DICHOTIC LISTENING TRAINING and CAPDOTS (CAPD Online Therapy System)

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Inaccurate communication provides a wealth of material for comedians. Misunderstandings have us laughing hysterically at Jerry Seinfeld while literal interpretations can have us bending over in stitches at the antics of Mr Bean. We easily identify with the way communication can change situations and relationships because we encounter it repeatedly in our daily lives. These encounters are quickly resolved with an explanation or apology. However, when poor communication occurs consistently – enough to disrupt interpersonal relationships, thwart academic or cognitive performance and threaten self-esteem, this 'comedy' can turn dark and the consequences negative.

Listening deficits have been described anecdotally for decades by teachers, therapists, psychologists, spouses, friends, parents and many others. The first suggestion of a listening disorder affecting learning was made by Helmer Myklebust in 1952 (Jerger, 2009) who noticed children who despite having normal hearing abilities still suffered poor language development. Since then, the term Central Auditory Processing Disorder (CAPD) has become increasingly familiar with a growing awareness amongst academics and the public.

CAPD

We use the word "listen" hundreds of times in our daily interactions – at work, at home, recreationally and socially. While the meaning of "listen" is tacit and its use prevailing, defining listening and a listening disorder are more elusive.

CAPD is a deficit in the perceptual processing of auditory information originating in the neurobiology of the Central Auditory Nervous System. It encompasses specific components including sound localization, lateralization, discrimination, pattern recognition, the perception of degraded or competing signals, and the temporal aspects of spoken language (ASHA, 2005). The specificity of this definition, therefore, necessitates exact diagnostic testing by qualified professionals before a diagnosis of CAPD can be confirmed. Such testing can indirectly allow the audiologist to make suppositions regarding the integrity of the ipsilateral or contralateral auditory pathways and the auditory cortical regions.

CAPD can occur in any individual – children, adults and the elderly. Its etiology is diverse - it can arise from distinct causes such as neurological lesions, head injuries or the use of neurotoxic drugs. Most often, however, CAPD occurs as a result of diffuse neurological dysfunction that is not related to specific events or injuries and is often manifested as difficulties with learning, language and reading. CAPD is also frequently a component of the aging process (AAA, 2010).

The functional impact of CAPD is extensive and affects developmental, educational, communicative, social, occupational and psychological realms. Besides the obvious consequences of weak academic performance, particularly in the language arts, CAPD may also contribute to the lack of self-confidence, inability to use verbal language to facilitate inter-personal relationships, lack of attention or focus and even school drop-out.

While the diagnosis of CAPD relies on specific audiological testing, its treatment and intervention may be multidisciplinary with input from speech-language pathology, psychology, occupational therapy, educators, parents and audiologists.

DICHOTIC LISTENING

Dichotic listening is required when different and competing auditory stimuli are simultaneously presented to each ear. It is a fundamental auditory processing skill that engages the contralateral auditory pathway, while suppressing the ipsilateral pathways. Since its first use more than half a century ago by psychologist Donald Broadbent in 1958, dichotic listening has become a cornerstone for our current knowledge of audition and CAPD, itself, through the work of Doreen Kimura in the 1960s.

Broadbent was interested in studying the ability of air traffic controllers who were able to process simultaneous information from multiple aircraft. He developed a test in which one or more pairs of digits were presented simultaneously, with different digits in each ear and the subject was required to repeat all the digits back. This became known as the dichotic digits test with a primary goal of determining how many channels of auditory information could be concurrently processed.

In 1967, Doreen Kimura, a neuropsychologist used Broadbent's dichotic digits test and other speech-based dichotic tests on subjects with neurological disorders. She noted a recurring deficit in the ear opposite to the side of unilateral temporal lobe lesions. This interaural asymmetry is now referred to as Ear Advantage which forms the basis for the current callosal relay model of dichotic listening (Keith & Anderson, 2007).

For auditory language to be perceived and understood, it must be received by the language-dominant cerebral hemisphere – and in most individuals this is the left-side. In these cases, under dichotic listening conditions, stimuli presented to the right ear will transfer directly to the left hemisphere; stimuli presented to the left ear transfers first to the right hemisphere and then needs to traverse the corpus callosum in order to reach the left hemisphere. As such, stimuli presented to the left ear is required to travel further to reach its destination and any delay in this callosal processing will result in a Left-Ear Deficit or Right-Ear Advantage (REA) as seen in Figure 1.

