navigation is attentional deficits—when one's ability to direct and sustain one's attention strategically most strongly threatens to undermine the ability to perceive and process nonvisual stimuli, which may be fragmented, subtle, or intermittent. Yet, even for those with attentional deficits, motivation still pays off in the end.

Adults who are blind

Although the basic principles are pretty much the same for all students, there may be some differences working with adults who are recently blind, as

opposed to those who have been blind for a long time. For adults, research has shown that a neurological adaptation seems to take place, at least in part, over about 5 years (Juurmaa, 1969). This was discovered in research that showed that "obstacle perception correlated positively with an early onset of blindness" (Juurmaa, 1969, p81). For children, this adaptation may occur in only a year or two. It is as if the nonvisual channels have warmed up. However, these channels may be sluggish for adults who are recently blind. The situation may be somewhat reversed for these adults, as compared to people who are congenitally blind. In the former, the imaging system may be intact, craving and reaching for information, ready to assimilate it into a dynamic, operational image, as it was accustomed to doing with vision. Yet, the nonvisual channels through which to gather this information may not be adapted as yet.

On the other hand, people who are congenitally blind may have moderately active channels for conveying nonvisual information, more or less, but if the student is relatively dependent or restricted, the imaging systems may be under-developed causing a disruption in the construction of mental images from nonvisual information.

Consider the following example. During a 2-day workshop, Daniel Kish worked with a woman in her 30's who had lost her vision only a few months before. She was still quite emotional about it, but she was very motivated and enthusiastic. It was a struggle to foster development of even the basic skills. She didn't warm up during the panel exercises. For sensitization work, he had to clarify those stimuli by using actual walls and corners. She did better at these dynamic exercises than the stationary panel exercises. One of the exercises involved having her walk along a library book shelf, and stop where the shelves were empty which gave off a decidedly hollower sound. This was her first "aha!" moment. Her exclaiming "aha!" is what gave this technical term its name. Though she made huge progress during her work with Daniel, she did not reach the more advanced abilities. The audience of attendees asked two congenitally blind rehab counselors from among them if they wouldn't mind undergoing some training in the advanced skills, to which they graciously agreed. Here's where the imaging differences were demonstrated. When it came to auditory scene analysis, the congenitally blind adults were good at detecting and describing various stimuli, but couldn't articulate the scene. Whereas the recently blind woman, once she heard the others describe the stimuli, could verbally put names and meaning to the scene. For instance, when looking at

someone's front yard, the congenitally blind adults might say, "There's something broad, tall, and sparse immediately in front of me. Behind it, there seems to be something tall but not so broad, maybe broader near the top. It sounds more solid. Then, behind that and further away, there seems to be something large and very solid." But, they often couldn't hazard a guess as to what they were looking at from a "big picture" perspective.

The recently blind woman would then chime in and say, "Wouldn't this maybe be a fence with a tree behind it, and maybe someone's house behind that?"

For people who are recently blind, the full complement of abilities should be able to be learnt to a functional level of proficiency. This will likely take longer and require more diligence on the part of the student than if he had been a child. Juurmaa (1969) found that "none [of his adult subjects] who had been blind for less than five years possessed an obstacle sense to a statistically significant extent" (p. 83). Developing these nonvisual channels may need to be addressed with care so as not to discourage the student.

However, within a few hours, many students report and express an "aha!" moment in which the echoes flash at them. They often report this as visual flashes, shadows, dark curtains or actual visual imagery with

depth and contour, and sometimes become quite delighted at the experience. Here they are seeing something when they had resigned themselves to never seeing anything again.

Daniel Kish writes: "On another occasion, I worked with a woman in her 40's who had been blind about 5 years. Her progress was rapid during the first of our two days, although very taxing for her. At one point, I asked her to walk along side a wooden fence, keeping herself parallel with it. This exercise was complicated by the fact that the fence was about a meter and a half away from her, on the other side of rows of small trees and bushes in a planter. She did as instructed, until she reached a gap in the foliage and commented, "There's something strange about the fence. It seems to have gaps," and she began counting the gaps, Then, she reconsidered, "No, not gaps . . . it's as if the fence somehow goes in and out," and as she moved, she remarked pensively, "in, out, in, out" in correspondence with the fences geometry. I then had her reach with her cane to verify tactually what the fence was doing, at which point she exclaimed almost tearfully, "It's just like I can see the fence! I never thought I'd ever see anything again!"

On another occasion, I worked with a woman in her 30s under blindfold. She had a bit of usable vision, but wanted to learn FlashSonar, as her vision had become unreliable. At one point, we were doing a “trace the car” exercise, where the student, after suitable warm up exercises, is asked to trace the outline of a car she’s never seen or touched, keeping her hand about an inch above the contour of the car as she moves along its length. As her hand rose and fell tracing the contours of hood, roof, and trunk, she reached the end of the car and exclaimed, “Holy Mother! It’s like I can see the car” (Moving on, 2007).

The next chapter contains exercises to use in FlashSonar training.

Chapter 5 – FlashSonar Exercises

This chapter contains suggested training exercises to help someone learn FlashSonar skills. These exercises do not need to be carried out in a specific order but should be chosen according to the learner's needs and the environments available. Different students will try different exercises in different sequences, depending on their learning style, preferences, and background experiences. Some students may not want or need to participate in every exercise. Some students will pass through the basic exercises very quickly or skip them altogether. Children who have been blind or have had low vision for more than 3 years or adults who have been blind or have had low vision for more than 5 years may have little need for the basic exercises. However, it is a good idea to try these exercises anyway, as they will provide a baseline of ability level and also give a sense of learning style. For maximum effectiveness, most of these exercises assume the use of a tongue click or suitable echo signal. For more information on how to produce an effective tongue click see Chapter Four.

Materials That You May Need: (For all target stimuli, transparency is ideal but not required.)

- A. Two approximately 1-gallon wide-mouthed jars, and one jar about half the size of the others. It doesn't matter what the jars are made of, but they should be made of the same material. Plastic will be easier to handle for the exercises because it is lightweight, but the jars can be made of other materials.
- B. Two large bowls or pots, at least 4 quarts in size. These can be salad bowls, mixing bowls, or whatever you may have at hand. If the bowls are made of plastic, they are ideal as they are easy to handle.
- C. Three bottles of about a pint or quart—one medium-mouthed and two normal-mouthed of the same size as each other. Health juices and sports drinks often come in these sized bottles, with mouths slightly wider than is typical for most bottles. Simple water bottles may serve for the normal-mouthed sized ones.
- D. Five flat, solid, more-or-less square panels in the following approximate sizes: 20 inches, 16 inches, 12 inches, 8 inches, and 4 inches (all

measurements to be based on the side of the square panel). If circles are used instead of squares, add about an inch diameter to each specification above. Precision is not required here. All panels should be made of the same material, but the material doesn't matter as long as the panels are hard and solid. Cardboard works.

- E. One 20-by-40 inch piece of cardboard, folded in half to a 20-by-20 inch square.
- F. One small, portable AM/FM transistor radio. The radio is to be tuned off station on the FM dial, so you just hear static or white noise.
- G. A handheld clicker. These can be found at toy stores often in the shape of bugs or small animals or at pet stores as they are used for dog training. Multi-clickers can be ordered online in the UK. These are handheld clickers with an adjustable volume control.
- H. About 40 square inches of soft material; a blanket, towel, or pullover may be used-enough to fill a 1 gallon jar or large bowl or to cover one of the panels discussed above.

General Exercises

- Notices echoes in echoey rooms
- Notices difference in sound between echoey and non-echoey rooms/hallways
- Notices difference in echoes between corners and walls
- Notices difference in sound as liquid is poured into mid-mouthed bottle or glass
- Notices difference in sound when student blows across identical standard-mouthed bottles holding different amounts of liquid

When the student is moving around indoors, the teacher should help her notice the presence of strong echoes. For example, many children who are blind love to play sound games in highly reverberate environments such as rest rooms, breezeways (outside hallways), or stairwells. The teacher can encourage the child to sing, repeat words, or clap in the bathroom, garage, or other large, uncarpeted places without a lot of furniture or other objects that absorb sound. If the child makes noise in places with strong echoes, she may notice that her voice sounds

different in these places than in other places. The teacher could make a noise in an echoey room (such as the bathroom) and then move quickly out into the hallway where there is less echo, and make the same noise there so that the child can compare. Corners in a room also usually emit stronger echoes than other parts of the room.

The bottles can be used to give the student clear examples of hearing differences in the environment. The student should be able to tell by ear when a liquid is reaching the top of the medium-mouthed bottle or glass. Liquids may be poured at different speeds to ensure that the student is listening and not just using timing. The teacher can put slightly different amounts of water in each of the two standard-mouthed bottles. The student should be able to hear the difference when blowing across the bottles, even if it is very slight. Only an extra tablespoon of water in one of the bottles will make it sound noticeably different. Students should be able to tell which one is the higher or lower pitch. If the student can't, the teacher can increase the difference a little more. The aim is simply to begin heightening auditory sensitivity in the student to changes that are more obvious before moving on to those which are more subtle.

