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Technologies to Facilitate Language, Sensory Processing, and Motor-Planning Capacities

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The rapid development and availability of technology is enabling many computer-assisted sensory, motor, and language training programs to be produced. There are hundreds of such programs available, and examples of the three types are included in this chapter. This chapter describes the contribution of technology to the area of *augmentative and alternative communication*, with some programs suitable for home as well as professional use. This chapter also briefly discusses the language therapies *Fast ForWord*® and *4wd*™, *Earobics*, and *The Sentence Master Program*, as well as a motor-planning and timing program, the *Interactive Metronome*®. In addition, auditory processing approaches using music are discussed. The programs described all have web sites that can be accessed for further information.

AUGMENTATIVE AND ALTERNATIVE COMMUNICATION

The field of augmentative and alternative communication (AAC) has found that it can combine assistance from technology with its basic efforts, and can make speech-language and the ability to communicate more widely available to populations with very special needs in this area. The AAC services, with the assistance of very creatively engineered technology products, are enabling many children and adults to interact with their world in spite of having little or no oral expressive language. Because humans have a universal need to communicate, AAC emerged as a service concept internationally, with the first efforts occurring during the 1960s in Canada, Sweden, the United Kingdom, and the United States. The International Society of Augmentative and Alternative Communication (ISAAC) has chapters in 11 countries and members in more than 50 countries. An international conference is held every 2 years in a different location. The organization recognizes the need to be research-oriented, and it follows each conference with a research symposium. There is also a journal, titled *Augmentative and Alternative Communication*, published by Decker. Much of this current information about AAC was graciously provided by Dr. Sarah Blackstone, past president of ISAAC. She is currently an AAC consultant, and has a web site that gives information about AAC as well as information regarding her widely read newsletter, *Augmentative Communication News*.

AAC serves groups of individuals with varying degrees of need within three general categories:

1. Individuals whose poor ability to speak is secondary to a primary organic condition,

such as cerebral palsy, aphasia, apraxia, multiple sclerosis, and traumatic brain injury, and who typically exhibit a big gap between their adequate receptive language and their lack of expressive language.
2. Individuals who are autistic or within the autistic spectrum.
3. Individuals who are physically able, but are, nonetheless, unable to engage in symbolic representation due to developmental delay or unknown cognitive disabilities.

AAC goals are grounded in speech-language communication. It is an ongoing process for most clients, over a considerable period of time, and requires a *team* approach. It starts with an analysis of a client's most immediate needs *at this time* in regard to communication and an assessment of his or her future needs, with the ultimate goal being independence. The AAC process involves working step-by-step toward the highest degree of independence in communication that a person can achieve. A *multidisciplinary* provision of services is necessary in accomplishing this goal.

Historically, the first AAC efforts involved Language Boards with pictures or, if the person was able to read, printed words and phrases to which the person pointed. Depending on the disability, a person in a wheelchair could find these boards physically difficult to handle. Manual signs were also used to augment the effort to communicate, and are still in use to some extent. The inclusion of technology started in England and Scotland in the 1970s, when electronic devices began to become available. There are more than 100 products available that use both synthesized and digitized speech. Some have become very sophisticated and somewhat difficult to use, which has led to a sense within the AAC community that these devices need to be made more user friendly. This improvement is most likely to occur through the Rehabilitation Engineering Research Centers (RERC) authorized by the Rehabilitation Act of 1973. The mandate of a RERC is to enhance opportunities for meeting the needs and addressing the barriers confronted by individuals with disabilities in all aspects of their lives. The Secretary of Education may make grants to public or private agencies to conduct research, demonstrations, and training activities related to rehabilitation technology, but the RERC must be operated in, or in collaboration with, an institute of higher education or a nonprofit organization. By most recent count, there are now RERC in 14 different locations.

For young children with cerebral palsy, Down syndrome, or autism, AAC serves as a bridge to speech-language communication. Its tools include manual gestures, signs, graphics, and print. These provide visible signs of communication that appear to stabilize beginning language input and enhance a child's ability to attend to it and acquire receptive language. Receptive language is the first level to be accomplished. Ultimately, however, AAC has a profound relationship with literacy. Until literacy is achieved, particularly the spelling aspect of literacy, the individuals are dependent on what someone else has put on their Language Board or in the technology device they are using.