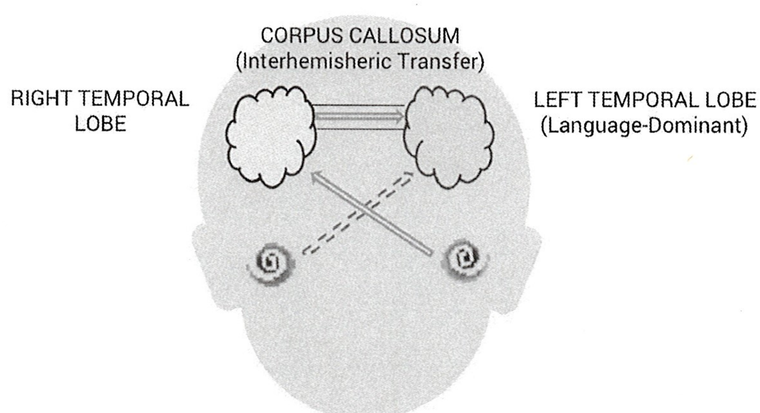

FIGURE 1: Schematic diagram showing Kimura's model of dichotic listening and the corpus callosal relay pathway for prevailing left (language-dominant) individuals.

Dichotic listening requires the integrity of the primary auditory cortices as well as the interhemispheric connections between them; and is a measure of temporal lobe function, attention, stimulus processing speed and language dominance asymmetry (Hugdahl & Helland, 2013).

DICHOTIC LISTENING DEFICITS

There are two types of dichotic listening deficits: if the stimuli in both ears are to be recalled then the task is referred to as integration and CAPD associated with this process is termed a *binaural integration disorder*; if one stimuli is to be recalled and the other ignored then the task is referred to as separation and CAPD associated with this process is termed *binaural separation/selective disorder* (Bellis, 2003).

It is uncommon and unlikely for parents and educators to identify auditory processing weaknesses with pattern recognition, distorted speech perception or temporal processing deficits. More conceivable would be comments related to behavioural symptoms and ultimate functional impacts from CAPD. These may include difficulty understanding speech in background noise, frequent requests for repetition, difficulty following complex directions, weak auditory attention and academic difficulties amongst others (AAA, 2010). Table 1 outlines the most common complaints and behavioural manifestations of those with Binaural Integration and/or Separation Deficits.

TABLE 1: Behavioural Symptomatology of Binaural Integration Deficit.

AUDITORY COMPLAINTS :
Significant difficulty hearing in background noise or multi-speaker environments
Gets overwhelmed or over-stimulated in busy settings
Difficulty understanding complex, multistep, group or inferred instructions
Vacillates between hyper-focus and distractibility dependent upon task
Reacts excessively to sound and noise
Tunes out during lengthy auditory inputs
RELATED SEQUELAE :
Needs explicit instructions, unable to read between the lines
Often comments: "I don't get it"
Poor multi-tasker with tendency to disorganization
Difficulty taking notes or dictation
Difficulty with word attack and reading comprehension
May be associated with multimodality challenges

Right-Ear Advantage (REA) is present in the majority of individuals (96% of right-handed and 70% of left-handed individuals) and reflects the typical left hemisphere dominance for language (Keith & Anderson, 2007). However, deviations from this typical representation is indicative of a Dichotic Listening Disorder of which there are 3 common types:

1. A dichotic processing disorder may be identified when the REA is atypically large for chronological aged norms. Bellis (2003) found that the right ear scores of young children did not differ significantly from an adult, while scores on the left ear were weak but naturally improved with age. As children get older, then, interaural difference and REA declines rapidly reaching adult levels by age 10 or 11 years. An *atypically strong REA*, not commensurate with normal auditory development, may be indicative of a neuro-developmental immaturity and a dichotic listening disorder.
2. A second indicator of dichotic listening disorder can occur where a significant *Left Ear Advantage (LEA)* exists. This is highly atypical and is consistent with mixed or reversed hemispheric dominance which is associated with language and learning difficulties (Keith and Anderson (2007).
3. It is also possible to get *binaural deficits* on dichotic listening tasks with no Ear Advantage, suggesting that the left temporal lobe (dominant, language hemisphere) as well as the corpus callosum may be involved (Bellis, 2003).

STAGGERED DICHOTIC LISTENING TRAINING

Dichotic listening as an auditory training procedure was first adapted by Musiek & Schochat (1998) and referred to as DIID (Dichotic Interaural Intensity Difference). This form of DIID training allows for dichotic stimuli to be presented at differing loudness levels in each ear. Loudness levels are then adjusted to approximate equal loudness in both ears as an individual moves through the training.

Staggered dichotic listening training differs from DIID by altering the interaural time lead/lag differences as indicated. One ear is presented with a stimulus slightly earlier than the other ear. This timing difference steadily decreases to increase the task difficulty as the program advances until the dichotic stimuli are presented simultaneously.