Stimulus Sensitization

As this term implies, the aim is to get students to “sensitize” to subtle stimuli, helping students to “hook in” to the experience. Training starts with sensitizing students to echoes, usually by having them detect and locate targets that are easy, such as large plastic panels or bowls. This helps them get a sense of what echoes sound like. Once this is established, the training moves to subtler and more complex stimuli. The teacher finds the level of stimuli into which the student can “hook”, then gradually moves to more subtle stimuli. Some students will pass through the earlier, more obvious stimuli very quickly, while others will need more time. (Stimulus sensitization is discussed in Chapter Four, while the concept of the hook stimulus is discussed in Chapters Two and Four.)

The Phase Effect

- Notices difference in sound when large panel is in front of face
- Notices difference in sound when large bowl or jar is in front of face
- Notices sound when large panel is further away in front of face

- Notices difference in sound when panel is close or far away in front of face
- Notices difference in sound when panel moves from in front to the left and right, parallel to face and head

The teacher can use the radio at low volume, a “shhhh” sound, or continuous vocal tone “aaaaaaah” and move the large, solid panel from above or behind the student’s head to directly in front of her face. The panel should seem to appear suddenly before her. If the panel is moved too quickly, the sound of the teacher’s arm or the wind burst from the panel may arouse the student’s attention. Also the teacher should try not to wear clothes that rustle or make a noise as this could distract the student or “tip off” the student to the panel’s whereabouts by cues other than echo cues.

The teacher then asks the student if she can tell the difference between the panel being there, versus not there, and test her. If the student can’t identify when the panel is there or not, the teacher clarifies the stimulus by moving to the salad bowl or the jar instead. Because the sound from the gallon jar or large bowl echoes more, it is easier for the student to identify.

Once the student can hear the presence of the bowl or jar, the teacher can then repeat the exercise with the large, flat panel but further away from the student's face.

Next the teacher can try slowly waving the panel toward and away from the student's face and discuss any changes the student notices as the panel moves. Can the student tell when the panel is just about to touch her? If not, the teacher is to try with the large bowl, then move back to the panel. (This is an example of stimulus clarification as discussed in Chapter Four).

Finally, the teacher can move the panel from in front to the left, and from in front to the right and ask the student to say which way it moved. The flat surface of the panel must continue to face the student's head. In other words, the panel shouldn't be just moved laterally along a plane from left to right, but along a circumference circumscribing the student's head such that the surface is always pointing at the student.

Stimulus target presentation

- Detects locations of single small jar

- Detects locations of large and small jars presented at the same time
- Detects location of large jar filled with soft material and same-size empty jar
- Distinguishes difference in sound between bowl and jar
- Identifies which large bowl is closer and which is farther away
- Indicates location of panel, jar, bowl, and panel with cloth draped over it when presented in pairs
- Identifies corner shape of long piece of cardboard folded at 90 degrees

The object to be detected is always presented to the student with the teacher standing behind the student so that the teacher's presence does not interfere with the detection of the stimulus targets. These exercises should ideally be done in a large, open, non-reverberant, fairly quiet space (not absolutely quiet; about the noise level of a quiet day in a suburban residential neighborhood). If there are constant noises in the area, such as air conditioning or traffic, it's ideal if the noise is more or less evenly diffused throughout

the environment so that it lacks directionality. If the noise is directional, then it should be placed behind the student so that sound shadows do not interfere with cuing of reflected sounds. If the exercises are performed in a large room, the student must not be facing a wall or be too near to a corner.

The stimuli are presented around the student's head as quietly as possible. It is best for the teacher not to wear long sleeves because clothing can rustle. When presenting a stimulus to one side of the head, the teacher should move both arms, including the empty one, but keep the elbow of the empty arm bent so that that arm is kept out of the student's auditory view. Moving both arms will keep the student from just cuing off the arm that moves, since they both are moving. But by bending one arm, the student won't be distracted or confused by the presence of the empty arm.

In general, these basic stimulus sensitization exercises move from presenting the jars first, then the bowl, then the flat panels. The teacher will generally progress from using the large flat panels to the smaller ones over time and at very near distances before moving to arm's length. Even if students seem well ahead of the game with their sonar, it may be a good idea to just zip through all the easy exercises

anyway. It can give material for the teacher to refer back to when the exercises get more complex. It is best to start teaching the student simply to detect the presence or absence of stimuli, before moving on to location (left, right, high, or low). The various stimuli can be brought up later to represent real features of the environment—chambers of various sizes, alcoves, corners, and walls. The students will often be slow and methodical at first in giving their answers, but eventually they should reach the point when they can instantly and almost casually give the correct answer without hesitation or second guessing.

The teacher can present a single large jar at various locations and test the student's ability to detect it. The teacher should begin with the large jar fairly close to the student, but then move further back. The teacher can then repeat but with the smaller jar. The teacher can then present both jars at the same time, one to each side of the student, having the student turn her head side to side to click or make some suitable noise into each and determine which is the larger and which is the smaller jar. Then the teacher can fill one of the large jars with the soft material and repeat the stimulus differentiation exercise, discussing the difference in sounds for each object.

The teacher can then present the bowl and jar to the student and ask her to compare the sounds. The jar may be described as sounding more hollow than the bowl, more like a chamber. The teacher can also present the large bowls to each of the student's ears simultaneously but at different distances and ask if the student can state which is further and which is closer. The exercise can start with the distances being very different, then slowly reduce the difference between the presentation distance.

Then the teacher can repeat the above exercise using the flat panels but not comparing size; compare panel to bowl, bowl to jar, panel to bowl or jar, solid panel to the one with soft material draped over it, etc. It may help to present both stimuli together to right and left, rather than alternating. The student may say, "The bowl is on the right; the panel is on the left." Or, "there's a panel above me and also one to the right" or "the solid panel is to the left and the soft one is on the right." The student should be encouraged to scan with her head to differentiate the presence and absence of the panel from one side to the other. The teacher reminds the student that people who are sighted scan with their eyes, and people who are blind can achieve similar results of target discrimination by moving their heads in a similar fashion. It actually makes the student look more engaged and alert.

After the teacher has done a few of the exercises above, she can then present the long piece of cardboard folded at 90 degrees as a corner, but without telling the student what it is. The student can discuss what it sounds like and what environmental feature it may represent.

Hearing real environmental features: Fences, blank walls, rooms of varying sizes

- Places front, back, and each shoulder next to blank wall after being disoriented in rooms of various sizes and click
- Places front, back, and each shoulder next to fence after being disoriented and click
- Faces wall and clicks, beginning one meter away up to twenty meters away
- Faces fence and clicks, beginning 1 yard away up to 20 yards away

The exercises above can, and should, be repeated using real environmental features such as blank walls, fences, and rooms of various sizes. Students can place their back, front, and each shoulder to a wall or fence after being disoriented. The exercises

can begin at a distance of about a yard from the wall then increase to perhaps 55 yards or further. Note that some students may find sonar characteristics easier to hear at first from greater rather than lesser distances. Real environment exercises need not be put off until all panel exercises are complete. They can be conducted between and among the panel exercises for the sake of variety and stimulation. It is often useful to the student to start to see the application of these exercises early in the program as this may not be self apparent, especially for young ones. In fact, young children may have a low tolerance for these drill exercises; they will probably need a more experiential approach involving real features most of the time involving movement.

Establishing Orientation Relative to Points of Reference

Orienting to and moving toward an object

- Faces and moves toward walls with or without radio playing white noise at target
- Faces and moves toward trees with or without radio playing white noise at target

- Faces and moves toward poles with or without radio playing white noise at target

The teacher should position the student between 6 and 8 feet from a wall and ask her to approach the wall directly. Then the distance between the wall and student should gradually increase until it is 60 feet or more. With a sharp hand clap, students may learn to direct themselves across several hundred feet of open space. Using this technique, self-direction across open spaces can be easily managed. Some students may need to be reminded to face the wall first before moving toward it. If a student has difficulty with this, it may help to place a sound source (such as the radio) at the wall, and gradually reduce the volume of the radio over a number of tries until the student's sonar sense takes over (This is called stimulus shift, and is detailed in Chapter 4). It may also be easier for some students to localize and approach walls starting from the more distant position first and then moving closer. For some students, the time delay aspect of FlashSonar at distances is easier to hear than phase cancellation at close distances. Pelegrin-Garcia, Rycharikova, and Glorieux (2015) discovered that for their participants "reflections with longer delays, coming from far walls, were easier to localize than reflections with shorter delays, coming from nearby walls" (p. 755).

Students should also learn to approach smaller objects, such as a pole, a tree, or a bush. It is common for children to meander around an object, even when they know where it is. The student may need to practice turning first, then moving toward the pole. In another exercise, the student can find the trunk of a tree. Note that the presence of the canopy may reduce the figure ground of the trunk, making it more difficult to locate than a pole.

It is best for the student to move on her own with minimal verbal or physical direction. FlashSonar cannot be learned from someone's arm or hand, nor can it be concentrated upon with someone narrating in the student's ear.

