Listening difficulties in children

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SAME OR DIFFERENT: THE OVERLAP BETWEEN CHILDREN WITH AUDITORY PROCESSING DISORDERS AND CHILDREN WITH OTHER DEVELOPMENTAL DISORDERS: A SYSTEMATIC REVIEW

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Ear and Hearing
Vol. 39 • 1–19 • 2018
DOI: 10.1097/AUD.0000000000000479.

ABSTRACT

Objectives: Children diagnosed with auditory processing disorders (APD) experience difficulties in auditory functioning and with memory, attention, language, and reading tasks. However, it is not clear whether the behavioral characteristics of these children are distinctive from the behavioral characteristics of children diagnosed with a different developmental disorder, such as specific language impairment (SLI), dyslexia, attention-deficit hyperactivity disorder (ADHD), learning disorder (LD) or autism spectrum disorder. This study describes the performance of children diagnosed with APD, SLI, dyslexia, ADHD, and LD to different outcome measurements. The aim of this study was to determine (1) which characteristics of APD overlap with the characteristics of children with SLI, dyslexia, ADHD, LD, or autism spectrum disorder; and (2) if there are characteristics that distinguish children diagnosed with APD from children diagnosed with other developmental disorders.

Design: A systematic review. Six electronic databases (Pubmed, CINAHL, Eric, PsychINFO, Communication & Mass Media Complete, and EMBASE) were searched to find peer-reviewed studies from 1954 up to May 2015. The authors included studies reporting behaviors and/or performance of children with (suspected) APD and children diagnosed with a different developmental disorder (SLI, Dyslexia, ADHD, and LD). Two researchers identified and screened the studies independently. Methodological quality of the included studies was assessed with the American Speech-Language-Hearing Association's levels-of-evidence scheme.

Results: In total, 13 studies of which the methodological quality was moderate were included in this systematic review. In five studies, the performance of children diagnosed with APD was compared with the performance of children diagnosed with SLI; in two with children diagnosed with dyslexia, one with children diagnosed with ADHD, and in another one with children diagnosed with LD. Ten of the studies included children who met the criteria for more than one diagnosis. In four studies, there was a comparison made between the performances of children with comorbid disorders. There were no studies found in which the performance of children diagnosed with APD was compared with the performance of children diagnosed with autism spectrum disorder. Children diagnosed with APD broadly share the same characteristics as children diagnosed with other developmental disorders with only minor differences between them. Differences were determined with the auditory and visual Duration Pattern Test, the Children's Auditory Processing Performance Scale questionnaire, and the subtests of the Listening in Spatialized Noise-Sentences test, in which noise is spatially separated from target sentences. However, these differences are not consistent between studies and are not found in comparison to all groups of children with other developmental disorders.

Conclusions: Children diagnosed with APD perform equally to children diagnosed with SLI, dyslexia, ADHD, and LD on tests of intelligence, memory or attention, and language tests. Only small differences between groups were found for sensory and perceptual functioning tasks (auditory and visual). In addition, children diagnosed with dyslexia performed poorer in reading tasks compared with children diagnosed with APD. The result is possibly confounded by poor quality of the research studies and the low quality of the used outcome measures. More research with higher scientific rigor is required to better understand the differences and similarities in children with various neurodevelopmental disorders.

INTRODUCTION

Children diagnosed with an auditory processing disorder (APD) have difficulty with listening. This is especially prominent in an unfavorable listening environment despite well-functioning peripheral hearing (e.g., American Academy of Audiology, 2010; Geffner & Ross-Swain, 2013). Notwithstanding the attempts of special working groups to obtain clarification about the construct of APD (e.g., American Speech-Language-Hearing Association, 2005; American Academy of Audiology, 2010; British Society of Audiology, 2011), discussion continues among professionals about the diagnostic criteria for APD, the overlap of APD with other developmental disorders, and whether APD exists as a unique diagnostic entity (Cacace & McFarland, 2009; Moore et al., 2013; DeBonis, 2015).

Because of the lack of a clear definition and the use of multiple diagnostic criteria, different professionals approach children with listening complaints from different perspectives (McFarland & Cacace, 2006). Different diagnostic criteria for APD are proposed in various position statements and by several researchers (Bellis, 2003; American Speech-Language-Hearing Association, 2005; Dawes & Bishop, 2009; McArthur, 2009; American Academy of Audiology, 2010; British Society of Audiology, 2011; Wilson & Arnott, 2013). The different sets of diagnostic criteria have in common that children with listening difficulties are classified as having APD based on their performance on one or more behavioral central auditory tests or checklists or questionnaires. They differ, however, in the types of tests on which they must demonstrate inadequate performance and on how abnormal the performance is actually considered to be (e.g., < 2 SD or < 3 SD below the mean). The lack of a clear definition of APD together with the variation in diagnostic criteria for APD results in a range of approximate prevalence rates from 0.5 to 1.0% to 7% of the population (Chermak & Musiek, 1997; Bamiou, Musiek, & Luxon, 2001; Hind et al., 2011). For instance, depending on which diagnostic criteria were used, Wilson and Arnott (2013) identified 7.3% (diagnostic criteria by Bellis 2003) to 96% (diagnostic criteria by ASHA, 2005) of the children in their study group with APD.

Children with difficulties in the processing and understanding of auditory stimuli and with normal pure-tone thresholds have been recognized from the mid-20th century. These difficulties are "characterized by poor perception of both speech and non-speech" (British Society of Audiology, 2011, p. 3). Frequently reported symptoms are difficulty understanding speech in noisy environments; problems in locating the source of a signal; fail to response correctly to verbal information; frequently asking for repetition of information; reduced attention to auditory information and easily distracted (American Academy of Audiology, 2010). Since the 1970s, these difficulties are more commonly known in the field of speech-language pathologists and audiologists as APD (American Speech-Language-Hearing Association, 2005; Bellis, 2007; Jerger ,2009; Lucker, 2013). During recent years, this group of children is also described as children with suspected APD (susAPD) or children with listening difficulties.