There are several compelling reasons for using a staggered dichotic listening paradigm in auditory training and CAPD intervention:

1. The corpus callosum plays a pivotal role in our current understanding of the callosal relay model. It is a band of heavily myelinated fibres that link the two cerebral hemispheres. The main purpose of the myelin sheath is to increase the speed of neural transmissions. Musiek et.al. (1984) have suggested that that myelination process may be key to the maturation of dichotic listening skills. The implication is that a lack of speed in neural processing may be responsible for impaired dichotic listening.
2. Strong REA is well documented to be part of the normal maturation of the auditory system in young children and decrease to adult values as children reach adolescence. The acquisition of adult REA values coincides with the time at which the corpus callosum is known to be fully myelinated, a time when maximum speed of neurological processing is attained (Keith & Anderson, 2007).
3. Several studies have compared reaction times to right and left ear targets under dichotic conditions. Jancke (2002) reported that right ear dichotic syllables were identified more accurately and more quickly than left ear syllabic targets both on right-handed and mix-handed subjects. Reaction times have been found to be 10 – 50ms faster for right ear targets than for left ear targets (Keith & Anderson, 2007) suggesting that processing speed is a factor in dichotic listening.
4. Jerger et.al. (2004) studied a pair of twin girls, one of which was suspected of having CAPD and the other not. Using diffusion tensor magnetic resonance imaging (DTI), the authors reported that the twin with poor dichotic listening presented with reduced myelin integrity leading to the conclusion that interhemispheric communication may be impaired by reduced or incomplete myelination.
5. The Staggered Spondaic Word Test developed by Katz (1962 cited in Katz, 1994) is an extensively used dichotic test using lead/lag time differences. Dichotic spondaic words are presented with a timing difference such that the second syllable of the first spondee overlaps with the first syllable of the second spondee on the other side. Berlin et.al. (cited in Musiek et.al. 2008) suggested that as interaural timing differences are decreased, reliance on contralateral auditory pathways are increased. In this way, by staggering the timing onsets of the dichotic stimuli, auditory training can be gradually made more challenging and to achieve performances approximating normative data.

CAPDOTS

Basic Design

CAPDOTS is an online CAPD therapy program that provides intervention for dichotic listening deficits using a staggered dichotic listening paradigm. The goal of dichotic listening training is to improve the performance of the poorer ear and indeed, both ears to within normal range, thereby allowing for improved interaural symmetry. CAPDOTS addresses Binaural Integration Disorders with its module CAPDOTS-Integrated (CAPDOTS-I), and Binaural Separation/Selective Disorder with its latest module CAPDOTS-Selected (CAPDOTS-S).

CAPDOTS-I presents a variety of dichotic stimuli in staggered lead/lag time differences. The lead/lag differences are largest at the Basic Level with nominal overlap, progressing through the Intermediate Level, and finally reaching the Advanced Level with simultaneous presentation - where there are no lead/lag time differences between the dichotic stimuli as seen in Figure 2.

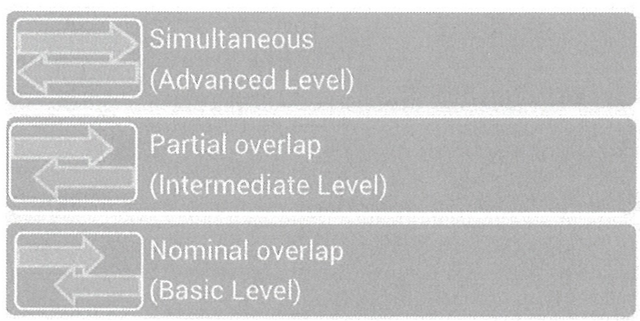

FIGURE 2: Schematic of increasing levels of difficulty by decreasing time lead-lag differences of dichotic stimuli in CAPDOTS-I.

The client repeats what is heard in both ears using free-recall and an assistant (usually a parent, older sibling or school support worker) scores the responses on the website. It is recommended that the training exercises are done 5 days per week, 30 minutes per day and is expected to take about 12 weeks to complete.

CAPDOTS-S contains prose and short stories parsed into phrases and sentences which are presented to the weaker (focus) ear. Discourse by the same reader is presented to the competing ear at intensity levels lower than the weaker (focus) ear. The intensity differences are largest at the Basic Level with the largest signal-to-competition ratios, progressing through the Intermediate Level, and finally reaching the Advanced Level where the signal and the competing discourse are both of equal loudness.

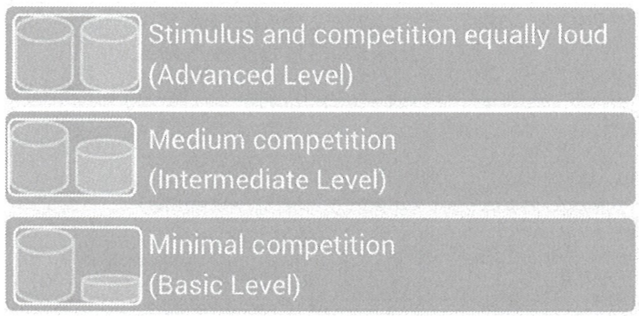

FIGURE 3: Schematic of increasing levels of difficulty by decreasing signal-to-competition ratios of dichotic stimuli in CAPDOTS-S.