For individuals who lack oral speech-language, or for whom the speed and ability to articulate oral language is extremely slow and burdensome, true independence in communication hinges upon their success in generating what they want to say in written language. For this reason, it is very important for AAC professionals to understand the role of phonemic awareness in literacy development, presented in the discussion of written language in

Chapter 23 in this volume. It has been reported that many individuals receiving AAC services are not literate, which severely limits their ability to use many of the technology devices or even a Language Board if it uses print. If these individuals have received traditional instruction in reading and spelling but have not been able to benefit from it*, a lack of phoneme awareness can be predicted*. If this is a need, it can and must be addressed, as phoneme awareness is a primary factor in literacy development. Age and intelligence do not guarantee the availability of this genetic tendency of phoneme awareness, but it can be developed by special procedures.

Practitioners in AAC have learned that the use of multiple systems is significantly more effective than the use of a single system. After a system for establishing or documenting some level of receptive language is successful, a current intervention of choice among AAC providers is The Picture Exchange Communication System (PECS). This system focuses on the initiation component of communication. In six phases of training, it integrates theoretical and fundamental teaching strategies from the fields of speech-language pathology and behavioral analysis. Its emphasis is on clarifying for family, residential-care providers, and educators the *how* of teaching initiation of communication rather than simply *what* to teach. The goal is the development of functional communication skills regardless of communication modality. PECS has been successful with individuals from preschool age to adults in a broad array of settings, and many preschoolers using PECS also begin developing speech. Training workshops for groups and programs are available both nationally and internationally, coordinated by Pyramid Educational Consultants.

Present research in AAC involves a federally funded, 5-year longitudinal study of the use of technology devices. Two groups in the study will receive AAC while using the devices, and one group will not use the devices. A pilot study found that devices help. Further research and sharing of experiences are needed to determine which individuals, with what types of abilities, benefit from what types of technology. The AAC goal is speech-language communication however it can best be accomplished, and the sense within the AAC community is that technology devices have their place as *one* of the many tools for individuals unable to speak. *Telerehabilitation* is a new element coming into play as the Internet is enabling expansion into distance access to AAC services. The issue of our aging population, the reality of strokes and other debilitating conditions that affect speech-language and the ability to communicate, and the fact that the Health Care Financing Administration (HCFA) is considering reimbursement through Medicare for AAC devices hold promise for impacting the expansion of AAC services and devices. What the future holds in full in respect to AAC and technology is yet to be seen.

LANGUAGE AND MOTOR PROGRAMS

There are a number of technologies that work on language functioning and a relatively new technology that works on motor-planning and sequencing capacities. The language technologies provide ways to exercise important language functions, especially receptive capacities. There are different theoretical rationales for the different approaches. Until there are comparative studies among the different technologies (and intensive speech-language therapy, employing the same number of hours as a particular technology) that can isolate the hypothesized mechanism of action, it will be difficult to know why a

given technology may help. For example, improvement might be the result of a general practice effect or a specific process, such as initially slowing down auditory input.

It is also vital to emphasize that the spontaneous, meaningful use of language is the cornerstone of progress. Computer-based technologies should not be allowed to detract from interactive play and conversation or peer play. In fact, during times of intensive computer-based work, it is important to increase dynamic interactive play and conversation to maintain the child's engagement, interactive capacity, flexibility, and creativity.

Fast ForWord® and 4wd™

These two computer programs work with the auditory and language processing abilities of individuals who have receptive language problems. *Fast ForWord®* was developed for children whereas *4wd™*, which uses the same technology as *Fast ForWord®*, was developed for adolescents and adults. The approach is based on research which shows that, at the rate phonemes occur in normal speech, language learning impaired (LLI) persons have difficulty accurately distinguishing short-duration consonants such as */b/, /d/, /p/, /t/* and even short-duration vowels such as /*e/, /i/* when they occur in proximity to other short-duration consonants. When these phonemes are electronically slowed down, and emphasized by increasing the intensity of the sounds, or when the time between the phonemes is lengthened, LLI persons may be able to perceive them more effectively. The programs start with phoneme segments that are electronically stretched and/or emphasized to the point where they become distinguishable for each student using the program. The programs also separate speech elements in time. Next, the programs repetitively adjust these rate, emphasis, and spacing elements until the brain's responses are trained and the ability to better process speech at the normal temporal rate is developed.

A number of research studies in this approach (Merzenich et al., 1996; Tallal et al., 1996; Tallal, Merzenich, Miller, & Jenkins, 1998) have been conducted, with encouraging results. It would be highly desirable to have additional, more specific information so comparisons can be drawn. For example, within the total number in the representative populations, how many students did not move into the average range on the various measures? In addition, there need to be comparative studies that contrast this approach with other similar approaches or with an equal number of hours of speech-language therapy.

Earobics

Earobics is an auditory-processing and phonics program with two levels: *Step 1, and Step 2*. The content is chosen and organized to teach phonemic awareness and auditory-processing skills. Using an interactive game format, *Step 1* provides 6 games with up to 114 levels of difficulty to be mastered within each game. This allows practice with each type of task presented. Acoustically modified speech, adaptive training, and careful control of learning variables are techniques given attention.