Alcove and interior corner location

- Locates interior corners or alcoves
- Walks diagonally from one corner of a room to the other
- Walks diagonally from one corner of a room to the other with obstacles in the path of travel
- Walks diagonally from one corner of a larger outdoor area to the other

Corners and alcoves are relatively easy to detect from great distances because they reflect so much acoustic energy back. They can thus be used to establish points of reference easily. For example, a student who may have difficulty finding her desk in a classroom or locating an office door may use nearby corners as her reference point. Such was the case with an adult who was blind in the Netherlands. He was quite a good traveler and well acquainted with his workplace. But he had difficulty reliably finding his way across a large, somewhat cluttered lobby to the correct hallway containing his office. He tended to get a little turned around and ended up quite off course, often requiring the receptionist to redirect him. The hallway in question happened to be located near one corner of the lobby. In one 15-minute training session, this gentleman learned to hear the corner near his hallway from the reception area, at about ten meters distance, and arrive at his hallway every time from that point forward.

Before the student does this exercise, she needs to be able to travel and move directly towards a wall. The teacher needs to locate a corner (or alcove) with at least 3 meters of clear space before it. The corner to be used could be indoors, such as a large room or it could be outdoors. The student is positioned so that she is facing oblique to the corner. The student

practices turning and moving directly to the corner while using her click. Some students may need to be reminded to turn their bodies first to face the corner, and then move toward it. The student should also be encouraged to move from one corner of a room diagonally to the other, sensing the opening of the corner behind her as she moves away, and the closing in on the corner in front of her as she moves towards it. This exercise is very helpful to break many students' attachment to straight lines and right angles, allowing them to be more comfortable with irregular and angular situations. Some students will find this exercise much easier than they expect, while others will struggle more than they expect. Many will simply start moving diagonally, then veer toward a wall and simply parallel that wall until they reach a corner. But, that corner will be an adjacent corner (one along the same wall), not a diagonal one. It may help to show them what they have done tactually using a square or rectangular surface. It may also help to walk with a student around the room to show her auditorily what she did, compared to what she is trying to do.

A good size for the initial room would be about fifteen feet square, then larger rooms (up to gymnasium size) could be used. To increase the difficulty of the task, various objects can be placed in the path

the student is likely to take between the corners. The student may not be expected to detect all the objects without touching them, but should be able to maintain orientation and direction from one corner to the next while navigating among the scattered objects using the cane. This diagonal corner to corner exercise need not be restricted to indoor environments. Large courtyards, quadrangles, and plazas may also suffice. The walls do not necessarily need to touch each other to form a corner-like phenomenon from an acoustic point of view. Two buildings standing at right angles with open space between them will suffice. This then allows the student to use corner acoustics to assist her in orienting even in large, outdoor, open spaces.

Tracking course boundaries

- Locates wall and walks along it using click
- Locates row of trees or poles and walks along them using click
- Locates boundary of store aisle and follows it down the aisle using click
- Locates boundary of aisle in parking lot (line of parked cars) and walks along it using click

- Locates boundary of wider area e.g., (wall of corridor in airport or train station, and walks along it using click
- Walks along boundary made of clusters such as chairs/tables in a food court or restaurant using click

This skill is about being able to guide one's motion auditorily along regular and irregular borders and boundaries, such as walls, fences, a row of poles, lines of foliage, hallways, or aisles in stores and parking lots.

It is preferable to start the student's training with solid, continuous surfaces (such as a wall) before moving to sparse or intermittent features (such as a row of poles or trees). The student should try to locate the boundary using her click and then walk alongside it. The distance at which students are locating boundaries should be increased - wide corridors may be found in transit stations, airports, and suburban alley ways. When boundaries consist of clusters of elements, such as tables and chairs in a restaurant, individual elements of the path boundary may not be discernible to the student, but these often cluster or aggregate to become detectable as a unit. For example, when winding one's way through a food

court or restaurant, the student may easily be able to thread her way gracefully among the furniture with minimal contact, without necessarily being able to distinguish or recognize any given piece (This process of aggregating items or features is covered in greater detail below). The teacher should encourage the student to move at a moderate or brisk pace, as this will make this exercise easier.

Centering

- Recognizes when centered between two similar, parallel surfaces about eight feet apart
- Indicates the closer surface when very close to one of two similar, parallel surfaces about eight feet apart
- Centers oneself between two similar, parallel surfaces about eight feet apart
- Performs these 3 exercises when surfaces are moved farther apart
- Performs these exercises using two parallel buildings approximately fifty feet apart

This is an exercise for the student to learn how to center herself between two surfaces. The teacher locates or arranges two more or less flat surfaces about eight feet apart. The two surfaces should be approximately similar in nature. It is best if the two surfaces are in an otherwise open area. They could be tables standing on end, parked cars, trash bins, or easels holding large boards. The surfaces don't necessarily need to be precisely flat, but they should be roughly uniform to each other. The teacher situates the student midway between the two surfaces and explains that the student is centered. The teacher then asks the student to feel the equal distance between the object with her cane. Then, the teacher disorients and re-situates the student much closer to one side, and asks "which side are you closest to." Young children often cannot answer this question when put this way, even when they know the answer. It may help to ask "which side can you reach right out and touch?" Or, "go to the side you can touch the easiest or quickest." Then the teacher re-situates the student so that she is near the center, but definitely not centered, and asks her to center herself using her FlashSonar. Exact centering may not happen right away. If she is within a few inches, the teacher should praise her effort. The teacher gradually increases the distances between the two surfaces to about fifty feet apart. The surfaces should be large, for example,

between two buildings. The teacher asks the student to repeat this exercise.

Circling

- Circles large object in both directions, stopping where first began
- Circles small object in both directions, stopping where first began

The goal of this exercise is that the student walks in a circle around a large object in either direction and then stops where she first began. The object does not need to be circular. It might be a minivan, a large column, a kiosk, a display case, a tree, etc. The object being traveled around should stand in an otherwise open space. There should be some defining feature that indicates the starting point. It can be the presence of another object such as a distant building, or it could be another noise such as traffic sounds. A student could be asked to use a compass, the sun, the wind, or some unique characteristic in the ground as a beginning point. The student should circle large objects first, and then the teacher introduces smaller objects to circle such as poles or bushes.

In the beginning, some students may wander far and wide from the circle, not realizing they've lost it because it fades gradually out of their perception. When a subtle stimulus fades gradually, one often does not realize it is fading until it's gone. Stabilizing attention often helps here as discussed in Chapter Four. The teacher can ask, "Where's that (thing)?" Students can often reorient themselves quite well just by this question. They may need to stop, reorient, then continue circling. The student should be asked to circle the object in both directions.

Negotiating Objects

Moving among objects with goal direction

- Approaches and avoids a single, large, solid, stationary object
- Approaches and avoids a smaller object
- Approaches and avoids a moving object
- Threads the way among objects while maintaining orientation in department stores, furniture stores, libraries, parking lots, restaurants, classrooms, forests, etc.

- Moves in a slalom manner among the cars in parking lot with cane shortened without touching cars
- Threads through crowd of people spaced out so there is sufficient gap for student to pass through

The student can learn to move among objects, maintaining goal directedness, with little or no physical contact with the objects through her body or cane. Generally it is best to start by letting the student approach and avoid a single, large, solid, stationary object first before advancing to smaller, sparser, possibly moving objects.

This can then be advanced to threading the way among objects while maintaining orientation. Congested environments with many objects needing to be negotiated may include department stores, furniture stores, libraries, parking lots, restaurants, classrooms, forests, etc. Rows of cars in parking lots work well as obstacle courses. The idea is that the student threads her way in a slalom manner among the cars with cane shortened without touching the cars. Not only does this help develop precision of movement, but it can help students address any fears they may harbor about traffic or parking lot areas. A crowd of people can also be used for the exercise,

spaced out so there is a sufficient gap for the student to pass through. Children may have the advantage here because their reduced height makes everything around them larger and more detectable.

Precision detection

- Repeatedly walks through door without touching sides as teacher slowly closes it, narrowing the gap for each trial
- Locates, then reaches toward or touches pole without fishing for it
- Aggregates clusters of smaller objects to form a spatial boundary

This exercise may help refine FlashSonar skills. A teacher asks a student to pass through a doorway on repeated occasions while slowly closing the door a bit more, thus narrowing the gap in each trial. The student needs to determine the breadth of the opening and ease through it without touching the sides. Locating, reaching toward, or touching a pole without fishing for it can foster precision movement. A teacher can ask a student to perform this task as well.

An advanced form of precision detection is a skill about aggregating one's surroundings as discussed above. When a person who is blind is threading her way through dense patches of objects and maintaining her goal directedness, she does not need to distinguish and identify every single object in order to be able to go around it. Instead she learns to chunk or aggregate the objects in order to get better cues about alignment. This can improve tracking course boundaries, especially if the boundaries are comprised of disjointed features rather than a solid border. A group of three or four tables might become one line. A bush with a tree or bench might become another line. A sign with a planter box and a mail drop box might become a third line, and so on - or all can be followed as one long line. It is like mentally drawing a line connecting multiple points; one can't take a line very well with just one point. In this way, the student is not overwhelmed or disoriented by each object and is not lost between or among objects. Should the student become disoriented, the teacher simply asks the question, "Where are your spatial boundaries?" and then coaches the student as needed to reestablish her boundaries, without taking over her own sense of direction.