The client repeats verbatim what is heard in the focus ear while ignoring the competing discourse in the other ear. An assistant scores whether target words have been repeated or not. Training on CAPDOTS-S is recommended to be done 5 days per week, 20 minutes per day ranging over approximately 12 weeks.

Both CAPDOTS-I and CAPDOT-S are online therapy modules that can be accessed either in the clinic or remotely from home, school or even on vacation.

Features of CAPDOTS

1. **Facilitates learning**
   Active participation is required in CAPDOTS as the client is required to repeat the stimuli in free recall mode. A list of dichotic pairs are presented to the client and the % correct scores calculated. Failure to pass a list will then oblige the client to repeat the same list but with a longer lead/lag difference. This slows down the presentation of the dichotic stimuli making it easier for a client to discern the dichotic stimuli. Once the slowed level has been presented,

the list is repeated again at the current faster level. This method of presentation allows for training and learning opportunities if a client is unable to pass a list and also allows for a review of skills at lower levels of difficulty if the original list proves too challenging. Progress requires reasonable proficiency of each level before proceeding to the next.

2. **Formalised Clinical Protocol**
   CAPDOTS utilizes a formal clinical protocol to ensure uniform auditory training across all clients to maximize therapy outcomes. While all clients need to follow the same protocol, it is possible for clients to move more quickly through less demanding levels and to spend more time at levels which are more challenging. Having all clients move through all levels ensures that all tasks can be reasonably mastered with an objective measure that both the client and the clinician can utilize. The use of scores allows for performances to be checked and compared, weak areas identified and progress tracked.

3. **Intense Auditory Training**
   Neuroplastic changes require frequent and intense auditory training and therefore necessitates that CAPDOTS be available at the convenience of its client. Frequent visits to a clinic over an extended period are often unfeasible, jeopardizing curriculum completion as other scheduled appointments and demands interfere. CAPD children are also prone to auditory fatigue and completing auditory training after-school before a clinic closes can be draining and overwhelming. Training sessions can, therefore, be variable and take place when daily schedules allow for more time – for example, following a break after school or whenever it is deemed a "good" time for both the client, the assistant and the family. CAPDOTS is an online system that can be accessed through an internet connection and be completed both at practical times and convenient places to the client and assistant.

4. **Online Therapy System**
   The client's participation and progress is monitored remotely by the clinician who ensures that the exercises are being done regularly and frequently. Progress through the different stimuli and through the different levels can be checked at the expediency of a busy clinician. The flexibility of CAPDOTS as an online training program maximizes the chances of successful completion especially when there are limited time, financial and energy resources available to the client, the assistant and the clinician.

5. **Versions**
There are 3 version available in both CAPDOTS-I and CAPDOTS-S: Junior (5 – 8yrs), Adolescent (9 – 13yrs) and Adult (14 yrs and older). The versions differ in the length of daily auditory training as well as the choice of stimuli based on vocabulary, syntactical complexity, content and task difficulty. Progress trackers and motivational pictures are also age appropriate in each version. While dichotic listening skills often reach adults levels by the early teens, older children and adults often require more challenging dichotic material which may be a reflection of top-down, cognitive processing that takes place in the more mature brain.

6. **Multispeaker Simulation**
Exasperation in multispeaker environments by CAPD sufferers often generates frustrated comments such as: "I can't hear if more than one person is talking at a time". "One at a time, please! Quiet, I can't think!" The use of staggered dichotic listening training simulates multispeaker environments with overlapping and competing speech as this is one of the most common complaints in binaural integration deficits.

This staggered dichotic listening adaptation as an auditory training paradigm has been referred to as DIID-II (Musiek, Weihing & Lau, 2008) and used in Integrated Werks (Weihing & Musiek, 2013) in previous literature - and is now presented as CAPDOTS. The paradigms used in each of these references (DIID-II, Integrated Werks, and CAPDOTS) are identical and the terms interchangeable.

Laterality Considerations

The ability to shift attention to a pre-cued side thereby enhancing the scores in that ear have been reported by Hugdahl & Helland (2013) such that natural ear advantages may be altered artificially and temporarily depending on verbal instruction. This conscious shift in attention to a particular side is also seen in some individuals who become self-aware of their difficulties in the weaker ear and attempt to compensate for that weaker side. It is quite prevalent in CAPD adults but also in a significant number of CAPD children. In addition, the longer a dichotic task continues, the more likely an individual will become aware of the asymmetry. In these cases, a binaural deficit may be observed as the one ear improves but often to the disadvantage of the other ear.