The *Earobics Clinician Version, Step 1*, provides professional users with the ability to customize the program for students through the selection of games and starting levels, the ability to skip or repeat levels, and the ability to keep records on each student, generate reports, and cite learning objectives for each activity in the Individual Educational Program (IEP) format required by many schools. There is also a *Home Version*, *Step1*, which does not include the customizing features of the *Clinician Version.* The *Earobics,*

Step 2, program continues building the phonemic and phonological awareness skills addressed in *Earobics, Step 1*, and provides practice in phonics activities and various auditory-processing skills. A clinical study with third- to fifth-graders identified as having central auditory processing disorder (CAPD) and/or as learning disabled based on language impairment (LI), and a public school study comparing *Earobics* effectiveness with two other programs are reported as completed, but analyses of the data are still in progress.

The Sentence Master

The Sentence Master is a linguistically based reading program that integrates computer activities and print materials to focus on developing automaticity in the reading of more than 350 frequently occurring *non-content* and *content* words. This program, designed by psychologist Marion Blank, is for children and adults who are at risk for reading difficulty or who have already had problems in reading. The program links diagnosis and intervention with structured materials and motivating rewards to address and overcome language deficits known to exist for the majority of poor readers; that is, problems with *naming, syntax*, and *comprehension.* Phoneme awareness development is not included, but Dr. Blank recognizes its contribution to decoding and recommends including a phoneme-awareness training program concurrently with her program for students who need it. Activities in the three areas of naming, syntax, and comprehension are included in each of the four levels of reading instruction.

No formal research on this approach is available at present, and this is needed. Sites using *The Sentence Master* could make an important contribution by organizing to collect data on program effectiveness with the different populations it serves.

Interactive Metronome® (IM) Motor Planning and Rhythmicity Program

The IM intervention has findings from several studies indicating that it appears to work on *underlying* processes involved in motor planning, sequencing, timing, and rhythmicity that support motor, cognitive, and learning processes. In the IM program, the participants complete seven movements by keeping pace with the metronome beep. Through the computer program, they receive feedback that enables them to establish a close connection between the metronome beat and then their own motor patterns. The movements include patting knees with both hands, clapping hands together, patting knees with alternating hands, patting knee with preferred hand, patting knee with the non-preferred hand, and toe-tapping the floor pad with alternating feet. In many types of learning and developmental challenges, motor planning and sequencing are involved in problem solving and other adaptive actions as well as in executive functions, such as organizing information and planning. In the past, it has only been possible to work with these capacities clinically.

In a recent study of the IM intervention, an attention deficit hyperactivity disorder (ADHD) population of 56 boys, ages 6 to 12, was randomly assigned to three groups and compared for findings on selected aspects of motor, attentional, and cognitive skills. The IM group received 15 hours of training, a placebo video group received an equal number of hours of training on selected nonviolent computer video games, and the other control group received no intervention. Each participant was pre- and post-tested with published tests in four areas of performance: attention and concentration; behavioral functioning; sensory and motor functioning; and academic and cognitive skills, including reading.

The IM group showed statistically significant improvements over both of the control groups in attention, language processing, reading, and the regulation of aggression. This study will be published in the *American Journal of Occupational Therapy* (Burpee et al., in press; Shaffer et al., in press). Other studies have suggested that IM is helpful for children with special needs and show correlations between IM performance and academic performance (Kuhlman & Schweinhart, in press; Stemmer, 1996). Current studies include work with different developmental and learning challenges and studies of IM performance as a diagnostic tool for categorizing types of motor-planning, sequencing, and timing differences in children and adults with developmental and learning challenges. Additional research on larger populations that look at patterns of improvement in relationship to severity of challenge and other clinical characteristics is needed.

AUDITORY PROCESSING THERAPIES USING MUSIC

Evidence is accumulating that when there is delay in speech-language development, various interventions can be offered at the *sensory* level that may help the emergence of relating and communicating behaviors. Music therapies are one type of sensory therapy being offered. Stimulation with classical music in highly structured experiences is provided in three of these interventions: the *Tomatis*, the *SAMONAS Sound Therapy,* and the *Berard Therapy.* These therapies are theorized to generally have a balancing or integrating effect between the left and right hemispheres and to improve comfort in the world of sound. At present, there is a problem in predicting which individuals may benefit from them, and there is insufficient formal research on their effectiveness, with some conflicting reports (American Academy of Audiology, 1993). However, there are many anecdotal reports of gains and a number of studies involving a small number of subjects that suggest improvements in aspects of auditory processing and social communication (Bettison, 1996; Edelson et al., 1999; Gravel, 1994; Highfill & Cimorelli, 1994; Madell, 1997; Madell & Rose, 1994; Porges & Barzhenova, 1997; Rimland & Edelson, 1991; Rimland & Edelson, 1994; Rimland & Edelson, 1995; Veale, 1994; Woodward, 1994). It appears to be a promising area, and is in the process of being researched.

