The Dichotic Interaural Intensity Difference (DIID) Auditory Training Procedure: A Commentary – Frank Musiek

It is fairly well agreed upon that each hemisphere of the brain is dominant for certain tasks. For example, the left hemisphere is better at performing analytical tasks while the right is better for Gestalt type processing. The degree to which each is dominant is somewhat debatable. For speech it is clear that for most people the left hemisphere is dominant – in fact to the degree that in most instances the right hemisphere cannot “handle” speech stimuli. In this situation, information that needs to spoken has to be transferred from the right hemisphere to the left to engage the speech mechanism. This transfer requires the corpus callosum. The corpus callosum connects the two hemispheres of the brain and send neural messages back and forth. Split brain subjects (individuals who have their corpus callosum surgically sectioned) do not have any transfer from the right to left hemisphere. The split brain patient becomes highly relevant to an audiologic procedure known as dichotic listening which involves the presentation of two speech stimuli to opposite ears at the same time. In dichotic listening there is suppression of the ipsilateral pathways hence the auditory system becomes a crossed system rather than one that has both ipsilateral and contralateral pathways to the cortex. Therefore, during dichotic listening right ear information goes to the left hemisphere and left ear information to the right hemisphere. Since most people are language dominant for their left hemisphere, words, numbers, sentences presented to the right ear are easily repeated. However, these stimuli presented to the left ear must cross the corpus callosum to access the speech hemisphere in order to verbally respond. Since the corpus callosum is severed, transfer is thwarted and a severe left ear deficit on dichotic listening occurs. This left ear deficit has been well documented. Interestingly, shortly after testing several split brain patients, we discovered that major left ear deficits also occur in children – especially those with learning disabilities (see Musiek et al., 1984; Musiek et al. 2002). This is probably due to delayed myelination of the corpus callosum. Many children we saw for evaluation of APD demonstrated severe left ear deficits on dichotic listening – similar to the split brain patients. Like split brain patients, these children did not show deficits on monaural low redundancy speech tasks such as filtered speech. In an early study we
noted this pattern of central auditory test results in about 1/5 of the children which had a diagnosed auditory processing deficit (Musiek et al. 1984). In an early study with split brain patients, it was shown that the left ear deficit could be offset by decreasing the intensity of the speech stimuli to the right ear to provide the left ear an intensity advantage. This concept was extended to an auditory training paradigm for children with left ear deficits on dichotic listening.

A published case study in 1998 (first publication of the DIID) demonstrated significant improvement in binaural listening tasks and academic performance when dichotic training tasks were incorporated into the auditory training program (Musiek and Schochat 1998). Pre-training, the listener demonstrated a unilateral deficit on dichotic digits tests and moderate symmetrical bilateral deficits on compressed speech with reverberation tests. The training technique for dichotic listening directs the stimuli to the stronger ear at a reduced level while maintaining a higher intensity level to the poorer ear. This allows good identification of the stimulus directed to the weaker ear. This auditory training procedure is called dichotic interaural intensity difference training or the DIID. Children that were trained on various kinds of dichotic stimuli using greater intensity to the left ear to maintain good performance in that ear. After some training the intensity level of the stronger ear could be gradually raised over a period of time and the poorer ear (usually the left) would maintain its high performance. Some children required more training than others but a high percentage did improve their left ear performance. Often after training, both ears would perform well on subsequent dichotic listening tests. Though the mechanisms underlying this “dichotic improvement” are currently being studied it appears that greater intensity to the left releases the left auditory pathway from right auditory pathway suppression (noted in dichotic listening). Our ongoing research has been highly promising for improving left ear deficits (see fig. 1). In addition pre and post training scores on the Com-Ed questionnaire show the children in our sample to improve in basic communication and academic skills – similar to what has been reported (Musiek and Schochat, 1998). A recent article on a patient with mild head trauma who demonstrated a left ear deficit on dichotic digits showed marked improvement on dichotic listening after DIID training (Musiek et al., 2004) Therefore, it seems possible that the
DIID procedure may not be limited to only children with learning difficulties. Clinical trials to test the clinical feasibility of DIID training continue at several centers.

The testing and set up for DIID is straightforward. At this point in time the dichotic test of choice is the dichotic digits (Musiek, 1983). This test is used because it reaches maximum intensity function between 15 and 20 dB sensation level (SL). This means that if the test is administered at 50 dB HL to normal hearers the intensity level can be dropped 30 dB without influencing audibility of the digits. This is an important factor as will be discussed. Certainly it seems likely that other dichotic materials can be used but they should reach PB max at low SLs. For training, a variety of dichotic test materials and a two channel audiometer or lap top computer is essentially all that is needed. The dichotic materials should include lists of monosyllabic words, numbers, consonant-vowels (CVs), sentences etc. for training. The training itself focuses on dropping the intensity of the strong ear (usually the right) until the poorer ear (usually the left) performs at near normal levels. What happens is that as the poorer ear improves with changes in intensity the better ear performance diminishes. There usually is a point of intensity asymmetry where the poorer ear will perform better than the weaker ear (often referred to as the cross over point). If a cross over point is not reached the patient is probably not a good candidate for therapy. This however, is an unusual situation. Most crossover points are reached within a 20-30 dB difference between ears (fig. 2). Using adaptive approaches emphasis early on in training should be making the left ear perform well. In time, the right ear intensity levels can be brought back up so that ear’s performance is normal. However, how this is done is important. Intensity increments for the right ear are dependent on maintaining normal performance in the left ear. If left ear performance is not maintained, the right must be dropped back down until this change can be made without compromising left ear performance. Sometimes increments in intensity need to be as small as 1 dB to maintain good performance in the left ear. The other alternative is to increase practice time with the left ear having the intensity advantage. Periodic testing with the dichotic digits will provide feedback as to how the left ear is improving. Details related to this therapy technique is beyond the scope of this
chapter. However, the desirable result is to allow both ears to perform at normal or near normal levels for dichotic listening and until that is achieved training should continue.

In training with the DIID, both binaural integration and separation tasks can be used. The integration task requires the patient to respond to the stimuli in both ears. In the separation tasks, usually the patient is asked to ignore one ear and respond to stimuli presented in the other ear. If the child shows a greater problem with binaural integration than separation, DIID training should emphasize this aspect of dichotic listening and vice versa. The amount and length of training that is needed is indicated on how well the child performs on day to day therapy, however, we generally suggest training 3-4 times per week for 20-30 minute sessions. Further research, however, may provide more direction in regard to this aspect of DIID training.

The DIID training procedure has been used for schools and at home using modifications of a stereo system and interchangeable earphones. This informal approach has worked but it should be realized that the stimuli cannot be controlled as well as in the formal situation (Musiek et al. 2004). It is too early to know if there are major differences between formal and informal approaches for DIID training.

This procedure can also be done by using temporal offsets that "lag" in the poorer ear. This lag allows the poorer ear to perform better, then by using adaptive techniques the offset differentials are reduced over multiple practice sessions. This allows the improved function of the good ear to stabilize back to normal and maintain the improvement of the weak ear at a higher level of performance.

The DIID procedure is an auditory training technique that is now emerging. It addresses a specific type of auditory processing deficit that can be readily measured by dichotic listening tests. Preliminary research shows improvement of left ear deficits on dichotic listening tests as well as improvement on communication questionnaires. This technique holds promise for a useful auditory training approach that can be readily used in a variety of settings.