Identification of Features and Elements

- Compares features of two objects to distinguish and identify them
- Identifies a pole by its features
- Identifies a tree by its features
- Identifies steps going upward by their features

All objects, features, and events in space are constructed of dimension (height, breadth), location (distance, laterality, elevation), and density (solidness, sparseness, absorption). The teacher should use this language to help students describe what they are hearing. A pole, for instance, is tall, uniformly narrow, and solid. A bush is sparse, broad, and short. A tree is narrow and solid near the bottom, but becomes broad and sparse with increased elevation; its breadth and laterality increase. Stairs are solid and near toward the bottom, but get further away with elevation. Here is where stimulus association, clarification, and comparison, as discussed in Chapter Four, can help students understand what they are hearing and learn to register and describe subtler characteristics. The question, "What does this remind you of?" (association) can often stimulate realization about

an environmental feature event being perceived. Sometimes densely packed foliage will register as solid because of the strong reflection of acoustic energy, until it is directly compared with something solid.

Environmental Layering/Scene Analysis (Gestalt)

- Describes layered elements of a scene

A student can learn to describe and image multiple events and layers of the environment. An example might be a bush in front of a wall, or a tree behind a fence, with a wall of a building behind that. The student should be encouraged to describe what she can hear most clearly, clarify that image, and then concentrate on other elements. It's all about awareness of depth and distance cues combined with distinctions in density. Distinctions in density may be likened to color contrast perception. Density distinctions can serve to make some objects really stand out from others. Ask questions such as: "What is close to you? What seems further away? How are they different?" Then, given what the student describes of the entire scene, what is their overall impression? "What is the picture? What are we looking at?" In the authors' experience, people who are more recently blinded may be better at the

imaging, getting the overall picture, even if their actual perceptions are duller than students who are blind early in life. This could be because they have a lot of visual experience of the way scenes are arranged in the world. A person who has been blind for a long time may be able to describe a scene quite accurately in terms of its characteristics, but may still not be able to identify the object or scene the way a person who has visually experienced it can do. Children who are blind and who were free to and encouraged to explore their environment prolifically can usually identify scenes quite well.

Dynamic Environmental Interaction (Self-Orientation)

Ultimately the aim is to foster students' ability to establish orientation and direct themselves through space. They should move through the environment in a goal-directed way, registering and processing all the elements.

Street crossing

- Detects object partway or fully across street and moves toward object to make straight crossing
- Detects quiet cars when stationary

- Detects quiet cars in motion

Students can learn to register elements part way or all the way across a street and can use this information as a kind of beacon to guide movement while crossing. It is like crossing to a wall, except that they are processing other stimuli (traffic) as well. The attention is not taken away from the traffic; that must be the primary cue. But, sonar goal direction can be closely secondary. The teacher should locate some quieter streets first, then move to noisy ones. Sonar and sound shadowing can also help to register quiet cars at rest, and warn against large quiet vehicles in motion. It isn't the complete answer to how people who are blind will locate silent cars but it can provide an additional layer of warning and protection.

Crossing a parking lot

- Orients toward large object (building) across parking lot
- Negotiates stationary and moving objects while crossing parking lot

This is a combination of orienting toward an object (a far off building) and negotiating objects, both stationary and moving. Once the student nears

the building, other features of the building can be determined to help her direct her course to the entrance. The entrance is often located in an alcove. Of course, there may also be other auditory cues suggestive of the entrance.

Self-orientation

- Identifies distinct point of reference audible from 50 feet away
- Travels from point of reference to locate 3-5 distinct environmental elements
- Returns to point of reference after locating each element
- Relocates each element from point of reference
- May use compass or information from the public
- May create GPS or tactile map of area

Students can learn to orient themselves to any new area. The teacher locates a large, complex space such as a park, school or college campus, transit station, playground, or shopping center. The teacher helps the student to identify a highly audible, distinctive point

of reference or point of departure. This is often a large alcove or corner where two buildings meet. It should be detectable from 50 feet away or so. The student practices leaving the point of reference and locating three to five distinct elements of the environment. These elements should be distinctive from each other. The student may touch them for verification, but should identify them, or at least describe them first. The student should then return to the point of reference, then go back to locate and identify each of the elements she had found. Students should not just stay on pathways, but should be encouraged or even required (as part of the exercise) to cut across open space (that's where the most fun is.) Objects might include distinctive trees or poles, park benches, trashcans, pavilions, fences, retaining walls, other buildings of unique character, steps, bushes or hedges and other plants, distinctive arrangements of objects, a particular vehicle in a nearby lot, etc.

The student should be encouraged to repeat the exercise with larger numbers of elements or different elements—not more than ten, but the elements should be further and further from the point of reference. Ultimately, the student will establish other key points of reference relative to each other and objects or features of smaller detail relative to those. Students may use other aids to help, such as

a compass. The student may also make occasional use of assistance from the public if the student has lost her bearings in returning to the reference point. Engagement of public assistance is an acceptable means of wayfinding. However, for FlashSonar exercises, we encourage use of FlashSonar as the principal means of information gathering and self direction. This could even be a great GPS exercise where students practice mapping their environment. In fact, a very advanced student may create a tactile map of what she finds. This process can be applied to orient oneself confidently and enjoyably to any type of space.

Very Advanced Exercises for Enthusiastic Students

Refined feature discrimination and location

- Identifies features/elements of objects held by teacher, touches objects, and attempts to identify objects when teacher presents them again in a different order

The teacher can hold various, distinct objects while the student discerns the differences and key characteristics, with a view toward identification if possible. The learner then touches each object to align

the auditory image with the tactual one. Then, the student is presented again with the objects randomly and must try to identify them. Next, the objects are hung from the ceiling of a large room. The student must locate and describe each object, with a view toward identification if possible. Then the student touches each one and must then relocate each one as requested by the teacher.

Target practice

- Hits targets of differing sizes and at various distances with ball or water gun

Targets of various sizes and concavities are erected, and the student must challenge herself to hit various targets from various distances, either by throwing a ball or using a water gun. Ben Underwood (McCaffrey, 2007) was able to shoot hoops without a sound source on the basket from about ten or fifteen feet with about 75% accuracy.

Scene representation

- Represents unfamiliar scene by describing or drawing it

The teacher can present the student with a scene with which she is not familiar. She must sketch, describe, or somehow represent the scene before her.

Bicycling

- Follows building line riding bicycle
- Rides bicycle through open space avoiding obstacles
- Rides bicycle through prearranged group of people; may follow sound of another rider with zip tie on bicycle wheel

The teacher locates a large, open space with some widely spaced objects, and preferably some buildings. School grounds, a high school parking lot, or church parking lot can work. The student can practice riding around the area, detecting, circumnavigating, and avoiding the objects and features. She may start by riding back and forth along a building line before venturing out among the objects. Eventually, the teacher arranges an array of human obstacles for the student to ride through. The teacher can place a zip tie on the rear fork of another rider's bicycle so that it creates a sound beacon. Then the student can follow while still controlling her own bike.

Group activities

Some of these exercises, particularly the last few, can be quite conducive to student groups. Students can help each other to register object characteristics and identify objects, image scenes and discuss what is perceived, and actively find their way around new spaces. The group energy often helps and encourages students to reach heights they might not otherwise reach. The group dynamic can serve as a tremendously motivating process. It's very interesting and powerful to observe a group of students come to consensus about what they perceive and how best to find their way.

Selecting Suitable Training Environments

Of course, FlashSonar can be practiced in just about any type of environment under just about any circumstance. However, certain environments are more conducive to learning, especially for students new to the process.

In general, environments should be reasonably quiet at first—about the noise level of a typical suburban environment.

Environments should be rich with varying surface types and qualities—buildings, walls, bushes and trees, shelters, poles and fences, open and bordered

spaces. It is helpful if stimuli that can be directly compared can be found in one area—for example, a fence near a wall, or a pole near a tree, or a bush near a bench, or a tall wall near a short wall, etc. Parks or school/university campuses are often useful. Older neighborhoods can also be suitable, as these often are comprised of a range of varying and distinctive landscapes and building fixtures.

For indoor environments, hardware or home improvement stores or large department stores can work very well. These often contain widely varying surface types going from aisle to aisle. An aisle of clothes or rugs sounds very different from an aisle containing canned goods or boxes. Aisles of furniture will sound very different from aisles of belts or cables. In an aisle of refrigerators for instance, the teacher can open one of the doors and have the student find the one that is open. The teacher can ask the student to find and enter the alcoves without touching the sides or can ask the student to describe each aisle to help build language for her experiences. All the while, the student would be expected to use her compass and all other cues and clues to maintain her orientation within the environment and find her way out in the end.

Self Exercises for Stimulating the Sonar Perception

The exercises below were originally designed for a teacher to do so that they could develop their own sonar skills. However, these exercises could also be applied to students of FlashSonar as beginning exercises.

- A. Find a large and small wide-mouthed container. Glass jars are good; seashells are excellent. Speak into the open air, then into each container. Note how the containers sound different from the open air and from each other. Close your eyes and have someone hold the containers in front of you as you speak. Try to hear when the container is in front of you and which one is the smallest or largest. Have someone else speak, and, with your eyes closed, guess which container is which.
- B. Hold the mouths of the containers to your ear. What do you hear from them? Do you recall the “ocean in the seashell” phenomenon? It is only sound reflecting inside the container. Can you hear the difference between small and large containers? Put each container at each ear simultaneously. Can you hear how each sounds different? With your eyes closed,

have someone present the containers randomly to each ear. Can you tell when the container is present or absent? Can you tell which container is which, large versus small?