The Tomatis music therapy was developed in the l950s by Dr. Alfred Tomatis, a French physician. It filters classical music through an Electronic Ear, initially blocking some high and low frequencies and then including them later. Input is first given to just one ear, then to the other, and later to both. Amplitude modulation of the signal is also used. Therapy is given in daily segments, in periods spaced over 2 to 3 months. The program is currently administered in more than 200 Tomatis centers worldwide. Its effect on a variety of problems are described in Tomatis' book, *The Conscious Ear*, and include voice and speech difficulties, developmental disturbances, and postural and social problems. Many parents are also reporting helpful clinical results, including improvement in reading, and efforts are being made to establish formal research.

SAMONAS is an acronym for *Spectral Activated Music of Optimal Natural Structure.* Ingo Steinbach, a German physicist, sound engineer, and musician, developed the intervention after years of studying the work of Dr. Tomatis. He discovered that, although the human ear can only process frequencies up to 15,000 Hz, the brain can detect frequencies above that. He developed special recording and playback techniques that provide these

higher frequencies on his compact disks (CDs), which he believes challenge the brain to function at higher levels and enhance the therapeutic value of music by facilitating alertness and interest. The SAMONAS program uses classical music on all CDs, with the exception of one that uses the sounds of nature. Some of the CDs are only available to professional therapists, while most are available to parents or others along with extensive directions regarding their use.

The *Berard* approach was developed in the 1960s, by Dr. Guy Berard, a French otolaryngologist/audiologist. This approach was introduced in the United States in 1991, and is also called *Auditory Integrative Therapy (AIT).* Berard worked with Tomatis and developed his own modifications. The first step of AIT involves a detailed audiogram: an individual is considered an appropriate program candidate if there are peaks of hypersensitivity or if there is hyposensitivity at certain frequencies. The individual takes another audiogram after 5 hours of listening to determine whether the auditory peaks are still present and whether new peaks have developed. A third audiogram is conducted after an individual completes the listening sessions. The listening sessions consist of two 30-minute sessions per day for 10 consecutive days, during which a person listens through headsets to ever-changing and unpredictable electronically altered music from an Audiokinetron device. Frick and Lawton-Shirley, occupational therapists, report on their web site that, in treating more than 300 children and adults, they have found persons with known vestibular dysfunctions to appear to make the greatest gains. There are also reports of some children increasing their sensitivities to sound rather than decreasing them. The American Academy of Pediatrics issued a policy statement in 1998 that, until further research information is available, AIT should be considered controversial, and pediatricians should provide guidance and assistance in obtaining and reviewing information for families considering this treatment option.

Clearly, more research is needed on technologies working with auditory processing. Until there is definitive research available, all aspects of a child's presenting symptoms and functioning should be weighed, and each family and the child's clinicians must make a careful decision whether to try one of these approaches. Nevertheless, this is an emerging area of intervention to watch and consider on an individual basis while it is under study.

SUMMARY

In addition to the programs described in this chapter, many other programs are available that use technology to assist the development of language, sensory processing, and motor-planning abilities. Most of them have web sites on the Internet, and many offer free demonstration CDs. A factor to be concerned about in evaluating their benefits for a given individual is whether, in assessing response errors, the programs assist the individual in analyzing the *nature* of their errors, rather than simply counting the number of right responses. The goal should be self-correcting behavior. Determining the nature of errors enables children as well as adults to consciously monitor and attend to what *causes* their errors so that, ultimately, they do not commit the same errors again and have to be corrected afterward.

Another factor to keep in mind is that learning to learn is a complex process that is sensory-based. We must keep alert to the difference between activities that require *application* of a particular sensory or language processing capacity, and those that *develop* a capacity so that it is available to be applied. In this respect, it is evident that some technology-assisted programs are complementary.

Rather than thinking of these programs as being competitive and researching their individual effects in comparison to each other, perhaps we should be researching how they could be sequenced, or whether they should be used concomitantly, for the best results. Many individuals have lives that are "on hold" because their sensory and/or language *processing* needs have not been identified and/or addressed adequately. For their sake, we can not afford to approach program effectiveness research only from a competitive stance. Research on complementary use of certain programs might result in these individuals realizing their potential for communicating and learning sooner and more fully. ■

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