In CAPDOTS-Integrated, the attempt to compensate on the weaker ear to the detriment of the stronger ear is acknowledged and accommodated. While this top-down, cognitive processing (Hugdahl & Helland, 2013) is a naturally occurring phenomenon, it can inhibit the training of bottom-up dichotic listening skills. It then becomes necessary when training binaural integration skills and interhemispheric transfer functions, that dichotic listening training should occur bi-directionally irrespective of ear advantage.

CAPDOTS-I does not require the clinician to choose a focus ear as each ear acts as a leading ear in half of the program, and as a lagging ear in the other half of the program. CAPDOTS-I can be used with atypical REA, LEA or bilateral deficits.

Recency Effect

Interaural timing differences can also affect dichotic listening outcomes. If there is a difference in timing between one ear and the other, the lagged ear will be perceived more easily than the leading ear. This is known as the "recency effect" and refers to the phenomenon that recent stimuli are recalled with greater ease and more accuracy than remote stimuli (Weihing and Atcherson, 2013). The recency effect is neutralized in the CAPDOTS-I design as each ear shares the lead or lag position equally.

Special Population: Hearing-Impaired

Since staggered dichotic listening does not require the manipulation of loudness intensity of the stimuli, the procedure is highly amenable for use with the hearing-impaired. While CAPD as a component of central presbycusis is acknowledged (Weihing & Atcherson, 2013), treatment and intervention is limited by the hearing loss per se. By creating equivalent loudness levels on both sides either with the use of the loudness balance function on the computer, or with the use of hearing aids accessed through bluetooth technology, the staggered time overlap allows for increasing levels of difficulty while controlling for hearing loss (Musiek et.al., 2008). The results of 3 such case studies using hearing aids with bluetooth accessibility have revealed noticeable improvements in hearing in background noise, improved auditory memory, less miscommunication and fewer misunderstandings. One case study who had been identified as a difficult colleague reported: "I'm not arguing as much with people. I seem to be getting along better" (Lau, 2014).

The advantages of CAPDOTS as a dichotic auditory training program are summarized in Table 2.

TABLE 2: Benefits and Advantages of CAPDOTS.

- Online application that maximises flexibility and convenience for the client and clinician.
- Does not require special equipment – internet access, two pairs of headphones and a splitter.
- Formalised, clinical protocol ensures standard, uniform auditory training to maximise therapy outcomes.
- Progressively difficult stages over 3 levels – basic, intermediate and advanced.
- Variety of acoustic stimuli modified to accommodate 3 age groups – Junior, Adolescent and Adult.
- Rigorous, frequent and intensive training conducted 5 days per week allows for neuroplastic changes.
- Progress in program requires reasonable mastery before proceeding to following stage.
- Progress tracker and reward system sustains interest, maximises compliance, decreases drop-out rate and ensures continued best effort.
- Simulates multispeaker environments.
- Can be used with hearing-impaired.
- **Does not require the selection of a focus ear – can be used on REA, LEA or bilateral deficits identified on dichotic listening tests.**

CAPDOTS-I RESULTS

Musiek et.al. (2008) reported on a pilot study by this author in which 14 children with diagnosed binaural integration deficits were treated with the first manual implementation of staggered timing onset (DIID-II). The results revealed significantly better performance on the poorer ear ($p<0.001$) with an average improvement of 30% on the Dichotic Digits Test and the conclusion was that altering interaural timing onsets could improve dichotic listening.

A web-based prototype based on staggered timing onset (Integrated Werks) was administered to 45 normal hearing subjects comprising 17 females and 28 males who were also diagnosed with CAPD, Binaural Integration type (Lau, 2012). Their average age was 9.11 years with a range 6.9 yrs to 18.3yrs. Intervention was completed as a home-based, parent-assisted program over a range of 12 – 14 weeks. Training was done for 5 days a week, 30 minutes per day. Pre- and post-training scores were then compared with the average time lapse between testing at 5.0 months to minimize contamination from maturational effects. The results indicated:

- Highly significant improvement ($p<0.0001$) in left-ear scores on the Dichotic Digits Test
- Significant improvements ($p<0.001$) on SCAN-Competing Words Standard Score and Percentile Rank, right ear performance on Dichotic Digits Test
- Significant improvements ($p<0.05$) on SCAN-Auditory Figure-Ground Standard Score and Percentile Ranks.

Figure 2 compares average scores on SCAN-Auditory Figure-Ground (SCAN-AFG) and SCAN-Competing Words (SCAN-CW) for both standard scores (SS) and percentile ranks (PR). Post-training test scores after CAPDOTS-I show an average improvement in standard score of 1.5 for SCAN-AFG ($p < 0.05$) and an average improvement in standard score of 2.0 for SCAN-CW ($p < 0,001$).

Figure 3 displays pre- and post- training test scores after CAPDOTS-I for % correct scores for right and left ear performance on the Dichotic Digits Test. Both males and females displayed improvements bilaterally, greater in the left ear than the right ear. An analysis of the total group ($n>45$) shows that the left ear improved by an average of 15.5% ($p < 0.0001$) and was greater than the right ear average improvement of 8% ($p < 0.001$), with a resulting increased interaural symmetry and reduced REA.