- C. Position yourself about a foot from a blank wall. Take a deep breath, and, with closed eyes, pivot your body while slowly exhaling in a "shhhh" sound. What happens to the "shhhh" sound as you turn your face away from the wall? How about toward the wall? While pivoting, try to hear when you are facing directly toward the wall. If the "shhhh" noise doesn't work for you, try an "aaaaah" sound.
- D. Position yourself about four feet from the wall. Take a deep breath, and, with closed eyes, approach the wall while slowly exhaling a "shhhh" or suitable sound. Now, step away from the wall while exhaling. See if you can bring yourself to within 6 inches of the wall without touching it. How about 3 inches?
- E. Stand in the middle of a sparsely furnished room with your eyes closed, and turn slowly while exhaling the "shhhh" or other suitable sound. See if you can locate the corner. Begin walking, and see if you can find the corner.

- F. In a car, find a residential street with several vehicles parked along it. (A parking lot will not do for this exercise). Open the window, and, as you drive, listen carefully to the sound of the car every time you pass a parked vehicle. The sound fluctuates. If you can get someone else to drive, try this with closed eyes, and listen through the passenger window. The effect is more pronounced here. You may even be able to tell by listening whether the street is heavily lined with parked cars, or sparsely so.
- G. In an area familiar to you, try walking with a blindfold and full-length cane. Try perceiving things around you by echoes. Do not try to ascertain exact locations of things; just strive for a sense of things flowing about you as you walk. Try clicking your tongue. Do you hear the shifting directions and distances of things as you move among them? O&M instructors may find that doing this at least once or twice a week will help them in sonar training with students, and to comprehend their own perceptual process adapting to integrate nonvisual information for efficient travel. Your students do this all the time.

- H. If you are a teacher, try accompanying the more advanced students under a blindfold in an area familiar to you. Practice sonar navigation with them. Let them help you. They will love it, and you will both learn something.

Online Practical Resources and Examples

It may help the reader to be able to read about or view some actual examples of FlashSonar training and application in real life. To this end, World Access for the Blind provides a series of practical examples of FlashSonar training activities and real life applications consisting of articles written by or about students that detail their training process and how they apply what they have learned to real life activities. Some articles and videos are also included depicting the course of training and application, together with student responses. Some pieces document family involvement and dynamics. A few pieces are also included to clarify some of the science. Various articles are also included to further expound on specific points or issues pertaining to perceptual navigation and freedom of movement. Articles about assessment practice and educational/rehabilitation planning are also included, along with recommendations for additional reading.

Please go to www.waftb.org/perceptual-navigation/current-resources-and-updates/ .

This page is continually updated as more materials become available, so please recheck from time to time for the latest information.

The next chapter is about the uses of FlashSonar in a wider context. The chapter also confirms the benefits of FlashSonar for those with reduced or no vision.

Chapter 6 – The Importance of Echolocation and Future Research

Research

There is a rapidly-growing body of research into echolocation and its use by human beings to identify, orient themselves in, and navigate their surroundings. Part of the challenge in locating this research is that it spans a number of different disciplines such as acoustics, child development, psychology, natural science, perception, neuroscience, education and biology as well as visual impairment. Daniel Kish's (2003) "Sonic Echolocation: A Modern Review and Synthesis of the Literature" available at <http://www.worldaccessfortheblind.org/echolocationreview.rtf> is comprehensive, but it does not include research published after 2003. A complete literature review is beyond the scope of this book because this book is intended to be a practical teaching guide to FlashSonar rather than a review of echolocation research. The extensive list of references will be useful to those who want more information.

The article "A Summary of Research Investigating Echolocation Abilities of Blind and Sighted Humans" by Kolarik, Timmis, Cirstea, Pardhan, and Moore

(2014) is a good starting point for those who are looking for more research. The remainder of this chapter addresses and presents research relevant to the benefits of echolocation and includes topics of interest not covered elsewhere in this book.

Are Humans More Like Dolphins or Bats?

Although dolphins use echolocation to recognize objects underwater, research has demonstrated that dolphins do not ‘see with sound’ but use a mix of hearing and seeing. This is known as sensory integration, “the neural process by which input from one sensory modality is organized and integrated with input from another” (Spitzer, Smith Roley, Clark, & Parham, 1996, p. 124).

In this research, the dolphin was either vision- or hearing-occluded. The dolphin was given a matching task in which a shape shown underwater was to be matched with one of three shapes shown above water. The dolphin scored higher in the hearing occluded tests than in the vision occluded ones. “These findings suggest that shape is not easily accessible to dolphins via echolocation, although it is accessible through vision. Dolphins integrate information about objects across modalities; it is likely that they gain most shape information through vision” (Harley, Fellner, & Losch, 2013, p. 4).

This suggests that, when dolphins have good vision, they use that vision in conjunction with their hearing. Their echolocation is useful for distance, location, and materials of an object, but they then use vision to investigate the detail of that object when they are closer to it. Dolphins use echolocation for specific tasks such as to “navigate, avoid predators and track moving prey” (Wisniewski et al., 2013, p. 2). Research comparing echolocation in dolphins and humans concluded that “if humans report amplitude and pitch cues in the echoes it is reasonable to assume that dolphins also have access to these cues. However dolphins have sharper frequency tuning curves than humans so they may be better able to interpret frequency information in echo stimuli than the human listeners” (DeLong & Stamper, 2007b, p. 616). Another study that compared the vision of dolphins, chimpanzees and humans concluded that “to our surprise, the visual perception of the bottlenose dolphins is very similar to that of primates” (Tomonaga, Uwano, & Saito, 2014, p. 4).

These findings are also true for human beings who are blind and who use echolocation. They will use echolocation to find objects especially at distances, but are likely to switch to tactile or other exploratory methods to examine the finer details. For example, a tree could be echolocated from some distance.

However, if someone wanted to know the exact type of tree she had located, she might need to tactually explore the leaves or bark.

Bats alter their own clicks according to their activities both in loudness and in the amount of pulses. (Stroffregen & Pittenger, 1995). One of the advantages of producing one's own echo signal is that it is easier to control various parameters of the signal such as loudness, direction, or frequency than it is with incidental sounds. Humans cannot use the same sonar signals as a bat because the frequency of the signals is too high for human ears to detect. For a human to hear bat sonar, the sound would need to be slowed down by a factor greater than ten (Waters & Abulula, 2001).

Many species of bats have evolved their use of echolocation to allow them to hunt in the dark, where their eyesight is relatively poor, suggesting a differentiated adaptation of their hearing sense more than a process of evolved sensory integration. "Echolocation in bats is a plastic sensory system which might readily adapt to the different tasks associated with diverging niche evolution trajectories among closely related species" (Russo, Jones, & Arlettaz, 2007, p. 174). This process of evolutionary adaptation highlights a similar adaptive process taking place

within humans who are blind and who adapt to their loss of vision by developing a more effective use of their hearing. In the animal world “echolocation is usually used in environments where light is limited e.g. underwater, or in caves. The visual information in these environments is unreliable and animals have adapted to use a more reliable means to understand their environments in the form of sound” (Deacon, Davies, & Pinder, 2013, p. 26).

A comparison of echolocation skills of dolphins and bats to echolocation skills of human beings who are blind indicates that echolocators who are blind use some skills that are similar to those of bats and some skills that are similar to those of dolphins to develop their own way of ‘seeing’.

Comparing FlashSonar to Electronic Travel Aids

Persons with visual impairments have been using sound to help them detect objects for centuries. As recently as half a century ago, “In China blind people. . . . [carried] a gong about with them, not only in order to attract other people’s attention, but also for the purpose of orientation” (Kohler, 1964, p. 26).

Welch (1964) reported that acoustic obstacle detection with electronic devices was being taught in some schools for the blind. Welch noted that

there was “a lack of desire by blind people to make distracting noises which would call attention to their handicap” (Welch 1964, p. 2). Students used electronic travel aids that indicated the presence and relative distance of an environmental feature by producing tones of varying pitches, vibrations of varying speeds, or both. In the years since Welch’s comments, various electronic travel aids have appeared on the market, and many of them have ultimately disappeared because of insufficient sales.

Electronic travel aids such as the ‘K’ Sonar and the Miniguide use sound to communicate presence, range, and sometimes porousness-solidity of environmental features. Those devices “which present their indication of [feature] detection and range to the user’s ears through earphones necessarily occlude the user’s normal sense of acoustic orientation and thus detract more than they add” (Welch, 1964, p. 2). Electronic travel aids requiring the delivery of tones through headphones or an earbud are problematic because “in a natural pedestrian environment the use of an ear-bud speaker or headset would compromise the pedestrians’ ability to attend to ambient sounds” (Gustafson-Pearce, Billett, & Cecelja, 2007, p. 265).

Attempting to resolve the problems associated with use of an earbud or headphones, some electronic

travel aids, such as the Miniguide when set to vibrate rather than to emit sound, communicate the presence and distance of an item by alterations in the speed of vibration. The Miniguide can detect items within range anywhere that the aid is pointed. However, when scanning the environment with the hand-held aid such as the Miniguide in one hand and a cane in the other, the traveler is left with no hands free.

