

Looking Beyond Processing of Auditory Stimuli - Could a More Generalised Problem with Processing Skills Contribute to Poor Learning and Listening?



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Introduction

Children who present to the audiology clinic with normal peripheral hearing but poor response to speech in noise or paired tones may have an auditory processing disorder (APD) [1].

Hearing involves a sequence of responses from ear to brain, including transfer of the acoustic stimulus across the ear, transduction of sound into neural impulses in the inner ear and transmission of the neural impulses to the brain. The interpretation of these impulses in the brain creates the perception and understanding of this information.

In APD inefficient processing occurs in the Central Nervous System, despite efficient sensory information production in the ear. If information processing is a generalised skill, rather than sense specific, then processing of one type of information, such as auditory information, is unlikely to be completely independent of the processing of other types of sensory information, such as vision, touch and awareness of body movement. More complex functions using sensory information, such as attention, modulating emotions, impulse control, special reasoning tasks, planning and scheduling, may also be compromised.

Children presenting in this way can have variable levels of dysfunction across a range of skills, such as learning, movement and balance control, attention and social interaction, and show features associated with a range of other conditions, such as Attention Deficit Hyperactivity Disorder (ADHD), dyslexia, dyspraxia, language delay, hyperacusis or social communication difficulties [2-9]. These children present to a range of professionals: audiologists, psychologists, speech therapists, physical therapists and paediatricians.

This paper aims to provide a better understanding of the range of conditions which may co-exist, have a common fundamental dysfunction or be different presentations of a

single disorder. We review current knowledge and strategies being used. A co-ordinated holistic approach to the management of these children is suggested, to consider all areas, beyond that of the professional to whom they present.

Clinical Presentation

Children with APD can present with difficulty in following oral instructions, listening, hearing in background noise, or with learning. It commonly presents in school age children. Some children have excessive reactions to sounds, with symptoms of hyperacusis (marked intolerance of noise) [10,11].

It is worth noting that children with identifiable peripheral hearing loss may also have co-existing APD. APD difficulties may predominate, or may co-exist with features of processing difficulties in other modalities [12-14]. As APD is associated with rare but potentially serious medical conditions these should be excluded [15]. Even with a strong history of APD, test batteries can be negative, suggesting other factors are involved. While the predominant area of difficulty varies, when processing difficulties are identified in one modality, difficulties in other modalities, such as postural control, literacy, attention control and communication, need to be considered.

Poor postural control may present with dyspraxic or Developmental Coordination Disorder (DCD) symptoms, with clumsiness in gross, fine or combined motor functions [16-19]. Many diagnostic terms have been applied to these difficulties [20]. DSM IV criteria for DCD suggest marked impairment of motor coordination, interfering with daily life, not due to a general medical condition. It may be a motor learning disorder [21].

Literacy difficulties occur with symptoms of dyslexia, commonly considered a phonological awareness problem [22]. The basis of phonological awareness is the consistent association

of sound and text, which is disrupted by inconsistent processing of text information [23].

When these basic tasks require excess effort to accomplish the children become mentally tired. This manifests as difficulty staying focused, and presents as ADHD symptoms [24,25], with associated behavioural and emotional variability.

Auditory and speech processing difficulties can manifest as unusual patterns of communication. It is not suggested that the criteria for formal diagnosis of the above problems would be satisfied, but that features of them exist and have a compounding effect on the child's functional performance.

The conditions mentioned may be hereditary [26-30], so either or both parents may have similar difficulties to their child. This can interfere with their ability to attend appointments and help with the child's management.

Explanation of the Presenting Problems in Relation to Processing Difficulties

For precise control of movement, rapid and accurate information from our somatosensory, visual and vestibular systems is required. If this information is present, but processed slowly, then control of posture (especially standing still or accurate movements) becomes difficult. Fine movement co-ordination may also be less accurate and consistent. Marked difficulties produce a DCD picture [31].

Poor fine control of posture and eye movement reduces the ability to process rows of similar small shapes (such as letters on a page) accurately and consistently. This makes decoding text difficult and can lead to dyslexic difficulties [32-35].

Inattentiveness and difficulty being still are core ADHD symptoms. With poor processing skills more effort is required to deal with information, producing mental tiredness and making continued concentration difficult. This can be seen as difficulty sustaining attention [36,37]. Tiredness and sleepiness are both associated with increased postural sway and movement [38-40].

In normal circumstances small movements are used to assess our postural control and remaining motionless will create anxiety that requires movement to relieve. Reduced use of the information required for postural control produces more sway and compensatory increased muscle tension. More areas of brain activity can be recorded at these times [41,42] and more attention is required [43]. People with anxiety disorders have more postural sway under normal conditions [44], and patients with vestibular disease and unsteadiness report feeling detached from their surroundings, depersonalization [45], possibly due to sensory mismatch, affecting concentration [46]. A combination of poor postural control and anxiety created by the need to move makes sitting still hard for these children.