One major issue that has dominated the field for many years concerns the distinction between APD and other developmental disorders, such as a specific language impairment (SLI), dyslexia, learning disorder (LD), attention-deficit hyperactivity disorder (ADHD), and autism spectrum disorders (ASD). The various developmental disorders have in common that they are characterized by developmental delays which can cause impairment in personal, social, academic or occupational functioning (American Psychiatric Association, 2014). Not all of the developmental disorders are well validated, and at the phenotypic level, the various developmental disorders overlap considerably with each other. Furthermore, research has shown that some disorders have in part the same genetic origin (Rutter & Pine, 2015). It is not clear whether there are different underlying mechanisms for the various disorders. Therefore, separation of the various developmental disorders from each other can be difficult for clinicians, but also for scientific

research (Rutter & Pine, 2015). This is also the case for APD. Several researchers have reported that the characteristics of children diagnosed with APD seem to correspond to the behaviors and symptoms of children diagnosed with other developmental disorders (Levy & Parkin, 2003; Dawes & Bishop, 2009; American Academy of Audiology, 2010; British Society of Audiology, 2011; Kamhi, 2011; Miller, 2011; Moore et al., 2013; DeBonis, 2015). For example, difficulties in comprehending and complying to verbal information are also commonly observed in children diagnosed with SLI. The concentration and attention complaints reported in children diagnosed with APD also correspond to the difficulties of children diagnosed with ADHD (Levy & Parkin, 2003; Dawes & Bishop, 2009), and atypical processing of auditory information (e.g., difficulties listening in noise, hyperacusis, hypersensitivity to pitch), something that can be also difficult for children diagnosed with APD, is also an inherent component of ASD (Dawes & Bishop, 2009; O'Connor, 2012). Likewise, it is contended that the diagnosis of a child may depend more on the referral route than on the symptoms of a child (Moore et al. ,2013).

The overlapping symptoms of children diagnosed with APD and children with other disorders also contribute to the discussion among clinicians and scientists as to whether or not APD can be considered a distinct clinical disorder (Levy & Parkin, 2003; Cacace & McFarland, 2009; Kamhi, 2011; Medwetsky, 2011; Moore et al., 2013). One study indicated that 94% percent of the children identified with APD also had a comorbid language impairment or reading impairment (Sharma, Purdy, & Kelly, 2009). In another study, 30% of the children with susAPD also had problems with reading and writing, 90% had additional speech-language problems, and 10% had ADHD. Sixty percent of the children had two or more accompanying problems (measured with a teacher-based questionnaire; Neijenhuis et al., 2003). Three possible explanations for the co-occurrence between APD and other developmental disorders are provided by Moore et al. (2013): (1) not all different disorders can be distinguished from each other; the diagnosis of a child depends more on the reference route than by the symptoms; (2) SLI and dyslexia are caused by an APD; (3) a more general neurodevelopmental deficit is the cause of the various disorders.

Our recent systematic review (de Wit et al., 2016) was aimed at establishing the characteristics of children with APD. The results showed that children with susAPD performed significantly poorer on tests of auditory processing when compared with typically developing (TD) children. However, significant differences between children with susAPD and TD children were not only found in the auditory domain. Children with susAPD also performed significantly poorer on tests of intelligence, memory, attention, and visual, language, and reading tests, as well as auditory brain measures. This again suggests that the characteristics of children diagnosed with APD overlap with the characteristics of children diagnosed with other developmental disorders. It is unclear whether a certain ensemble of symptoms exists that is solely attributable to difficulties with auditory processing. Such a distinctive symptom or group of symptoms could assist audiologists and speech-language pathologists in differentiating APD from other developmental disorders.

This present systematic review intends to describe the overlap between the characteristics of APD, SLI, dyslexia, ADHD, LD, and ASD. Our goal is to contribute to the discussion on whether APD is a distinct disorder that is separate from the other conditions that are mentioned. The central questions of this systematic review are the following: (1) Which characteristics of APD overlap with characteristics of other developmental disorders? and (2) Are there characteristics that distinguish children diagnosed with APD from children diagnosed with other developmental disorders?

METHODS

Studies published in peer-reviewed journals from 1954 up to May 2015 were considered for inclusion in this systematic review. The four stages of the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) 2009 flow diagram (Moher et al., 2009; prisma-statement.org) of (1) identification, (2) screening, (3) eligibility, and (4) inclusion, were used for systematically going through the different phases of a systematic review. Stages 1 and 2, in which author 1, 4 and 7 of the current review were involved, are equal to those stages as described in the study of de Wit et al. (2016).

After each stage, there was a consensus meeting held with the reviewers (author 1, 3, 4, and 7) who were involved in the process of assessing the studies that were found. A study was included or excluded in the subsequent stage when complete consensus was reached between reviewers.

Table 1. Search strings and databases used.

Databases	Search string
PubMed	("Auditory Diseases, Central"[Mesh] OR auditory processing[tiab] OR auditory perceptual[tiab]) AND (child[tiab] OR children[tiab] OR adolescent*[tiab])
PsycInfo, Eric, CINAHL, Communication & Mass media complete	(TI "auditory processing" OR TI "auditory perception" OR TI "auditory perceptual") OR (AB "auditory processing" OR AB "auditory perception" OR AB "auditory perceptual") AND (AB child OR AB adolescent)
EMBASE (until March 15 2012):	"auditory processing", "auditory perception", "auditory perceptual" child:ab OR children:ab OR adolescent:ab OR adolescents:ab.

Stage 1: Identification

To identify appropriate studies for this systematic review, the following databases were searched: Pubmed, CINAHL, Eric, PsychINFO, Communication & Mass Media Complete, and EMBASE. As described in de Wit et al. (2016), the original search consisted of two separate search queries, which have been combined in this review to one search. Search strings used in the different databases are depicted in Table 1. The used search strategy can be found in the Supplement, which demonstrates the review protocol of this systematic review. RefWorks was used to manage, store, and share the found studies and for removing duplicates.

Stage 2: Screening

The screening stage consisted of two steps, namely, (1) screening of titles and (2) screening of abstracts. For both steps in this stage, studies were screened against the inclusion and exclusion criteria by two researchers (author 1 and 4 or 1 and 7).

