Disassociation Between Neurologic and Pediatric Subjects for Dichotic and Filtered Speech Tests

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Abstract

Low pass filtered speech (LPFS) and dichotic listening (DL) both evaluate central auditory deficits but may have different mechanisms. LPFS consists of spectrally degraded words, by low pass filtering, and results in a muffled, yet intelligible word list for normal subjects and decreased performance in individuals with certain types of auditory processing deficits (APD). The bilateral deficits typically seen in LPFS are thought to be due to auditory closure deficits. Dichotic Digits (DD) is a dichotic listening test that is thought to evaluate integration and typically reveals interaural asymmetries, namely a left ear deficit, when deficits exist. The current retrospective study aims to investigate the relationship between LPFS and DL performance to substantiate the theory of different underlying mechanisms in a neurologic and pediatric group. Preliminary results of 269 patients demonstrate that DL has a significantly higher failure rate in the neurologic group while LPFS shows no group differences. This finding supports differences in the underlying neural mechanisms between LPFS and DL and may suggest greater callosal involvement in the neurologic group. Further investigation aims to describe the relationships between LPFS and DL performance, neurologic status and receptive language.

Introduction

Low pass filtered speech (LPFS) and dichotic listening (DL) are tests that have been used clinically for a number of years. Many reports show a difference in sensitivity between these testing procedures. Clinical experience has also demonstrated differences in performance between pediatric populations with learning disabilities and adults with confirmed neurologic involvement. Redundancy facilitates auditory processing, such that low redundancy materials, like LPFS, require more complex processing and are more sensitive to CAPD. The intelligibility of the LPFS signal is reduced by low pass filtering the speech at 500 Hz with 18 dB per octave roll off and results in a muffled, yet intelligible word list for normal subjects and decreased performance in individuals with certain types of auditory processing deficits (APD). Musiek & Chermak (2013) define auditory closure as the ability to subjectively complete a degraded word or phrase by using language knowledge and inductive and deductive reasoning to derive the meaning of a message. An auditory closure deficit theoretically would present as a bilateral deficit and is therefore more consistent with a more global auditory-cognitive deficit, commonly seen clinically in the pediatric population. Tests of DL assess binaural integration and/or separation by presenting stimuli to both ears at the same time. These tests have been shown to be sensitive to cortical lesions of the temporal lobe and corpus callosum, which present as deficits in the ear contralateral to the lesion due to a stronger crossed ascending pathway. Interaural asymmetries are prevalent in the adult neurologic population, as they are theoretically consistent with bottom-up deficits in auditory processing. The concept of different underlying mechanisms is largely theoretical; however, with a large sample of learning related and neurological individuals, insights to mechanisms may be revealed.

Methods

This retrospective study was conducted on the records of 269 English-speaking individuals, aged 7 to 92 years, that were seen for a central auditory processing evaluation at the University of Connecticut's Speech and Hearing Clinic and Dartmouth-Hitchcock Medical Center. The participants were categorized based on neurological status and diagnosis of central auditory processing disorder (defined by failing at least 2 tests in a battery of tests) as follows:

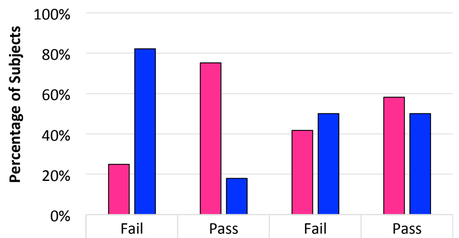
- Neurological Status –
  - 213 individuals were categorized as pediatric
  - 56 individuals were categorized as adult neurologic
- CAPD Status –
  - 127 individuals were categorized as CAPD
  - 142 individuals were categorized as non-CAPD.

All individuals had normal hearing sensitivity. Central auditory tests that were included in this analysis include Low Pass Filtered Speech (LPFS) and Dichotic Digits (DD). For the LPFS test, listeners repeat monosyllabic consonant-vowel-consonant (CVC) words passed through a filter that rejects energy above 500 Hz (high frequencies). Words are presented monaurally to each ear at 50 dB SL re: SRT or PTA. For the DD test, two different digits (one through ten, excluding seven) are presented simultaneously, one to each ear (dichotically) at 50 dB SL re: SRT or PTA.