Specific Language Impairment (SLI) may be considered at three interacting levels [47]: Central cognitive production

and understanding of language, processing this information and or motor function to produce speech. Hence processing difficulties can also be a factor in language disorders [48,49]. Slow processing can lead slow response to questions, which may be interpreted as showing low cognitive ability.

Evidence for Variability in Speed of Sensory Processing

The ability to distinguish similar sensory inputs is decreased in children with dyslexic difficulties. This has been shown in skin point-to-point separation sensitivity, visual point to point discrimination, and discrimination of similar sounds [50-53]. Recently similar findings have been reported in persons with Aspergers syndrome [54].

These problems may arise from processing deficits within individual systems [55-57], but the cerebellum has a central role in processing, and could be the connecting factor in sensory processing problems [58-66]. The question of whether this is cause, effect or simply co-occurrence (i.e. cerebellar abnormalities and sensory processing abnormalities may have the same cause but may not be causally related themselves) has also been raised and has caused much debate [67-72]. This may explain the feeling that many people working in this area have that dyslexia, dyspraxia, ADHD, APD and SLI, rather than being distinct entities, may be the variable presentations of processing difficulties with different dominant problems and that the experience of the professional whose advice is sought may influence the diagnosis given [73].

Suggestions for A Holistic Approach To The Management of These Children

Most specialist clinics cannot comprehensively rule out all the diagnoses mentioned above, but a combination of clinical awareness and targeted questions will allow identification of children who may benefit from more in depth testing. A multi-disciplinary approach would be beneficial

The history is very important, and asking targeted questions about literacy, postural control, attention control, speech and communication, will give a clear picture of the areas of difficulty (Figure 1).

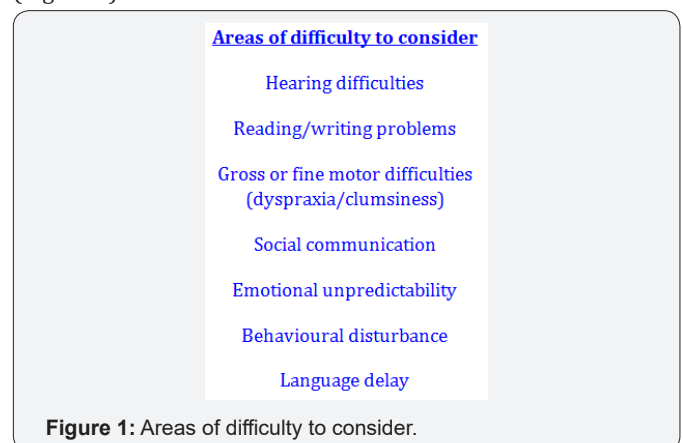


Figure 1: Areas of difficulty to consider.

In addition to the usual examination, soft neurological signs may also be sought. There are examination systems that are reliable, though the predictability of the findings is disputed [74-80]. These are often seen in DCD, but are common in many children with processing difficulties [81-85]. These require experience to attain the frame of reference to distinguish them from the "usual" reactions.

Investigations to help to focus on the problem areas for the child

Speech-in-noise test; Diagnostic test batteries for APD exist, [86] but the speech-in-noise test can give an insight into problems associated with noisy classrooms, known to be a problem for children with learning problems [87]. -Reading/writing skills (dyslexia screening tests); these usually test against the population average, so a bright child may get a good score, despite having dyslexic problems [88,89].

An awareness of the child's intelligence or IQ; this is relevant to both the child's ability to cope with poor processing (better if they are bright), and also that less bright children may not have the capacity to deal with information, even if it is processed well.

Questionnaires for ADHD symptoms (short version Connor's rating scale or SNAP IV [90]) have been developed from the diagnostic criteria of DSMIV; these can be used to give an impression of the presence of these symptoms, though they are not diagnostic, due to their brevity and non-pervasive testing environment.

While there are formal ways to assess for dyspraxic difficulties (such as Movement ABC [91]), the history alone is often strongly suggestive as the children are often felt to be clumsy, to often spill or bump into things, and do not enjoy team sports.

Management

It is worth noting that while the management options here are being used in practice the value of the research evidence that exists has been disputed.