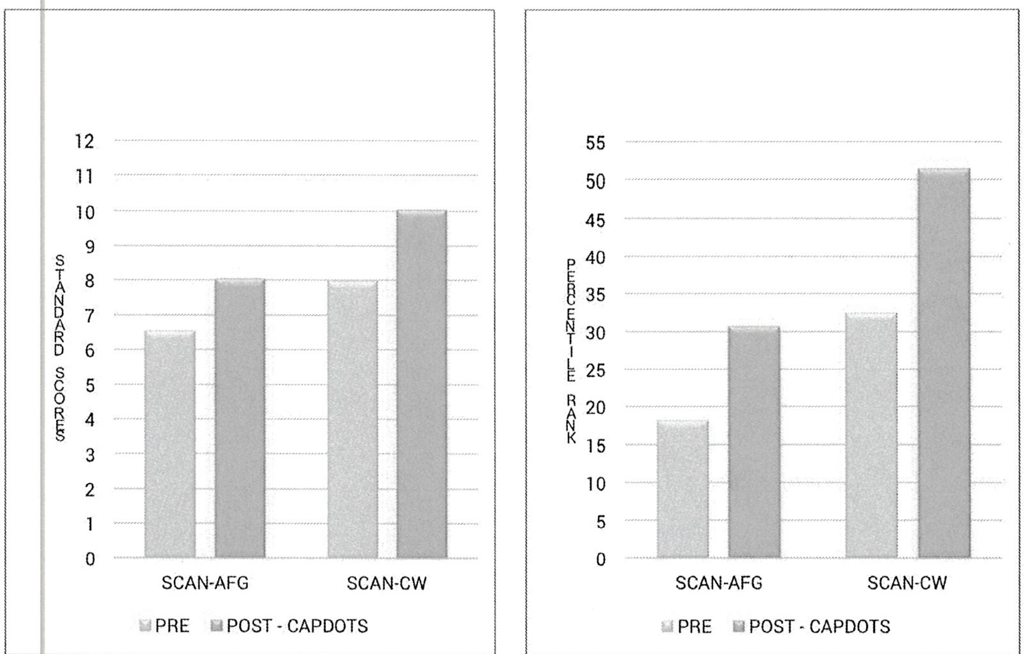

FIGURE 3: Pre- and Post- CAPDOTS standard score and percentile rank comparison on SCAN-C Auditory Figure Ground (AFG) and Competing Words (CW) subtests for total test group (n = 45).

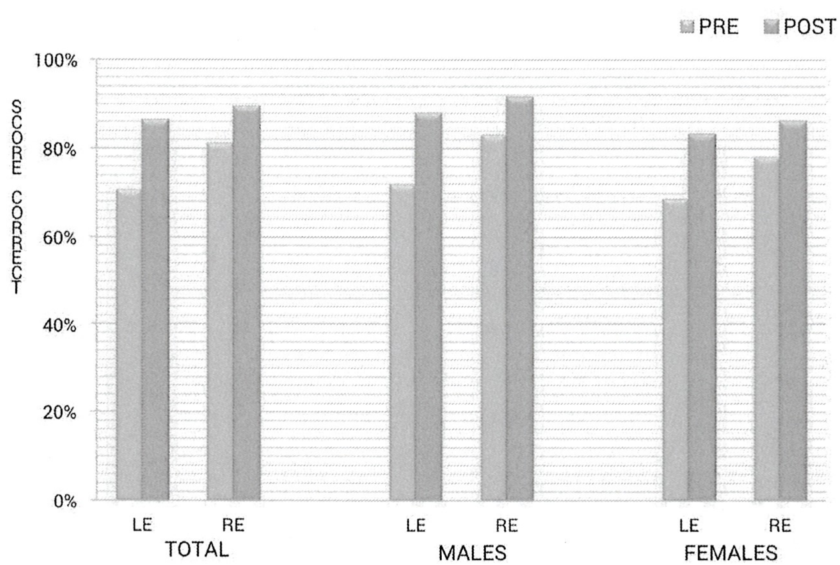

FIGURE 4: Pre- and Post- CAPDOTS training scores on Dichotic Digits Test for right and left ears for total test group (n = 45), males (n =28) and females (n = 17).

Hearing screening questionnaires were also provided to the parents and teachers of 10 children from the above group after CAPDOTS training. Both parents and teachers were asked to complete the questionnaire independently with the instruction of comparing current performance to 3 months prior. The questionnaire rated behaviour improvements on a scale of 0 – 5, with 0 = no improvement and 5 = very significant improvement.

Analysing the parent questionnaires, nearly all children had significant improvement in all categories. There were variable reasons for those who reported limited improvements including comorbid attention, language, sensory processing or interpersonal issues.