To be included in the review, the title and abstract of the study must meet the following criteria: (1) published in English and in a peer-reviewed journal; (2) addressed factors in title about auditory processing in combination with deficit(s), impairment(s), problem(s), difficulties, or disorder(s); (3) addressed elements in the abstract regarding the characteristics of susAPD or children at risk for APD in the presence of normal hearing. The terms/synonyms for APD that were also considered for inclusion can be found in the Supplement. In addition to these three inclusion criteria, studies must contain data regarding participants under the age of 18 years. The age limit of 18 years was chosen, in order to search somewhat broader than the age at which the final step in structural maturation of the auditory cortex normally occurs (between the age of 6 and 12 years; Moore & Linthicum, 2007). Studies that included neonates or participants with neuropathy, cochlear implants, Down syndrome or another syndrome, peripheral hearing loss, chronic otitis media, or brain damage were excluded from this review.

Stage 3: Eligibility

At the eligibility stage, it was decided which of the selected studies specifically matched the research question of the present study. Therefore, it was necessary that the focus of the study be on the comparison of the behaviors or performance of children with susAPD with children diagnosed with a different developmental disorder such as SLI, Dyslexia, ADHD, ASD or LD. This stage consisted of two sequential steps: (1) full text articles assessed for eligibility and (2) full text articles assessed for methodological quality.

The full text of each identified study was individually evaluated by one of the three reviewers (author 1, 4, and 7). The reviewer assessed whether the study was appropriate for the topic of the current systematic review.

Table 2. Quality Indicators in the ASHA Levels-of-Evidence Scheme (Mullen, 2007).

Indicator	Quality Marker
Study design	**Controlled trial**
	Cohort study
	Single-subject design or case control study
	Cross-sectional study or Case series
	Case study
Blinding	**Yes = Assessors blinded**
	No = Assessors not blinded or not stated
Sampling	**Yes = Random sample adequately described**
	No = Random sample inadequately described
	No = Convenience sample adequately described
	No = Convenience sample inadequately described or hand-picked sample or not stated
Group / participant comparability	**Yes = Groups comparable at baseline on important factors (between-subject design) or subject(s) adequately described (within subject design)**
	No = Groups/subjects not comparable at baseline or comparability not reported or subject(s) not adequately described
Outcomes	**Yes = At least one primary outcome measure is valid and reliable**
	Reasonable = Validity is unknown but appears reasonable; measure is reliable
	No = Invalid and/or unreliable
Significance	**Yes = *P* value reported or calculable**
	No = *P* value neither reported nor calculable
Precision	**Yes = Effect size and confidence interval reported or calculable**
	No = Effect size or confidence interval, but not both, reported or calculable
	No = Neither effect size or confidence interval reported or calculable

Boldface indicates highest level of quality marker.

Subsequently, the methodological quality of each included study was independently reviewed by two reviewers (author 1 and 3 or 1 and 7) with the American Speech-Language-Hearing Association's levels-of-evidence scheme (ASHA's LOE; Mullen, 2007). A description of this quality assessment tool can be found in Table 2. The quality indicator 'intention-to-treat' was removed from the scheme. Each quality indicator that complied with the highest quality level was assigned one point (see Table 2). The maximum achievable quality score for a study was seven points.

To classify the evaluated studies, the final quality score of the individual studies was used (adapted to the quality assessment tool developed by Gyorkos et al., 1994). Based on their final quality score, studies were classified as strong (5-7 points), moderate (2-4 points), or weak (0-1 points). For inclusion in this systematic review, a study must have been appraised as a moderate or strong study. Studies rated as weak were excluded.

Stage 4: Inclusion

In stage 4, relevant data from the included studies with moderate and strong qualities were extracted and analyzed. The following data were extracted from the studies: (1) study characteristics; (2) subject characteristics; (3) measurement instruments; and (4) study results. Pooling the results of all of the studies was not possible because of the substantial variation in outcome measures and the inconsistent manner of presenting the results between studies. Therefore, the results of the individual studies were summarized in a table (Table 5 - 8). The overlap and differences between groups on the outcome of various measurements used in the included studies are summarized in a nonsymmetric Venn diagram (Fig. 2).

RESULTS

The result of stages 1 to 4 of the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) 2009 flow diagram (Moher et al., 2009) is illustrated in Figure 1. Database searching yielded 3317 unique studies (stage 1) of which the titles were screened independently by two reviewers. This yielded 548 studies of which the abstract was assessed (stage 2). Subsequently, three reviewers screened the eligibility of 194 full-text studies (stage 3). One hundred and eighty studies were excluded in this stage. Of these 180 studies, 53 studies matched the research question of the previously published systematic review, and 24 studies did not satisfy the research question of both reviews. In 70 studies, the auditory processing skills of children diagnosed with disorders other than APD were investigated. However, these studies were excluded because these studies are beyond the scope of our review and did not fit the research question and inclusion criteria of this review. Finally, 14 of the full-text studies were rated as appropriate for inclusion in the current systematic review (stage 4).

Methodological Quality of the Studies

Based on the total quality score, one study (Simoes & Schochat, 2010) was classified as a study with weak quality (see Table 3 for details). Table 4 shows the methodological quality assessment of the included studies. As indicated in the data in Table 4, none of the studies were classified as being methodologically strong (≥5 points). In all of the included studies, significance and precision was either reported or could be calculated from the data; however, in none of the studies were the subjects randomly enrolled or subjects or assessors blinded.

