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Communication Disorders: Auditory Processing Disorders

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Auditory Processing Disorder (APD) is an umbrella term used to describe various difficulties in the ability to discriminate, identify, or comprehend auditory stimuli, particularly when the auditory signal is in any way degraded, in spite of normal peripheral hearing thresholds and cognitive abilities. In the following sections we will present available definitions of APD and discuss whether current empirical evidence supports the existence of APD as an independent pathological condition. We shall then describe how abnormal auditory processing is associated with multiple conditions such as dyslexia, attention deficit disorder and hearing impairments and conclude by discussing the potential use of auditory and musical training for the alleviation of APD symptoms.

The Definition of APD

The term Auditory Processing (AP) refers to the ways by which the auditory system acts on acoustic information. Thus localizing sounds in space, discriminating sounds, recognizing auditory patterns, responding to the temporal aspects of sound (integration, discrimination, ordering, and masking), and extracting auditory information from non-ideal acoustic environments are all examples of auditory processes. Subsequently, the operational definition of APD refers to poor performance in one or more of these skills (ASHA 2005).

APD was first recognized more than half-century ago in a series pioneering observations made by Myklebust in the 1950s who showed that some children referred for evaluation of hearing thresholds, had normal peripheral hearing, and yet showed reduced functioning in complex listening situations in which the auditory message was not clear (e.g., when there was a competing background noise or multiple speakers). Since then, audiologists have encountered similar cases often, nevertheless, underlying mechanisms still remain poorly understood, and APD is not included in diagnostic classifications such as the Diagnostic and Statistic Manual (DSM-IV-R), or the International Statistical Classification of Disease and Related Health Problems (ICD-10).

The presence of APD among individuals with developmental disorders such as dyslexia, language impairment and ADHD (Ahissar, Protopapas, Reid, and Merzenich, 2000;

Amitay, Ahissar, and Nelken, 2002; Basu, Krishnan, and Weber-Fox, 2010; Chermak, 2007; Chermak, Hall, and Musiek, 1999; Farmer and Klein, 1995; McArthur and Bishop, 2005; Tallal, 1980; Tallal and Piercy, 1973; Walker, Hall, Klein, and Phillips, 2006) further complicates the picture because it would suggest that either APD plays a causal role in these conditions (for which there is little evidence) or that APD symptoms in and of themselves are irrelevant, because similar non APD symptoms are present in children with a particular developmental disorder with and without APD. Another option is that what appears as APD is merely a manifestation of impaired neurocognitive processes such as auditory attention or memory which lead to difficulties in challenging listening conditions.

Nonetheless, both the American Speech and Hearing Association (ASHA, 2005) and the British Society of Audiology (BSA, 2007) have suggested that APD is an outcome of the abnormal function or development of the neural mechanisms underlying the perceptual analysis (e.g., discrimination, localization, grouping) of sound and that it cannot result solely from co morbid attention, learning or language deficits.

Types of APD tests

The types of tests that are available for determining the presence of APD and describe its parameters are categorized according to the various auditory processes documented in the operational definition of APD. For example, a behavioral diagnostic test battery may make use of:

1) Auditory discrimination tests assessing the ability to differentiate similar acoustic stimuli that differ in frequency, intensity or temporal parameters. Examples for tests in this category include frequency discrimination and gaps in noise detection.
2) Auditory temporal processing and patterning tests assessing the ability to analyze acoustic events over time (e.g., pitch patterns and duration patterns).
3) Tests assessing the ability to recognize speech presented in non optimal settings such as the presence of noise or competing speakers (e.g., SCAN, LISN, HINT).
4) Tests assessing binaural processing designed to determine whether there is a deficit in how the brain integrates information from the two ears (e.g., dichotic digits).

At present there is no standardized test battery that utilizes non-verbal stimuli as suggested by the recent ASHA or BSA definitions of APD that is available for wide scale clinical use, even though the use of such non-verbal stimuli is desirable, if one wishes to separate difficulties arising from malfunctioning auditory processing from language based difficulties.

There is currently little data to support diagnosing APD as a "stand alone" disorder

Many individuals with developmental disorders such as dyslexia, language disabilities and ADHD (see above) as well as individuals with various forms of hearing loss, (Billings, Tremblay, Souza, and Binns, 2007; Kelly, Purdy, and Thorne, 2005) and the

elderly (Fitzgibbons and Gordon-Salant, 2004; Pichora-Fuller and Singh, 2006) exhibit symptoms of APD in the form of difficulties in perceptual analysis of sound as measured with psychoacoustic tasks, that are unaccounted for by their peripheral hearing level. It is unclear however if the opposite is also true, that is if individuals diagnosed solely based on the ASHA/BSA criteria actually suffer from any impediment to their daily function that merits a separate diagnosis. This is mainly due to the scarcity of epidemiological or population based investigations (as opposed to the investigation of clinical samples) on the consequences of poor auditory processing.