General points that may be beneficial whichever areas of difficulty the child has

- a) Seating in class, with attention given to how the teaching staff are seen and heard.
- b) Decrease background noise, using sound field and FM systems, where available [92]
- c) Structured approach to learning, including pre "teaching".
- d) Small amounts of information, rather than given in bulk.
- e) Allowance for slow speed of response and copying speed (pre-printed sheets).

f) Excess unstructured homework may be counterproductive (due to tiredness).

g) Loss of confidence has a negative feedback effect.

h) Computer based educational programmers (evidence for efficacy is lacking) [93,94].

General exercise requirements

Exercise often acts as a release of the tension created by being still. Physical exercise is associated with calmer and less disruptive behaviour in children with ADHD, as well as with better behavioural compliance and academic performance in the general population [95-99]. The teacher, instructor or coach needs to know the child's problems and make allowances, especially for those with DCD difficulties. The child should not be put in situations they are not ready for, where they may be humiliated. Each of the medication and therapy portions of this review are brief overviews of complex subjects, and evidence for each is debated.

Nutrition

Omega 3 fatty acid supplements: alleviate ADHD-related symptoms in some children [100,101]. they can produce improvements in behaviour, reading and spelling skills in children with DCD [102]. They may improve mood disorders, as well as other skills [103,104] while negligible side effects were noted.

Food additives may contribute to behavioral disorders, especially to hyperactivity. Other than additives, milk, wheat and eggs have been found to be the commonest diet allergens, leading to suggestions of exclusion diets [105-108].

Medication

Stimulant medication: (such as Methylphenidate, Dexamphetamine and Amoxetine) use has provoked much discussion about the long and short-term effects, and their use for young children. Many studies showing improved attention skills with use of these medications in ADHD [109]. They can be useful for the academic difficulties that can accompany ADHD [110,111]. Discussion on the long term effects are ongoing, though a minor decrease in height has been noted, medication use is associated with a reduced incidence of associated negative outcomes (substance abuse, prison, and domestic problems) [112,113].

Therapy

Behaviour therapy

Therapy to modify the behaviour of children (such as cognitive behaviour therapy and social skills training), especially those with ADHD, has been shown to have positive effects, either alone or in combination with medication, and is used to different degrees in many situations. It is time, expertise and personnel intensive, which may be a drawback [114-116].

Specific exercise therapy

Physical exercise has long been appreciated to have effects on cognitive function. In the same way that in sport people can be trained with repetition of basic functions to allow more complex functions to be concentrated on, programmes of repetitive exercises to improve basic function in areas of postural and eye movement control can allow more complex functions to be addressed. This has been formalized and discussed in numerous ways, with programmes of exercises that may be generalized or adapted to individual patients [117-121], though the outcome data, where available, has been criticised [122,123]. Other studies suggest that other movement programmes, such as Tai chi, may also be of benefit [124]. Exercise programmes to improve co-ordination and sensory processing may be beneficial.

Auditory Therapy

a) Music therapy has been developed [125], and has a role in the management of children with communication difficulties [126]. Though the science behind its effects are still not fully elucidated [127], there is evidence that musically trained people have altered cognitive-perceptive function on fMRI compared to those not musically trained [128-131], though whether this is because people with certain skill profiles take up music is not addressed.

b) Auditory integration therapy (AIT) (music modulated across the acoustic frequencies after assessment of the child's audiogram) may benefit children with APD, as well as learning and communication disorders, though it is still considered to be experimental due to lack of formal research evidence [132-134].

c) Auditory perceptual training: is a method of training a child's response to sound, usually delivered via computer programmes. It has shown some success in altering children's auditory responses, with suggestions that can help in many areas of learning difficulties as well as in post cochlea implant patients [135-138]. Training may improve auditory response times and neural plasticity is demonstrated after training [139,140].

Visual Therapy

a) Coloured lenses and overlays have been shown to alter the perception of text, increase reading speed, and to reduce migraines. This has been discussed as visual stress, Meares-Irlen syndrome and Scotopic sensitivity.

Conclusion

Children with auditory processing problems may have a wider range of learning problems, and may present to a variety of professionals. Poor processing of information in one area may co-exist with poor processing of information in other areas. Our clinical impression that poor processing skills are a factor in these children's problems is supported by current evidence. It is important to take a holistic approach to the assessment and management of these children. Many of the therapies being used have anecdotal reports of success but need more research

evidence. Well designed studies to show which interventions work best for children with specific strength and weakness profiles will be vital to extend our knowledge in this area. The combined effect of a number of individually minor features of recognized conditions may have a compounding effect on the child. Despite having features of recognized conditions a child may be performing well above average academically in school, whilst not fulfilling their own potential. If the features are recognized and addressed they may perform better in the present competitive world, but changing teaching strategies may only be of benefit if child's problems acknowledged. It is essential that the strengths and weaknesses of each child be identified so that the parents and the educational institutions can provide appropriate help.

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