In addition, all electronic travel aids require batteries. Some batteries are rechargeable, while others are not. Battery replacement is sometimes problematic, and batteries may die at inopportune moments. Many electronic travel aids would be damaged if used in heavy rain or snow. Some potential users have commented that such aids make them 'stand out' either by the noises they make or by their appearance. Sensing devices such as these discussed also have a range of detection typically between 2 and 5 meters. We have found no handheld sensing devices that report a detection range beyond 10 meters. Indeed, ultrasonic energy attenuates very quickly in air, so its detection range is necessarily limited.

FlashSonar on the other hand is discrete, always available, never has batteries to change, can be used at any time, is as loud or soft as the user requires,

and is 'hands free'. Because FlashSonar relies on sound waves within the human audible range, it is less susceptible to attenuation in air. Therefore, the detection range of FlashSonar can extend between several dozen and up to several hundred yards depending on the signal being used, environmental noise levels, and reflection of the target.

Is There an Alternative to the Long Cane?

The long cane acts primarily to serve as a mobility aid rather than an orientation aid. Aside from providing some echo cues that may result from tapping on hard surfaces, the long cane does not give the user information about where he is apart from clues that the user may physically contact with his cane. The cane can only warn of objects according to its physical length which, even with extremely long canes, will not exceed several yards distance from the user. However, the long cane has become the most popular mobility aid for persons who are visually impaired perhaps because it is the choice of persons who are visually impaired. Loomis refers to "the adoption of the long cane by the blind community as the primary means of detecting obstacles" (Loomis, Golledge, & Klatzky, 1998, p. 194). Manduchi & Coughlan (2012) state, "the long cane is difficult to surpass. The cane is economical, reliable and long-lasting and never runs out of power" (p. 3). However, the suitability of

the long cane for older people has been questioned because they experience fatigue from using the cane particularly in two point touch technique for long periods of time. The slower reaction times of older persons may make it difficult for them to avoid fast moving objects (Kim & Cho, 2013, p. 101).

FlashSonar cannot be used as a person's only travel aid because "low obstacles not reaching up to a person's knee which are also rather narrow are usually undetectable. To find them it will be necessary, as before, to make use of a stick" (Kohler, 1964, p. 47). It is the combination of a long cane and FlashSonar skills that makes a confident skilled traveler.

Sensory Substitution Devices (SSDs) are devices which "convey visual information to the visually impaired by systematically substituting visual information in one of their intact senses" (Maidenbaum, Abboud, & Amedi, 2014, p. 4). The three main components are (a) input sensors capturing visual input, (b) a processing unit, and (c) the human machine interface that provides data to the user (Maidenbaum, Levy-Tzedek, Chebat, & Amedi, 2013).

There have been many attempts to produce a "smart cane" that uses other sensory technology, such as

laser, infrared, or ultrasound, and transcodes the signals into auditory or tactual information. Infrared sensors used on some Smart canes are affected by sunlight, causing the “smart” part of the cane to be nonfunctional outdoors. Also, laser technology can be “fooled” by transparent surfaces or surfaces at odd angles or of certain colors. Loomis et al.(1998) suggest that a cane could have “an augmented echolocation signal, like those used in many ultrasonic avoidance devices” (p. 197). Ways to improve the design of Smart Canes include making them lighter, having a variable tactile feedback intensity, including a floor detecting sensor, using rechargeable batteries, and providing a faster reaction time (Kim & Cho, 2013).

Another “smart cane”, called the AUDEO (Audification of Ultrasound for the detection of Environmental Obstacles) (Deacon et al., 2013) is currently being tested. It uses a continuous ultrasound signal (that is beyond human hearing range) and provides audible sound based on the size and distance of obstacles from the user through earphones. This device however seems to only detect obstacles at head height.

A new system called KinectSee based on using a depth camera (in combination with a long cane) which

converts the structures in the environment into sonic information to warn the user of objects has been described as needing just minutes to learn how to use (Häkkilä et al., 2013, p. 258). This system was inspired by human echolocators. The sound produced by the KinectSee can be modified for the user's needs. The sound is louder the nearer the object is to the user and indicates a left or right position by increasing the sound through the left or right speaker. The higher the pitch of the sound, the higher up the object is; and the lower the pitch of the sound, the lower the object is. The unit can be worn around the user's neck and pointed upwards or downwards to scan the area for objects. The researchers hope to develop the system so that it will be used via a mobile phone and a normal long cane. At the moment, the system can only be used effectively indoors. The sound can be easily deactivated for times that the user wishes to concentrate on other environmental sounds.

It could be arguably cheaper and more intuitive for users to generate their own echo signal than to buy and learn how to use a technical device that utilizes an artificial form of echolocation. FlashSonar would also be more accessible to users who are blind in non-technically developed regions which do not have the infrastructure to afford, train, or maintain the technology. However these canes or similar devices

could be useful for those that either cannot generate effective echo signals or are not able to hear them. A “smart cane” or other sensing device can detect objects about two to four meters away from the user and is easy to use for persons who already use a long cane because of similarities to a long cane (Kim & Cho, 2013).

It should be noted, however, that the technology in many of these canes, such as the ultra-cane and K-Sonar, weigh the cane down considerably, thereby producing a type of cane that cannot be used to the level of refinement and effectiveness that we would consider optimal.

Research has demonstrated that, when designing a high tech mobility device, “spatialized sound will be more effective in conveying . . . information [about the surrounding environment] than synthesized speech” (Loomis et al., 1998, p. 202).

In a qualitative study, Arditi & Tian (2013) asked ten people who were blind what sort of guidance system they would find most useful. The medium chosen for information was speech with a keypad system for inputting. “Most travelers who are blind highly value the acoustic information they receive about the environment and rely on it for many things,

including determining direction of vehicular traffic, acoustic landmarks, and echolocation, so the benefit of speech information that might mask other sounds important for travelling safely must exceed the loss or degradation of other acoustic information” (p. 126). “Our sample consisted only of those with very low or no vision rather than being inclusive of those with significant usable vision. We view this as a strength, however, since this is the very subpopulation who will benefit most from our envisioned device” (p. 128).

Regardless of the types of systems that may be designed in the future, it is important that the technology “should adapt to the user, not require adaptation by the user” (Davies et al., 2012, p. 131).

However, research into the use of SSDs has suggested that “echolocation may be utilized to successfully navigate through apertures while avoiding collisions, potentially increasing the spatial awareness and mobility of those who have lost their sight” (Kolarik, Timmis, Cirstea, & Pardhan, 2014, p. 983).

Can Virtual Reality Technology Assist the Visually Impaired?

Despite the amount of virtual worlds and games that exist, “virtual environments are currently barely accessible to the blind, as they are designed

mainly around visual contact with the user, and standard tools such as screen-readers for making computerized information accessible to the blind are not designed for this purpose” (Maidenbaum et al., 2013, p. 1). “3D virtual environments are increasingly used for education, business and recreation but are often inaccessible to users who are visually impaired, effectively creating a digital divide” (White, Fitzpatrick, & McAllister, 2008, p. 1).

The potential of Virtual Reality (VR) for persons with visual impairments is that “if one can find one’s way in a virtual environment before attempting to do so in the physical world, the chances of avoiding some potentially serious mistakes are much better” (Sjostrom & Rassmus-Grohn, 2001, p. 50). Caird (1996) agrees saying that “cases where VE [Virtual Environment] systems appear feasible is where injury and loss of life might be incurred during more realistic training exercises” (p. 125). Learning orientation and mobility skills in a virtual environment could be easier for some people, especially for those with multiple impairments or those who are anxious and need to build their confidence.

A system called BlindAid uses a haptic sensor Phantom and audio sounds in a virtual reality to familiarize people who are blind with an environment before

they experience it in reality. "Advanced technology, particularly haptic interface technology, enables blind individuals to expand their knowledge by using artificially made reality through haptic and audio feedback" (Lahav, Schloerb, & Srinivasan, 2009, p. 37). A user group felt that the virtual environment "resembled the way they explored real space with a long cane" (p. 48). Researchers suggest the system has four potential uses: (a) as a training guide for those that are newly blind to learn navigation skills in a safe environment; (b) as a tool to allow O&M instructors to track their students' progress; (c) to support people in learning a new environment before experiencing it in reality; and (d) for a multimodality version to allow all groups to explore public areas before visiting them (e.g., museums, shopping areas, university buildings etc.) (Lahav, Schloerb, Kumar, & Srinivasan, 2012).

Learning to cross streets in busy traffic environments can be frightening, especially for someone who has recently lost vision. "Training in a real environment where actual vehicles are running is sometimes dangerous and stressful for novice trainees" (Seki & Sato, 2011, p. 95). "It is difficult for the novice trainee to listen to important sounds selectively from many other environmental noises" (p. 95). A virtual training environment (that can be edited) was created

with ten possible sound sources such as vehicles, pedestrians and background noises and the ability for an O&M instructor to visually observe the position of a student in the VR through the monitor. The researchers tested 39 adults that were sighted and had no experience of O&M training. The “difference of the virtual and real environments was that the virtual training environment provided only acoustic cues simply, whereas the real training provided many other complex cues such as textures of ground, smells, winds etc.” (p. 99). “The virtual training group improved the veering most of the three groups” (p. 100) compared to the ‘no training group’ and those trained in the real environment. The explanation given for this was perhaps because “they could concentrate on acquiring the auditory orientation skill” and weren’t distracted (p. 100).