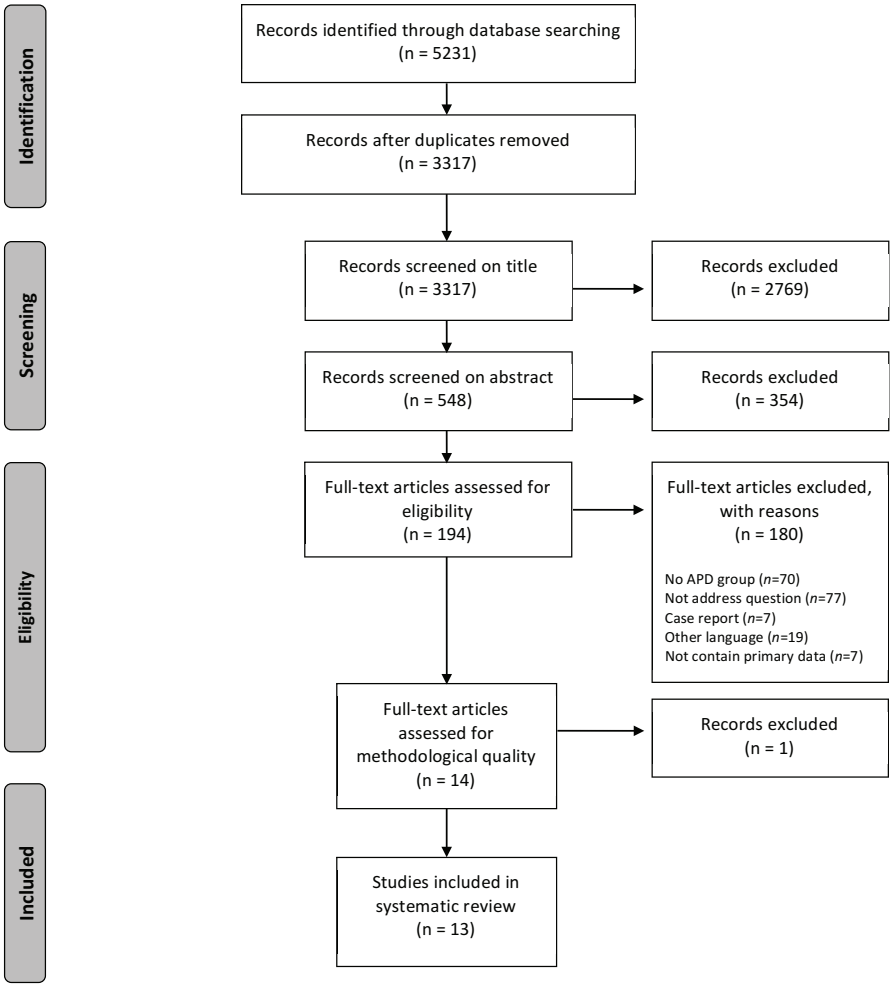

Figure 1. Process for identification of included studies. APD, auditory processing disorder. From PLoS Medicine. 2009;6:e1000097.

Table 3. Methodological quality of the excluded studies.

Study	Study Design	Assessor Blinded	Random Sample	Groups / Participants Comparable	Valid Primary Outcome Measure(s)[a]	Significance Reported or Calculable	Precision Reported or Calculable	Total Quality Score
Simoes & Schochat, 2010	Cross-sectional study	No	No	No	Reasonable	**Yes**	No	1/7

Critical appraisal ratings of excluded studies evaluated with the ASHA's levels-of-evidence (ASHA's LOE) scheme (Mullen 2007). Based on the quality score studies awarded with one or no points were classified as weak and were excluded from the review.

[a]At the criterion "Valid primary outcome measures" three answer options were possible, namely: Yes, Reasonable, and No. Al other criterion had two possible outcomes, Yes or No. Boldface indicates highest level of quality in each category.

Table 4. Methodological quality of the included studies.

Study	Study Design	Assessor Blinded	Random Sample	Groups / Participants Comparable	Valid Primary Outcome Measure(s) [a]	Significance Reported or Calculable	Precision Reported or Calculable	Total Quality Score
Bellis et al., 2011	Cross-sectional study	No	No	No	Reasonable	**Yes**	**Yes**	2/7
Dawes et al., 2009	Cross-sectional study	No	No	No	Reasonable	**Yes**	**Yes**	2/7
Iliadou et al., 2009	Cross-sectional study	No	No	No	Reasonable	**Yes**	**Yes**	2/7
Rocha-Muniz et al., 2014	Cross-sectional study	No	No	No	Reasonable	**Yes**	**Yes**	2/7
Cameron & Dillon, 2008	Cross-sectional study	No	No	No	**Yes**	**Yes**	**Yes**	3/7
Dawes & Bishop, 2010	Cross-sectional study	No	No	No	**Yes**	**Yes**	**Yes**	3/7
Ferguson et al., 2011	Cross-sectional study	No	No	No	**Yes**	**Yes**	**Yes**	3/7
Ferguson & Moore, 2014	Cross-sectional study	No	No	No	**Yes**	**Yes**	**Yes**	3/7
Riccio et al., 1994	Cross-sectional study	No	No	No	**Yes**	**Yes**	**Yes**	3/7
Riccio et al., 1996	Cross-sectional study	No	No	No	**Yes**	**Yes**	**Yes**	3/7
Rocha-Muniz et al., 2012	Cross-sectional study	No	No	No	**Yes**	**Yes**	**Yes**	3/7
Walker et al., 2011	Cross-sectional study	No	No	No	**Yes**	**Yes**	**Yes**	3/7
Miller & Wagstaff, 2011	Cross-sectional study	No	No	**Yes**	**Yes**	**Yes**	**Yes**	4/7

Critical appraisal ratings of included studies evaluated with the ASHA's levels-of-evidence (ASHA's LOE) scheme (Mullen 2007). Based on the quality score studies awarded with two to four points were classified as moderate, and studies awarded with five to seven points were classified as strong. Studies are arranged from low to high quality score. [a]At the criterion "Valid primary outcome measures" three answer options were possible, namely: Yes, Reasonable, and No. Al other criterion had two possible outcomes, Yes or No. Boldface indicates highest level of quality in each category.

General Study Characteristics

Thirteen studies are included in this systematic review. In one of the 13 studies, a comparison was made between children diagnosed with LD and children with APD + LD (Walker et al., 2011) and, hence, not children diagnosed with only APD. In the other 12 studies, the performance of children diagnosed with APD was compared with the performance of children diagnosed with a different developmental disorder. In five studies, a comparison was made with children diagnosed with SLI (Ferguson et al., 2011; Miller & Wagstaff, 2011; Rocha-Muniz, Befi-Lopes, & Schochat, 2012; Ferguson & Moore, 2014; Rocha-Muniz et al., 2014), two with children diagnosed with dyslexia (Dawes et al., 2009; Dawes & Bishop, 2010), one

with children diagnosed with ADHD (Bellis, Billiet, & Ross, 2011), and another with children diagnosed with learning or attention disorders (LD group; Cameron & Dillon, 2008). In three studies, a comparison was made between children diagnosed with APD and a group of children with comorbid disorders: two studies compared children diagnosed with APD with a group of children diagnosed with APD + ADHD (Riccio et al. 1994, 1996), and one compared children diagnosed with APD with a group of children diagnosed with APD + dyslexia (Iliadou et al., 2009). No studies were found in which a comparison was made between the performance of children diagnosed with APD and children diagnosed with a disorder in the autistic spectrum.