There is some evidence that when university or college students with no history of developmental disorders or hearing problems are tested with auditory psychophysical tests, those who fall outside the normal range also exhibit somewhat lower cognitive abilities (Banai and Ahissar, 2004; Deary, 1994; Raz and Willerman, 1985; Raz, Willerman, and Yama, 1987; Watson, 1991), but it is unclear whether poor performance is due to a genuine difficulty in sound processing, or due to the cognitive demands of the psychophysical tasks used to assess sound processing, such as the ability to attend to the relevant auditory cue, to compare the tones in order to select the correct response, or to implicitly tune into the context of recently presented stimuli. However, we are aware of only a single study in which a large population (n ~ 1600) of children was screened on a battery of non-verbal auditory tests. In this study, conducted by a group of researchers and clinicians from the Institute of Hearing Research in Nottingham, UK, a battery of non-verbal auditory tasks was administered to 6-11 year old children, in addition to tests of speech perception and cognitive abilities. Parental reports on communication and listening skills were also collected. It has been found that children, who perform outside the normal range on the auditory tests, also have lower cognitive and listening skills. However, a careful analysis of performance on the auditory tasks revealed that poor performance typically results from poor auditory attention, rather than from a specific deficit in the spectral or temporal analysis of sound (Ferguson, Riley, Ratib, Edmondson-Jones, and Moore, 2009). Thus, while further studies are required to determine the exact nature of the auditory attention deficit, it seems that poor auditory processing may be indicative of some other cognitive deficit, but also that there is little clinical significance in screening for it in the absence of presenting symptoms that actually impede performance in academic settings or otherwise affect the quality of life of affected listeners.

The population approach presented above could be criticized on the grounds that often, individuals are referred to audiologists because their presenting symptoms involve mainly listening behaviors, and particularly listening in challenging conditions. If this is the case, comparing the cognitive profiles of children that were referred for evaluation and received an APD diagnosis with that of those children who did not receive an APD diagnosis but were or were not diagnosed with another developmental disorder should reveal group differences at the level of clinical symptoms, performance on auditory tasks and/or measures of potential underlying cognitive mechanisms. This however does not appear to be the case. Dawes, Bishop, Sirimanna and Bamiou (2008) compared the profiles of two groups of children referred to a specialist APD clinic. In one group were children who received a diagnosis of APD, in the other, children in which APD was ruled

out. APD was confirmed if the child scored less than – 1 S.D. below the mean of the SCAN test, which is a test of speech perception in difficult situations commonly used in the diagnosis of APD and failed on one or more tests of non verbal auditory processing. There were no significant differences between the two groups in how the listening behavior of the children in a range of conditions was rated by parents or teachers. Nor were there group differences in the average number or types of symptoms reported in a clinical interview. In both groups high rates of reading, spelling and memory problems were reported, in addition to the expected difficulties with speech in noise and spoken instructions, and they did not differ in the incidence of co-morbid conditions such as dyslexia, language problems, ADHD, articulation problems and autism.

Furthermore, there are few apparent differences between children diagnosed with APD and those diagnosed with dyslexia or language problems on measures of both auditory and language processing (Dawes et al., 2009; King, Lombardino, Crandell, and Leonard, 2003). For example, Dawes et al., (2009) compared children diagnosed with dyslexia and children diagnosed with APD on a range of auditory, visual and psychometric tasks. Interestingly, they found that similar proportions of children with dyslexia and APD performed poorly on the SCAN test, even though this test was part of the APD diagnosis. Moreover there were no differences between the APD and dyslexia group on any of the auditory processing tasks used. Similarly, no differences on a range of language and speech perception tasks were found between children diagnosed with APD and SLI, even though both groups performed more poorly than a normative group of age matched children (Ferguson, Cowan, Riley, Booker, and Moore, 2007).

Finally, the findings of one study suggest that children diagnosed with APD were distinguishable from children diagnosed with ADHD in terms of their verbal memory spans (Maerlender, 2007), but neither auditory attention data, nor information on other aspects of performance were provided. Therefore, the lower memory spans in the APD children could have been a part of a more general disorder involving both language and attention. Indeed, it has been shown that both ADHD and APD are associated with high incidences of inattentive and distracted behaviors (Chermak, 2007).

Taken together, it seems that auditory processing deficits are part of the clinical picture of several developmental disorders, including dyslexia and SLI, even though causal relationships are poorly understood. Theoretically, this clinical picture suggests several possibilities. One option is that poor auditory processing is one factor contributing to the overall profile of symptoms in different developmental disorders (Dawes and Bishop, 2009). Another option is that what appears as poor auditory processing actually reflects a problem in other cognitive processes such as attention or context processing. Findings consistent with this alternative option have been reported for poor auditory processors screened form the general population (Ferguson et al., 2009). Furthermore, auditory processing deficits in dyslexia were found to critically depend on the assessment procedure. In particular, individuals with dyslexia perform poorly on tasks in which performance in the general population benefits from the consistent presentation of repeated anchor stimuli, consistent with the idea that individuals with dyslexia are not

making as efficient use of the context of recently presented stimuli as does the general population (Ahissar, Lubin, Putter-Katz, and Banai, 2006).

Intervention for APD

Intervention for APD involves direct remediation (auditory training and enhancement of compensatory strategies) as well as environmental modification (improving individual's access to auditory information presented in environments such as classroom, work and other communicative settings).

The reservations expressed above concerning the necessity of the separate diagnosis of APD should not obscure the troubling fact that no matter what diagnosis they have received, the outcomes for many children with learning disabilities (estimated at 25% by Hatcher et al., 2006) even following gold standard interventions are not encouraging. If, as we suggest above, poor auditory processing is a reflection of a wider cognitive deficit involving the use of context, ameliorating this deficit via auditory training may generalize to other skills that are affecting academic or daily function of affected individuals. Preliminary evidence that this may be the case were reported by several groups who showed that consistent practice on auditory tasks (Banai and Ahissar, 2009; Moore, Halliday, and Amitay, 2009; Moore, Rosenberg, and Coleman, 2005) or musical skills (Forgeard, Winner, Norton, and Schlaug, 2008; Moreno et al., 2009) can generalize to literacy related skills. Thus, if more conventional forms of remediation fail, auditory or music training may be considered, especially in the cases in which inability to use auditory context effectively can be shown. It should be noted however that, at present, there is little evidence from well controlled clinical studies that would recommend the use of auditory training for language, learning and reading disorders.

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