Three potential circumstances in which the BlindAid system could be useful were highlighted as: (a) a training simulator for O&M, (b) a diagnostic tool for O&M instructors, and (c) to explore unknown spaces perhaps even available on the Internet (Lahav, Schloerv, Kumar, & Srinivasan, 2015, p. 5).

Another experiment included 16 participants, 11 of whom had received additional O&M training on the BlindAid system and 5 who had not. The participants

who had received extra training performed tasks quicker, used more direct paths, and used other strategies rather than the perimeter compared to the control group (Lahav et al., 2015, p. 14).

Another computer system called the "EyeCane attempts to augment the classic white cane using sensors to detect objects from a greater distance (5m) and transforms this information into a simple auditory cue (the user hears a series of beeps, where the closer the object the user is pointing at, the higher the frequency of cues)" (Maidenbaum et al., 2013, p. 2). To test the system, 23 participants travelled through three virtual training routes. "The results clearly show that all participants both sighted and blind, were able to navigate all routes successfully following minimal training. These results suggest that the approach of using virtual canes in virtual environments is both feasible and beneficial to potential users, and enables them to perform virtual tasks which are otherwise impossible for them" (p. 5). "First, our extendibility into existing virtual environments, and second, the Virtual-EyeCane enables the user to receive identical input in both the real and virtual environment, and thus creates a far more similar experience for the user" (p. 6). At the moment the Eyecane is limited to just conveying information about distance. However, hopefully in the future, it could be developed

so that it can be used in combination with other computer simulations to provide other environmental information.

Spatial Awareness Using Sound

Virtual reality software is now capable of producing dimensional sounds. "The human hearing system has remarkable abilities identifying sound source positions in 3D space and allows directional positioning in space" (Haraszy, Cristea, Tiponut, & Slavici, 2010, p. 412). Haraszy et al. describe a future situation where they will be able to substitute visual reality with acoustical virtual reality, so that objects will generate sounds that can be interpreted by the listener to avoid them or to move towards them if they choose.

Easton and Bentzen (1999) created an acoustic environment with a head mounted sonar device. The participants (made up of 12 adults who were congenitally blind and 12 sighted students) had echolocation training for three to four months then were tested again. They had to give verbal estimates of the target distance. "The structured experience of acoustic flow in an enhanced acoustic environment improved the ability of the adults who were congenitally blind to keep track of the changing relationships between them and objects in their environment, especially with regard to distance" (p.

412). The researchers suggest that all infants who are congenitally blind should receive such training as this may help them learn spatial ability that sighted children would learn naturally during locomotion.

The University of Southampton created a game and educational program called "beat the dolphin" where the user can use echolocation sounds to identify four different objects. The game can also add ambient sounds to show how human made environmental noises such as a ship passing by interferes with the echolocation signal (Papadopoulos et al., 2009).

Standardized Measure of Echolocation

The Snellen chart is used as a standard measure of acuity for vision. To allow accuracy in echolocation to be compared to visual acuity, researchers invented a standardized measure for echolocation. "Functionally, echolocation for blind practitioners is similar to vision in that it serves to generate a spatial representation of the environment" (Teng et al., 2011, p. 485).

The measure is the Echoic Vernier acuity measure. The three best echolocators in the experiment (who were all early blind) had performance thresholds of less than 2°, this compares to a bat study in which the bats achieved 1.5°. "The subset of human echolocators who were blind from an early age shows spatial resolution comparable to that observed in

a species with specializations for echolocation” (p. 493). The researchers found a significant correlation between age of blindness onset and echolocation acuity. However, because “age and duration of blindness co-vary, future studies are necessary to disentangle whether age or experience is the critical factor for the extraordinary precision of echolocation found here” (p. 486). Participants who were sighted in the same experiment but using their sight to judge distance achieved a threshold of 1.4°. This “precision of echolocation is comparable to visual acuity in the periphery, which, when compared to foveal acuity, is quite poor” (Milne et al., 2014, p. 1835). The authors note that these experiments were conducted under highly controlled conditions, and it has yet to be studied how such levels of precision found in this experiment translate into a typical environment or movement situation.

Links Between Visual Impairment, Hazards, and Falling

“Intuitively, there are two main reasons why people with visual impairment are more susceptible to injury: They have fewer visual clues to alert them to potential hazards such as oncoming traffic, and home environments and workplaces have not been suitably adapted, for example, with adequate lighting” (Legood et al., 2002, p. 2). On a practical level, it would be

difficult to adapt every environment to make every visual clue into a verbal or tactile warning for those with a visual impairment; the amount of information would be too complex to convert and the feedback received would be too great in volume to be helpful.

Using both qualitative and quantitative methods, Manduchi & Kurniawan (2011) investigated the risk of falls and object collisions by asking more than three hundred persons who were visually impaired or blind questions about their travelling habits. Surprisingly there was no difference found between the frequencies of falls and head-level incidents for cane users versus guide dog users suggesting that “the type of mobility aid has little influence on these types of accidents” (p. 8). Neither the long cane nor guide dog prevented the individuals from having head-level collisions on a fairly regular basis. “13% of the respondents experienced head-level accidents at least once a month; 7% experienced falls while walking at least once a month” (p. 10).

“86% of the head-level accidents [self-reported by the respondents] happened out of doors . . . due to tree branches (the majority), poles and signs, construction equipment and trucks. Indoor incidents were due to doors and cabinets left ajar, shelf and tables, staircases (hit from side) and walls” (Manduchi & Kurniawan,

2011, p. 8). Many of these objects could be easily located, identified and then avoided using FlashSonar techniques.

“In 26% of the time, a head-level incident affected the respondent’s confidence as an independent traveler, with some avoiding certain areas and others opting for a sighted companion for their travels” (Manduchi & Kurniawan, 2011, p. 9). This is quite a troubling statistic because it suggests that some independent travelers with visual impairments, after experiencing a collision, restrict their mobility by not going to that place again or opt for assisted travel methods.

The “main causes of falls were (a) lack of attention to surroundings or to warnings from the guide dog, (b) unexpected objects where there were no objects before, and (c) misjudgment of distances or angles” (Manduchi & Kurniawan, 2011, p. 10). It should be noted that no data are available in this study concerning the type, quality, or quantity of instruction received by the participants. Furthermore, we have no information about the types of travel environments or other factors such as additional disabilities that may or may not have been diagnosed. These authors have not observed such travel concerns in experienced, seasoned blind travelers. The lack of attention to

surroundings is potentially a problem for any traveler, but an experienced confident traveler is probably more likely to subconsciously take in environmental clues and act upon them. Unexpected objects are not always going to be detected. A long cane will only detect objects that are about two to three steps in front of the user and below waist height, whereas FlashSonar can detect objects from a longer distance and above knee height (if the echolocator is scanning). A person using FlashSonar and a long cane is much more likely to detect the object and take evasive action.

Another study found “a positive association between falling and visual impairment in people over seventy five years of age” (Legood et al., 2002, p. 4). “The risk of falling is exacerbated in certain groups, such as older people, who tend to be more dependent on vision to maintain vertical posture” (Legood et al, 2002, p. 2). The lack of mobility for persons whose visual impairment is recent possibly contributes to this problem as does the prevalence of general health deterioration as people become older. A study comparing numbers of falls of elders whose visual impairments occur later in life and elders whose visual impairments occurred early in life might clarify the relationship between lack of adaptation to recent visual impairment and numbers of falls.

Unemployment

In the US population, “the yearly average labor force participation rate among working-age individuals with visual impairments ranged from about 40% in 2009 to 36% in 2012”(Kelly, 2013, p. 511). This percentage is similar to the UK where the “employment rate among the population of working age people who are registered blind or partially sighted is estimated as 33%” (Douglas, Pavey, Clements, & Corcoran, 2009, p. 4). One possible reason for low percentages of employment among persons with visual impairments is that travelling to and from work and even to a job interview may be difficult or overwhelming.

People who are blind or visually impaired and have better mobility skills may find it easier to find work. Thaler (2013a) discovered that blind people who used echolocation were statistically more likely to have a higher salary. “It is possible that for example the increased mobility in unfamiliar places as mediated through echolocation may have a positive impact on blind people’s professional autonomy and in this way also on their salary” (p. 7).

Improved mobility skills could include better cane skills, more effective traffic detection, use of FlashSonar, and more strategies for wayfinding.

Possible Developmental Delays in Children With Visual Impairments

While the bulk of research indicates a wide spectrum of developmental delay among blind children, other research (such as Ferrell, 1998) shows minimal losses, most of which are regained by school age. Much of the research about developmental delay has been criticized by Warren (1984) as being fraught with visual bias and lack of understanding about non-visual competence. Much of this developmental research confounds developmental disruptions that may be attributed directly to vision loss and those secondary to vision loss that may result from socially or environmentally restricted movement or from other external variables that impose limitation.

Ferrell's study, known as Project Prism, researched the development of children who were blind and partially sighted over a 5-year period starting from birth. "Results indicate that the greatest impact on developmental outcome appears to be the presence of disabilities in addition to visual impairment, although differences were also found based on gestational age at birth and some types of visual disorders" (Ferrell, 1998). Twelve milestones showed delayed development, while five milestones were the same as for children who were sighted and two milestones were acquired earlier. Children without additional

impairments acquired six milestones sooner than and four milestones within the range of typically developing sighted children. "At age groups 36-47 months and 48-59 months children with mild additional impairments were more like those with no additional impairments, suggesting that the effects of mild impairment may dissipate with age, while the effects of severe disability are sustained longer" (Ferrell, 1998). Premature children in the study reached milestones later than those who were born full-term.