In this systematic review, the diagnosis which primarily has been studied and was the focus of the original study was used in the comparison of the groups. It has been found that it is not always possible to fit children with developmental issues into stiff diagnosis-categories. Ten of the studies included children who met the criteria for more than one diagnosis. In the studies of Ferguson et al. (2011) and Ferguson and Moore (2014), more than 25% of the included children had an additional diagnosis of ADHD, ASD, or dyslexia. In the studies of Dawes et al. (2009) and Dawes and Bishop (2010), these percentages were even higher: 52% of the children with a diagnosis of APD also met the diagnostic criteria of SLI, dyslexia, or both, and about 20% of the children in the dyslexia group also fits the diagnosis of SLI. In addition, there was also a high percentage of abnormal cases of hyperactivity and inattention in both groups. Riccio et al. (1994, 1996) disclosed information about comorbid psychopathology (e.g., ADHD and conduct disorder). The authors also suspect coexisting language disorders because of low scores of the subjects on language tests and measures of cognitive ability. Miller and Wagstaff (2011) reported that the parents of 16 children indicated that there was also a diagnosis of attention deficit disorders (ADD) or ADHD. There was no co-morbidity with ADHD or dysorthography in the subjects included in the study of Iliadou et al. (2009); however, three children with low IQ and three children with borderline IQ were included. Cameron and Dillon (2008) and Walker et al. (2011) included children with LDs. These studies included children with different kinds of problems, like ADD, ADHD, SLI, dyslexia, and working memory deficits. In three studies, no information about additional diagnoses was given (Bellis, Billiet, & Ross, 2011; Rocha-Muniz, Befi-Lopes, & Schochat, 2012; Rocha-Muniz et al., 2014).

Some participants took part in more than one study. In the study of Ferguson and Moore (2014) and Dawes and Bishop (2010), participants were recruited from, respectively, the study of Ferguson et al. (2011) and Dawes et al. (2009). For the study of Rocha-Muniz et al. (2014) and Riccio et al. (1996), it is not clear whether the authors used partially the same participants as in the preceding studies (Riccio et al., 1994; Rocha-Muniz, Befi-Lopes, & Schochat, 2012). The number of subjects ranged from seven to 41 in the APD group (mean = 20.8 subjects) and from ten to 29 in the comparison group (the group of children included with a different developmental disorder: mean SLI = 23.8 subjects, mean dyslexia = 19 subjects, ADHD = 10 subjects, LD = 11 subjects, mean comorbid disorder = 13.5 subjects). The ages of the subjects in the APD group ranged from 6 years to 15 years and 11 months; in the SLI and dyslexia groups, from 6 years to 13 years; in the LD group, from 7 years and 2 months to 11 years and 8 months; in the group with comorbid disorders, from 8 years to 15 years and 11 months; and in the ADHD group, the average age was 13 years and 1 month.

Diagnostic criteria for inclusion in the APD group varied among studies. Seven studies used the diagnostic criteria of a below normal performance on at least two behavioral diagnostic tests of auditory processing (Riccio et al., 1994; Iliadou et al., 2009; Bellis, Billiet, & Ross, 2011; Miller & Wagstaff, 2011; Walker et al., 2011; Rocha-Muniz, Befi-Lopes, & Schochat, 2012; Rocha-Muniz et al., 2014), and three studies used a below normal performance on at least one behavioral diagnostic test of auditory

processing (Riccio et al., 1996; Dawes et al., 2009; Dawes & Bishop, 2010). The remaining three studies used typically APD symptoms reported by parents or a referral for an auditory processing assessment for inclusion in the APD group (Cameron & Dillon, 2008; Ferguson et al., 2011; Ferguson & Moore, 2014).

Five studies, which included an SLI group, used the diagnostic criteria of Leonard (1998), referring to children with significant speech or language difficulties that could not be explained by factors such as hearing loss, autism, learning or physical disability, or bilingualism.

Participants in the studies that included children with ADHD met the diagnostic criteria from the Diagnostic and Statistical Manual of Mental Disorders (American Psychiatric Association, 1980, 1999). In the two studies by Dawes et al. (2009) and Dawes and Bishop (2010), the diagnosis of dyslexia was established by an educational psychologist in the event of a below normal performance (standard score <85) on a reading or spelling tests in the presence of an average intelligence (nonverbal IQ ≥80). Iliadou et al. (2009) used the Diagnostic and Statistical Manual of Mental Disorders-IV criteria for the diagnosis of dyslexia.

Cameron and Dillon (2008) and Walker et al. (2011) used a very diverse patient population in their comparison group. The LD group in the study of Cameron and Dillon (2008) comprised children with various types of difficulties, such as working memory deficit, ADHD, and dyslexia. Also, the children in the LD group in the study of Walker et al. (2011) had various types of learning difficulties, including ADD, language and reading impairment, and more general learning impairments. All of the children in both studies had an overall intellectual performance within normal limits (Cameron & Dillon, 2008: a scaled score of eight or above, a standard score of 90 or above, or the equivalent percentile rank of 25 or above; Walker et al. 2011: full-scale IQ scores of 85 or greater).

Children Diagnosed with APD Versus Children Diagnosed with Other Developmental Disorders

Table 5 to 8 show, per included study, a summary of the participant characteristics, measurement instruments used, and differences between children diagnosed with APD and children diagnosed with a different developmental disorder. It is apparent from this table that there were only marginal differences between these groups of children. Children diagnosed with SLI can be separated from children diagnosed with APD on the speech measures (weaker performance on the Children's Communication Checklist – second edition [CCC-2]; subscale speech; speech-evoked auditory brain stem response; speech-in-noise test with monosyllabic words; and the Dichotic Digit test), and children diagnosed with dyslexia can be separated from children diagnosed with APD on the reading measures. On the contrary, children diagnosed with APD can be separated from children diagnosed with SLI and dyslexia on the listening questionnaire (Children's Auditory Processing Performance Scale [CHAPPS] total score and subscales noise, multiple inputs, and attention). Opposed to children diagnosed with ADHD, children diagnosed with APD perform poorer on auditory and visual temporal ordering measures. Finally, children diagnosed with APD may be separated from children diagnosed with a variety of LDs by their problems with auditory stream segregation.