TABLE 3: Number of parents (total = 10) responding to questionnaire rating improvements pre- and post CAPDOTS training. Improvement rating on 5 point scale (0 = no improvement, 5 = very significant improvement).

LISTENING BEHAVIOUR	N/A	0,1,2	3,4,5
Have you noted an improvement in hearing/listening?		1	9
Has there been an improvement in following directions?		1	9
Has communications been easier?		1	9
Has there been a decrease in asking to repeat?		1	9
Has misunderstanding in communication decreased?		1	9
Has attention span increased?		0	10
Has hearing in background noise improved?		0	10
Has the level of alertness, responsiveness improved?		1	9
Has hearing to understand TV, radio and phone improved?	1	1	8

Similar findings were reported by the teachers of the same children. Average or above average improvements were noted in almost all categories.

TABLE 4: Number of teachers (total = 10) responding to questionnaire rating improvements pre- and post CAPDOTS training. Improvement rating on 5 point scale (0 = no improvement, 5 = very significant improvement).

LISTENING BEHAVIOUR	N/A	0,1,2	3,4,5
Have you noted an improvement in hearing/listening?	1	1	8
Has there been an improvement in following directions?	1	1	8
Has communications been easier?		0	10
Has there been a decrease in asking to repeat?		0	10
Has misunderstanding in communication decreased?		1	9
Has attention span increased?		0	10
Has hearing in background noise improved?		1	9
Has the level of alertness, responsiveness improved?		1	9
Has hearing to understand TV, radio and phone improved?	2	1	7

The observed changes were startling, visible and dramatic. While the analysis of test scores and data provide empirical evidence of improvement in auditory processing skills, it did not come close to capturing the dramatic changes that had been seen. Use of the Hearing Screening Questionnaire also limited questions to specific auditory behaviours but, as one mother commented: "this questionnaire does not at all reflect the broad and extensive changes that have taken place in my son".

It is commonplace for comments to be made by family members and friends who had not seen a child client recently to note on the remarkable improvements in in-person and telephone conversations and social interactions following CAPDOTS training.

Even from a distance, changes in appearance, posture, verbal engagement, social appropriateness, attentiveness, alertness, increased use of humour and witticisms, relaxation and self-confidence were quite apparent as individuals sat in our waiting room for their post-training recheck.

Case Studies

Three case studies are presented to provide a detailed picture on the use of CAPDOTS-I on specific clinical populations.

Table 5 describes the results of CAPDOTS-I on a Grade 8 male who was diagnosed with Autism Spectrum Disorder and identified as a Gifted-Twice Exceptional Learner. Table 6 describes a 24 year old male with Severe Learning Disability who was unable to complete his Grade 12. Table 7 describes a 65 year old female with co-morbid hearing impairment and head injury as a result of a motor-vehicle accident.

TABLE 5: Case Study MW, 13.8yr male diagnosed Gifted Learner and Autism Spectrum Disorder.

BACKGROUND

MW was referred for CAPD testing by his educational consultant. He had difficulty focusing in multi-speaker settings and frequently mishears conversations. He gets frustrated with group work and prefers one-to-one interactions. He has also been identified as a gifted learner and attends Advanced Science classes privately. He was diagnosed with ASD at 5 yrs of age.

PRE- AND POST IW TRAINING COMPARISON

TEST	PRE-IW	POST-IW
SCAN Auditory Figure-Ground	SS = 1, PR = 1	SS=8, PR=25
SCAN Competing Words	SS = 6, PR=9, REA+2	SS=11, PR=63, REA+3
Dichotic Digits (RGT>75%, LFT>65%)	RGT = 95%, LFT = 92.5%	RGT = 100%, LFT = 100%
60% Compressed Speech	RGT = 70%, LFT = 68%	RGT = 88%, LFT = 84%

GRAND-PARENT QUESTIONNAIRE POST-CAPDOTS –I (Self-Rating Scale : 1 = No improvement, 5 = Very significant improvement)

HEARING/ LISTENING	FOLLOW DIRECTIONS	COMMUNI-CATION EASIER	ACADEMIC IMPROVE-MENT	DECREASE IN REPETITION REQUEST	MISUNDER-STANDING DECREASE	ATTENTION SPAN INCREASED	HEARING IN NOISE	ALERTNESS RESPON-SIVENESS	UNDER-STAND TV, RADIO & PHONE
3/5	4/5	3/5	4/5	4/5	3/5	3/5	4/5	4/5	N/A

COMMENTS

Mom noticed that MW was sharing more information at home. He showed more initiative in the classroom and socially and was overall much happier at school than before.

TABLE 6: Case Study, BK 24yr old male diagnosed with Severe Learning Disability.