Warren (1984) warns of the danger of direct comparison between sighted and visually impaired children. He says "the danger lies in the easy conclusion that developmental norms for the sighted population should be set as goals for the visually impaired population" (p. 275). He also points out that in some areas there does not appear to be a delay. For example, perceptual discrimination for texture, weight and sound do not show differences between children with normal vision and children with visual impairments. There is little evidence of developmental difference in language development.

Warren (1984) is also critical of conclusions being drawn from research which used small samples. He cautions that "because of the extreme heterogeneity

of the blind population, the sample chosen for any given piece of research may be quite non representative” (p. 319).

Warren recommends that more longitudinal studies should be carried out so that long term differences can be studied. He also points out that some researchers have used a common pool of children in successive studies and notes that the effects of this must be considered. It also may not be appropriate to use research models for sighted children in studies of children with visual impairments.

Finally, participant cohorts may be drawn from regions which differ widely in training practices or development opportunities, particularly in the areas of autonomous movement and self-reliance. For instance, many western European countries are known even to this day to provide little to no training in the use of the long cane for young blind children prior to primary school age—at least 5 or 6 years. This would be considered well beyond the ideal age of developmental readiness in other countries. Thus, research studies focusing on populations which have access to fewer developmental opportunities or are otherwise more restricted necessarily yield results that show delays or deficits which would not be represented in cohorts

where less restrictive developmental opportunities are more common-place.

However, regardless of the reason, some studies do show pervasive developmental delays among children who are blind or visually impaired. Such threats to development where they may exist can be addressed by self-directed discovery and FlashSonar.

“Vision is the main input sense for many aspects of development and contributes substantially to most; and because all five senses interact and are to a large degree interdependent, the impact of severe visual impairment on development is wide-ranging and cumulative, especially in the early months” (Sonksen, 1993, p. 1). Lack of vision can lead to developmental delay, especially when the parents do not encourage the child to explore. When this happens, “blind infants have limited opportunities to experience control over their environment” (Troster & Brambring, 1992, p. 222). This lack of self-directed movement and interaction with the environment can lead to further developmental delay and dependent behavior. In a study that examined children who are blind drawn from populations in and around Germany, it was concluded that, “The broad lack of self-initiated interactions in blind infants during their first year seems to be a direct consequence of the lack of those

motor competences that require visual-motor coordination" (Troster & Brambring, 1992, p. 211). "As a consequence the delayed acquisition of locomotor and fine-motor skills in the blind can be regarded as being predominately a direct consequence of the lack of visuomotor coordination. In contrast, lack of vision has less impact on areas of motor development such as postural skills that require no or only a limited integration of distal sensory information" (Troster, Hecker, & Brambring, 1994, p. 62). Children who are blind from this western European cohort, "show marked developmental delays in their ability to change posture and position and in self-initiated locomotion" (Troster et al., 1994, p. 71).

Preterm children who are blind often also experience developmental delay. "On average, they were able to sit steadily at about 4 months later than sighted children, could stand firmly about 20 months later, and there was a long delay before they could sit up by themselves (8.7 months) or stand up by themselves (23.4 months)" (Troster et al., 1994, p. 69). Interestingly "prematurity seemed to represent a greater risk to motor development than blindness" (p. 69).

To try to prevent or shorten the timeframe for developmental delay, all children with visual

impairments must be encouraged to investigate and explore their surroundings. (See Chapter Two for further information about self-directed discovery and its role in brain development and Chapter Three for strategies to facilitate and support nonvisual development). “Everyday environments must provide blind children with a variety of opportunities so as to help them to get meaningful auditory information and motivation to perceive space by means of the sense of hearing” (Hug et al., 2014, p. 2024).

Other Uses for Echolocation Skills

Echolocation could potentially be used by disciplines other than visual impairment. “In a fire-fighting context, the likelihood of having to operate in smoke filled spaces makes 3D sonar an interesting and potentially quite a useful complementary sensing modality to human vision” (Steckel, Vanuren, & Peremans, 2011, p. 2549). However, such an echolocation system would need to use earphones or a helmet because the noise of fire and water would make active echolocation impractical. In a further development of this concept, the BatSLAM is a navigation device that maps an environment using sonar and proprioceptive sensors. Its future uses are considered to be underwater or in environments with dust or smoke (Steckel & Peremans, 2013). As yet it cannot search the environment to find something, but

it can take the robot to a particular specified place. So, if it was suspected that there was someone trapped in a specific area of a blazing building, the BatSLAM could take the robot there to check the area.

Another way of using echolocation is a system that uses acoustic microphones to tell the shape of room. "As an extension of our method, a person walking around the room and talking into a cell phone would enable us both to hear the room and find the person's location" (Dokmanic, Parhizkar, Walther, Lu, & Vetterli, 2012, p. 12186).

Some previous research has been criticized for not involving persons with low vision or blindness in the design of equipment or devices that may help them because they are the useful group to consult (Smith et al., 1992).

Clearly it will be difficult to duplicate the complex human brain or match its complex processing system. "Humans might be said to exhibit three key components that enable them to be so effective at navigating and manipulating their world. These are: Sensors, such as the ears; the nervous systems; and the motor functions. Together these make up a most extraordinarily sophisticated cognitive system" (Smith & Baker, 2012, p. 1). The process of interpreting

echolocation via a computer will be difficult because “the sophistication of the human brain will be immensely challenging to replicate” (p. 2).

More Research is Needed

Although much research on echolocation has been conducted during the last 10 years, there are still many areas that need further investigation. Ferrell recognizes a need for more educational research on children with visual impairments and children with normal vision as “we are often left with best practices that are more philosophical than proven, more descriptive than empirical and more antiquated than modern” (Ferrell, 2007).

“An important issue for future research is to establish whether systematic training can lead to the acquisition of echolocation skills among blind adults who have failed to develop such skills, and also to establish whether training can enhance the acquisition of echolocation abilities among those who have newly lost their vision” (Kolarik, Timmis, Cirstea, Pardhan, & Moore, 2014, p. 65). Given the practical application of FlashSonar skills, it is important to research the best ways to effectively teach and pass on this knowledge. As FlashSonar instruction is not universally taught, more research would help raise its profile and

hopefully result in its incorporation into many more worldwide university programs.

Other areas needing further research that have been identified by Kolarik, Timmis, Cirstea, Pardhan, and Moore (2014) are (a) FlashSonar's effectiveness in rain or snow conditions; (b) how FlashSonar can be best taught to those with hearing loss, both congenital and age acquired; (c) examining the effect of background noise; and (d) to establish the functional benefits of echolocation.

The Benefits of FlashSonar

To summarize, FlashSonar is not a special skill, but one that can be learned relatively quickly by someone who is sighted or blind. "We believe that the use of echolocation should be more actively promoted in the blind community because, even if one learns to echolocate only at a very basic level, it would provide another resource for perceiving one's surroundings and gaining further independence in life" (Milne, 2014, p. 47).

Benefits of learning to use FlashSonar and making it a part of daily life, which have been discussed throughout this book, are summarized below.

- Basic training in FlashSonar shows an improvement in identifying echoes in just a few hours, so the benefits are quite immediate.
- Use of FlashSonar enhances freedom of movement and independent travel. FlashSonar can work in harmony with the long cane to overcome some of the long cane's limitations.
- FlashSonar allows the user more engagement with his surroundings.
- FlashSonar provides the user with details about an object such as its location, dimension and depth.
- FlashSonar allows the user to avoid or to identify and negotiate objects while travelling without physically touching them.
- FlashSonar allows users to walk more fluidly and gracefully because they do not have to stop to identify objects.
- FlashSonar can aid the user to stay on an intended path of travel.
- FlashSonar leads to improved ability to travel in unfamiliar places.

- Using FlashSonar keeps the head up, resulting in better posture. Keeping the head up also allows individuals to make the most of any residual vision they may have.
- Research has shown links between mobility competence and gainful employment.
- FlashSonar aids neural development by discovery based interaction with the environment.
- Echolocators' brains have been rewired because of brain plasticity to show improved spatial sound processing.
- Effective use of FlashSonar will involve physical movement, which can be lacking for those with vision impairment.
- FlashSonar has advantages over electronic travel aids because there are no batteries and no maintenance. FlashSonar is hands free and costs nothing.
- FlashSonar supports self-direction.

- FlashSonar leads to independence and choice because the user will have improved navigation and orientation skills.
- Structured learning can improve self-taught echolocation skills.
- The knowledge of learning FlashSonar can be passed onto other people.

FlashSonar Training

If you are interested in obtaining additional FlashSonar training, you may wish to contact World Access for the Blind (WAFTB) at www.worldaccessfortheblind.org. Since 2001, WAFTB has both designed and delivered practical, individualized training to more than one thousand students in forty countries throughout the world. This figure doesn't include those with cascaded knowledge, who have learned skills from those who attended courses. Most of WAFTB's instructors themselves have a visual impairment. Their approach is that self directed achievement is optimized by natural perceptual engagement, rather than a structured skills repertoire.

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