Five studies included different types of assessment of IQ, attention, and memory abilities in their study (Riccio et al., 1994, 1996; Dawes & Bishop, 2010; Ferguson et al., 2011; Miller & Wagstaff, 2011). No significant differences were found between clinical groups on one of these tests. Five studies examined the language and reading skills of children diagnosed with APD compared with children diagnosed with SLI, dyslexia, or ADHD (Riccio et al., 1994; Dawes & Bishop, 2010; Ferguson et al., 2011; Miller & Wagstaff, 2011; Walker et al., 2011). Furthermore, all 13 studies assessed the auditory processing capabilities of the included children with auditory behavioral tests, speech-evoked auditory brain stem response, or parental/ teacher questionnaires.

Table 5. Summary of the participant characteristics, reported measurements, and differences between children diagnosed with APD and children diagnosed with SLI.

Study	Participants/Groups: APD n; Gender; Age Range; Mean age (*M*)	Participants/Groups: SLI n; Gender; Age Range; Mean age (*M*)	Measurement instrument	Significance difference between clinical groups	Difference with TD group	Summary of significant differences APD vs. SLI
Rocha-Muniz et al., 2014	n = 25 NR 6 – 12 M = 8.72	n = 25 NR 6 – 12 M = 7.84	Auditory tests:			
			Speech-in-noise test (monosyllabic words)	+	U	Poorer performance for SLI group (lower mean scores for left and right ear).
			DDT	+	U	Poorer performance for SLI group (lower mean scores for left and right ear).
	No information available about additional diagnoses.		PFT	o	U	
Ferguson et al., 2011	n = 19 13 M, 6 F 6.2 – 13.9 M = 9.07	n = 22 14 M, 8 F 6.4 – 11.7 M = 8.7	CPRS-R:S	o	E	
			CCC-2:	o	U	
			General Communication Composite	o	U	
			Social Interaction Deviance Composite	o	O	
	More than a quarter of the children in the SLI and APD groups had an additional diagnosis of ADHD, ASD, or dyslexia.		Subscales:	o	U	Poorer performance for SLI group on the Speech scale only.
			Speech	+	U	
			Syntax	o	U	
			Semantic	o	U	
			Coherence	o	U	
			Inappropriate initiation	o	U	
			Stereotype language	o	U	
	Three children in the APD group had an additional diagnosis of ASD and 3 children undergoing assessment for dyslexia.		Context	o	U	
			Nonverbal communication	o	U	
			Social relations	o	U	
			Interest	o	U	
	Four children in the SLI group had an additional diagnosis of Dyslexia and 2 children undergoing assessment for dyslexia.		CHAPPS total score:	+	U	
			Subscales:			
			Ideal	o	E	
			Quiet	o	E	
			Noise	+	A	Poorer performance for APD group.
			Multiple Inputs	+	A	Poorer performance for APD group.
			Attention	+	U	Poorer performance for APD group.
			Memory	o	U	

Study	Participants/Groups: APD n; Gender; Age Range; Mean age (*M*)	Participants/Groups: SLI n; Gender; Age Range; Mean age (*M*)	Measurement instrument	Significance difference between clinical groups	Difference with TD group	Summary of significant differences APD vs. SLI
			Speech intelligibility test: ASL derived from the BKB sentences and VCV nonwords (in quiet and in speech-modulated noise)	o	E	
			Matrix Reasoning and Vocabulary subtest of the WASI	o	U	
			The repetition of nonsense words subset of the NEPSY	o	U	
			Spoonerisms subset of the Phonological Assessment Battery	o	U	
			TOWRE	o	U	
			TROG-E	o	U	
			Digit Span subtest of the WISC-III	o	O	
Ferguson & Moore, 2014	n = 19 13 M, 6 F 6 – 13 *M* = 9.7	n = 22 14 M, 8 F 6 – 13 *M* = 8.4	IHR-STAR software:			
			Tone detection in quiet:			
			1k200	o	U	
			1k20	o	U	
			Derived Auditory Processing: Temporal Integration	o	O	
			BM	o	U	
			SM			
			SM0	o	E	
			SMN	o	U	
			Derived Auditory Processing: Frequency Resolution	o	E	
			FD	o	U	
Rocha-Muniz et al., 2012	n = 18 14 M, 4 F 6 – 12 *M* = 9.17	n = 21 16 M, 5 F 6 – 12 *M* = 8.0	Speech-evoked ABR (speech syllable /da/):			
			Timing measures: Defined as the latencies of the 7 prominent response peaks (V, A, C, D, E, F, and O)			
			V	o	O	
			A	o	U	
			C	o	O	
			D	o	E	
			E	+	O	Increase latency for the SLI group.
			F	+	O	Increase latency for the SLI group.
			O	o	O	

Study	Participants/Groups APD n; Gender; Age Range; Mean age (*M*)	SLI n; Gender; Age Range; Mean age (*M*)	Measurement instrument	Significance difference between clinical groups	Difference with TD group	Summary of significant differences APD vs. SLI
	No information available about additional diagnoses.		Spectral encoding measures:			
			Pitch			
			F0	o	E	
			F1	o	E	
			Harmonics			
			HF	+	O	Smaller amplitude for the SLI group in encoding the higher harmonic HF.
Miller & Wagstaff, 2011	n = 35 25 M, 10 F 8.5 – 12.7 M = 10.3	n = 29 15 M, 14 F 8.5 – 12.7 M = 10.0	Language tests:			
			Formulating Sentences subtest of the CELF-4	o	E	
			Concepts and Following Directions subtest of the CELF-4	o	E	
			PPVT-3	o	E	
			Expressive Vocabulary Test or the Picture Vocabulary subtest of the W-J III	o	E	
	ADHD was not an exclusionary criterion. Parents of 16 participants reported that their child had been diagnosed with ADD or ADHD.		Auditory tests:			
			FPT	o	NR	
			DPT	o	NR	
			DDT right	o	NR	
			DDT left	o	NR	
			SSW left competing	o	NR	
			SSW total errors	o	NR	
	There was no agreement between the clinical diagnoses with which children entered the study and the test-based classifications. The results in this review are based on the clinical diagnosis children entered the study with.		Nonword Repetition test	o	NR	
			NV-IQ:			
			Symbolic Memory subtest of the UNIT	o	E	
			Cube Design subtest of the UNIT	o	E	
			Reading fluency:			
			GORT-4	o	U	
			Motor speed	o	E	
			Verbal working memory:			
			CLPT	o	NR	
			Visual-spatial working memory:			
			SWMT	o	NR	
			Attention:			
			CADS-P	o	E	