BACKGROUND

BK was referred to our clinic on a suspicion of CAPD while completing an intensive cognitive retraining program. His mother reported that BK seemed to be a slow processor, requiring more time to process information. He also tended to lose track during lengthy conversations or lectures. His severe learning difficulties precluded him from high school graduation.

PRE- AND POST IW TRAINING COMPARISON

TEST	PRE-IW	POST-IW
SCAN Competing Words	SS = 5, PR = 5, EA -5	SS=9, PR = 37, EA 0
SCAN Competing Sentences	SS = 1, PR = 1	SS = 9, PR = 37
Dichotic Digits (RGT>90%, LFT>90%)	RGT = 62.5%, LFT = 87.5%	RGT = 82.5%, LFT = 95%
60% Compressed Speech	RGT = 68%, LFT = 64%	RGT = 92%, LFT = 96%

PARENT QUESTIONNAIRE POST-CAPDOTS-I(Self-Rating Scale : 1 = No improvement, 5 = Very significant improvement)

HEARING/ LISTENING	FOLLOW DIRECTIONS	COMMUNI-CATION EASIER	ACADEMIC IMPROVE-MENT	DECREASE IN REPETITION REQUEST	MISUNDER-STANDING DECREASE	ATTENTION SPAN INCREASED	HEARING IN NOISE	ALERTNESS RESPON-SIVENESS	UNDER-STAND TV, RADIO & PHONE
3/5	4/5	3/5	4/5	4/5	3/5	3/5	4/5	4/5	N/A

COMMENTS

Mom noticed that he was sharing more information over the phone (parents live in another country), he seemed confident and happier. At the clinic, he was engaged, made jokes, spoke to other staff members, took better care of his appearance.

TABLE 7: Case study VS, 65yr old female with head injury and hearing loss.

BACKGROUND

VS is a classroom teacher who suffered a concussion after falling off a ladder. Her primary complaint was memory loss but also noted an extreme difficulty hearing in multi-speaker environments ("inability to filter out unwanted sounds").

PRE- AND POST IW TRAINING COMPARISON

TEST	PRE-IW	POST-IW
Hearing	Normal, sloping to mild, high-frequency loss	Did not retest
SCAN Auditory Figure-Ground	SS = 9, PR = 37	Did not retest
SCAN Competing Words	SS = 9, PR = 37, EA = -2	Did not retest
Dichotic Digits (RGT>90%, LFT>90%)	RGT = 45%, LFT = 70%	RGT = 90%, LFT = 97,5%

PATIENT QUESTIONNAIRE POST-CAPDOTS-I (Self-Rating Scale : 1 = No improvement, 5 = Very significant improvement)

HEARING/ LISTENING	FOLLOWING DIRECTIONS	COMMUNI-CATION EASIER	ACADEMIC IMPROVE-MENT	DECREASE IN REPETITION REQUEST	ATTENTION SPAN	HEARING IN NOISE	ALERTNESS/ RESPONSIVENESS	UNDERSTAND TV, RADIO & PHONE
4/5	3/5	4/5	N/A	4/5	5/5	3/5	5/5	4/5

COMMENTS

VS also commented after the training that she was "getting along better with others" and that there had been a significant decrease in misunderstandings and miscommunications. However, functioning still had not returned to pre-accident levels.

CONCLUSIONS

CAPDOTS is an online CAPD therapy system that allows for intensive auditory training for binaural integration and binaural separation deficits. It is easily accessible and convenient to use, minimizing time, financial and travel resources for both clinicians and their clients. CAPDOTS has been shown to significantly improve dichotic listening performance as well as auditory figure-ground discrimination.

As with any CAPD intervention, CAPDOTS must be recommended and applied to individuals with specific deficits and it is not presented as an absolute recommendation for all individuals with CAPD. CAPDOTS-I is appropriate for those with binaural integration deficits while CAPDOTS-S is appropriate for those with binaural separation deficits.

CAPDOTS has widespread application. The author has personally administered staggered dichotic listening training programs to over 600 individuals with a wide range of diagnoses including : dyslexia, autism (Lau, 2012; Musiek et.al., 2013), Down's Syndrome, sensory processing, learning disabilities, gifted twice-exceptional, neurological involvement and the hearing impaired (Lau, 2014). The changes witnessed in these individuals were significant on testing and noticeable in behaviour. As an audiologist and speech-language pathologist, it has been wholly gratifying to be able to "make a difference".

Carol Lau is the designer of CAPDOTS. She is a dual-qualified audiologist and speech-language pathologist with over 25 years of clinical practice. Since witnessing the profound changes that CAPD therapy and dichotic listening training can produce from as far back as 2003, she has grown a full-time CAPD specialty clinic in Vancouver, Canada. Her clinic tests and treats patients from the USA, Australia, New Zealand and of course, Canada. As a mother of a daughter with CAPD, she understands the field intimately and her personal interest spurs a passion and dedication to meet the needs of this special group of individuals.

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