Results

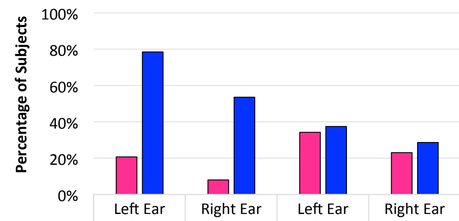
Analysis of this data demonstrated similar trends across neurological status and diagnosis of CAPD for LPFS. The trends are markedly different for dichotic digits (DD) compared to LPFS, with nearly 25% of the pediatric group failing DD, compared to the nearly 46% that failed LPFS, and 82% of the adult neurologic group failing DD, compared to the 50% that failed LPFS. There is a statistically higher ($p<0.05$) failure rate for DD in the adult neurologic group compared to the pediatric group that is not seen in LPFS.

Overall Failure Rate in Dichotic Digits Test & Filtered Speech Test



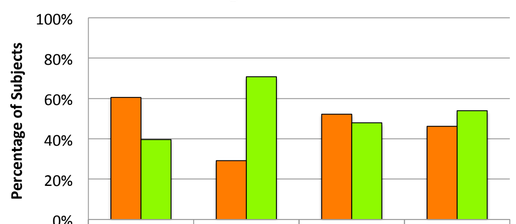
	Dichotic Digits Fail	Dichotic Digits Pass	Filtered Speech Fail	Filtered Speech Pass
Pediatric	25%	75%	42%	58%
Adult (Neurological)	82%	18%	50%	50%

Left vs. Right Ear Failure Rate in Dichotic Digits Test & Filtered Speech Test



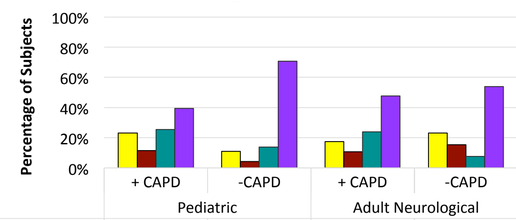
	Dichotic Digits Left Ear Fail	Dichotic Digits Right Ear Fail	Filtered Speech Left Ear Fail	Filtered Speech Right Ear Fail
Pediatric	21%	8%	34%	23%
Adult (Neurological)	79%	54%	38%	29%

LPFS Failure Rate Configuration By CAPD Criteria and Neurological Status



	Pediatric + CAPD	Pediatric -CAPD	Adult Neurological + CAPD	Adult Neurological -CAPD
Clinical Fail	60%	29%	52%	46%
Clinical Pass	40%	71%	48%	54%

LPFS Failure Rate Configuration By CAPD Criteria and Neurological Status



	Pediatric + CAPD	Pediatric -CAPD	Adult Neurological + CAPD	Adult Neurological -CAPD
Bilateral Fail	23%	11%	17%	23%
Right Fail	12%	4%	11%	15%
Left Fail	26%	14%	24%	8%
Bilateral Pass	40%	71%	48%	54%

Discussion & Conclusions

This finding may suggest greater callosal involvement for the neurologic group, for which DL, and not LPFS, is sensitive. This is supported by the split-brain studies which demonstrate large interaural asymmetries and left ear deficits with callosal lesions. Damage is rarely isolated to gray matter as the corpus callosum is commonly involved in neurological disorders (i.e. diffuse axonal damage in head injury, vascular insufficiency from an infarct, etc). This mechanism may very well explain the resulting perceptual differences between groups on these two tests of central auditory function, although delays in callosal maturation have been implicated in some forms of pediatric (developmental) CAPD. Similar performance on LPFS argues that performance is not dependent on interhemispheric transfer so much as a non-lateralized mechanism, such as auditory closure. Further investigation will aim to better expound the relationships between LPFS and DL test performance, neurologic status and receptive language.

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