Studies are arranged in order of the total quality score. o, no significant difference between clinical groups. +, significant difference between clinical groups. A, APD group underperformed significantly compared with TD children; E, both groups displayed equal performance in comparison with TD children or norm values; O, other clinical group (SLI, dyslexia, ADHD, or LD) underperformed significantly compared with TD children; U, both groups underperformed significantly compared with typically developing (TD) children or norm values.

ADHD, attention deficit hyperactivity disorder; ADD, attention deficit disorder; APD, auditory processing disorder; ASD, Autism Spectrum Disorder; SLI, specific language impairment; TD, typically developing children. F, female; M, male; NR, not reported.

ABR, auditory brainstem response; ASL, Adaptive Sentence List (MacLeod & Summerfield 1990); BKB, Bamford-Kowal-Bench sentences

(Bench et al. 1979); BM, Backward masking; CCC-2, Children's Communication Checklist, second edition (Bishop 2003); CELF-4, Clinical Evaluation of Language Fundamentals, fourth ed. (Semel, Wiig, & Secord 2003); CHAPPS, Children's Auditory Processing Performance Scale (Smoski et al. 1998); CLPT, The Competing Language Processing Test (Gaulin & Campbell 1994); CPRS-R:S, Conners' Parent Rating Scale, revised: Short From (Conners 1996); DDT, Dichotic digits test (Musiek, Gollegly, Kibbe & Verkest-Lenz 1991; Tzavaras, Kaprinis & Gatzoyas 1981; Musiek 1983); DPT, Duration Patterns test (Musiek 1994; Pinheiro and Musiek 1985); FD, frequency discrimination; FPT, Frequency Patterns test (Musiek 1994; Pinheiro and Ptacek 1971); GORT-4, The Gray Oral Reading Tests- 4th edition (Wiederholt & Bryant 2001); HF, high frequency; IHR-STAR software, Institute of Hearing Research STAR software (Barry et al. 2010); NEPSY, Neuropsychological Test Battery (Korkman, Kirk & Kemp 1997; 1998); NV-IQ, non-verbal intelligence quotient; PFT, pattern of frequency test; PPVT-3, Peabody Picture Vocabulary Test- 3rd edition (Dunn & Dunn 1997); SM, Simultaneous masking; SM0, Simultaneous-masking noise task - bandpass noise; SMN, Simultaneous-masking noise task - spectrally notched noise; SSW, Staggered Spondaic Word Test (Katz 2001; 1962); The Spoonerisms subset (Walton & Brooks 1995) of the Phonological Assessment Battery (Frederickson, Frith & Reason 1997); TOWRE, Test of Word Reading Efficiency (Torgesen, Wagner & Kashotte 1999); TROG-E, Test for Reception of Grammar – Electronic, version 2 (Bishop 2005); UNIT, Universal nonverbal intelligence test (Bracken & McCallum 1998); VCV, vowel-consonant-vowel; WASI, Wechsler Abbreviated Scale of Intelligence (Wechsler 1999); WISC-III, Wechsler Intelligence Scale for Children, third edition (Wechsler 1991); W-J III, Woodcock-Johnson Tests of Achievement- 3rd edition (Woodcock, McGrew, & Mather 2001).

Table 6. Summary of the participant characteristics, reported measurements, and differences between children diagnosed with APD and children diagnosed with dyslexia.

Study	Participants/Groups: Diagnosis Reported n; Gender; Age range; Mean age (*M*)	Participants/Groups: Diagnosis Reported n; Gender; Age range; Mean age (*M*)	Measurement instrument	Significance difference between clinical groups	Difference with TD group	Summary of significant differences APD vs. dyslexia
Dawes et al., 2009	APD n = 22 14 M, 8 F 6-13 M = 10.1	Dyslexia n = 19 17 M, 2 F 6-13 M = 9.8	SCAN-C or SCAN-A Experimental Tests of auditory processing:	NR	NR	27% of the dyslexia group and 31% of the APD group scored below -1 SD.
	Twelve of the 22 children (54%) in the APD group also met criteria for dyslexia.		Auditory: 2-Hz FM	o	E	
			Auditory: 40-Hz FM	o	U	
			Auditory: 240-Hz FM	o	A	
			Auditory: IRN detection	o	A	
			Visual: Coherent form detection	o	E	
			Visual: Coherent motion detection	o	E	
Iliadou et al., 2009	APD n = 41 NR 8-15.11 NR	APD + Dyslexia n = 14 NR 8-15.11 NR	Auditory tests: Speech in babble, right ear	o	NR	
			Speech in babble, left ear	+	NR	Poorer performance for APD group (without dyslexia).
			DDT, right ear	o	NR	
			DDT, left ear	o	NR	
			FPT, right ear	o	NR	
	No co-morbidity with ADHD or dysorthography. Six of the children in the whole sample (N=55) had low or borderline IQ.		FPT, left ear	o	NR	
			DPT, right ear	+	NR	Poorer performance for APD + dyslexia group.
			DPT, left ear	+	NR	Poorer performance for APD + dyslexia group.
			RGDT	o	NR	
			MLD	o	NR	
Dawes & Bishop, 2010	APD n = 25 15 M, 10 F NR M = 10.4	Dyslexia n = 19 17 M, 2 F NR M = 10.1	CAST CCC-2:	o	A	Six children with an APD diagnosis fell within the clinical range for Asperger syndrome.
			General Communication	o	U	
			Composite Subscales:			
			Speech	o	U	
			Syntax	o	U	
			Semantic	o	U	
			Coherence	o	U	
			Inappropriate initiation	o	U	
			Stereotype language	o	U	
			Context	o	U	
			Nonverbal communication	o	U	
			Social relations	o	U	
			Interest	o	U	
	Thirteen of 25 (52%) of the children in the APD group would also fit a diagnosis of either SLI, dyslexia or both.		CHAPPS total score	+	U	Poorer performance scores for APD group.

Study	Participants/Groups: Diagnosis Reported n; Gender; Age range; Mean age (*M*)	Diagnosis Reported n; Gender; Age range; Mean age (*M*)	Measurement instrument	Significance difference between clinical groups	Difference with TD group	Summary of significant differences APD vs. dyslexia
			Language composite Average of the standard of six language tests: TROG-E Sentence Repetition of the NEPSY Repetition of Nonsense Words of the NEPSY ERRNI story telling ERRNU Mean length of utterance (MLU) ERRNI story Comprehension	o	E	
	Eleven of 19 (58%) of the children in the dyslexia group would also fit a diagnosis of SLI (score < -1 SD on two or more out of 6 language tests).					
	Hyperactivity/inattention: the proportion of abnormal cases was 37% and 46% for the dyslexia an APD groups.		Literacy composite Average of the standard of three literacy tests: OSCCI spelling test WORD Reading of the TOWRE Non-word Reading of the TOWRE	+	U	Worse performance for dyslexia group.
			Matrix Reasoning and block design subtest of the WASI	o	E	10 of 25 of the APD group and 4 of 18 of the dyslexia group scored in the clinical range (< -1 SD).
			SCAN-C or SCAN-A	o	E	

Studies are arranged in order of the total quality score. o, no significant difference between clinical groups. +, significant difference between clinical groups. A, APD group underperformed significantly compared with TD children; E, both groups displayed equal performance in comparison with TD children or norm values; O, other clinical group (SLI, dyslexia, ADHD, or LD) underperformed significantly compared with TD children; U, both groups underperformed significantly compared with typically developing (TD) children or norm values.

ADHD, attention deficit hyperactivity disorder; APD, auditory processing disorder; SLI, specific language impairment; TD, typically developing children. F, female; M, male; NR, not reported.

CAST, Childhood Asperger Syndrome Test (Williams, Scott, Stott, et al. 2005); CCC-2, Children's Communication Checklist, second edition (Bishop 2003); CHAPPS, Children's Auditory Processing Performance Scale (Smoski et al. 1998); DDT, Dichotic digits test (Musiek, Gollegly, Kibbe & Verkest-Lenz 1991; Tzavaras, Kaprinis & Gatzoyas 1981; Musiek 1983); DPT, Duration Patterns test (Musiek 1994; Pinheiro and Musiek 1985); ERRNI, Expression, Reception and Recall of Narrative Instrument (Bishop 2004); FPT, Frequency Patterns test (Musiek 1994; Pinheiro and Ptacek 1971); FM, frequency modulation; IRN, iterated rippled noise; MLD, Masking Level Difference (Auditec, St Louis); NEPSY, Neuropsychological Test Battery (Korkman, Kirk & Kemp 1997; 1998); OSCCI, Oxford Study of Children's Communication Impairments (self-developed); RGDT, Random Gap Detection Test (Keith 2000b); SCAN-A, test for auditory processing disorders in adolescence and adults (Keith 1994a); SCAN-C, test for auditory processing disorders in children—revised (Keith 2000a); Speech in babble test (Iliadou, Fourakis, Vakalos, Hawks, Kaprinis 2006); TOWRE, Test of Word Reading Efficiency (Torgesen, Wagner & Kashotte 1999); TROG-E, Test for Reception of Grammar – Electronic, version 2 (Bishop 2005); WASI, Wechsler Abbreviated Scale of Intelligence (Wechsler 1999).

Table 7. Summary of the participant characteristics, reported measurements, and differences between children diagnosed with APD and children diagnosed with ADHD.

Study	Participants/Groups: Diagnosis Reported n; Gender; Age range; Mean age (*M*)	Participants/Groups: Diagnosis Reported n; Gender; Age range; Mean age (*M*)	Measurement instrument	Significance difference between clinical groups	Difference with TD group	Summary of significant differences APD vs. ADHD
Bellis et al., 2011	APD n = 7 NR NR *M* = 10.9	ADHD n = 10 NR NR *M* = 13.1	Auditory tests:			
			DDT	o	U	
			FPT	o	U	
			DPT	+	U	Poorer performance for APD group. APD group exhibited a significantly larger HLD.
	No cognitive, sensory, developmental or related disorder unrelated to the primary diagnosis.		Visual analogs (self-developed):			
			Dichoptic Digits	o	U	
			Visual High-Low	o	U	
			Visual Duration Patterns	+	U	Poorer performance for APD group.
Riccio et al., 1994	APD n = 15 NR 9.0 – 13.3 *M* = NR	APD + ADHD n = 15 NR 9.0 – 13.3 *M* = NR	Auditory measures:			
			SSW, right competing	o	NR	
			SSW, left competing	o	NR	
			LPFS, right	o	NR	
			LPFS, left	o	NR	
			FPPS, right	o	NR	
	Whole sample: N = 30 (25 M, 5 F) *M* = 10.10 Of the 30 subjects, 17 met criteria for one or more diagnoses. One child in the APD group had an additional diagnosis of overanxious disorder.		FPPS, left	o	NR	
			SRT	o	NR	
			WISC-R/WISC-III	o	E	
			CELF-R	o	E	
			PPVT-R	o	E	
Riccio et al., 1996	APD n = 15 NR 9.0 – 12.11 *M* = 11.20	APD + ADHD n = 15 NR 9.0 – 12.11 *M* = 10.55	ACPT	o	U	
	Whole sample: N = 30 (24 M, 6 F) *M* = 10.87 No information available about additional diagnoses.		WISC-III	o	E	

Studies are arranged in order of the total quality score. o, no significant difference between clinical groups. +, significant difference between clinical groups. A, APD group underperformed significantly compared with TD children; E, both groups displayed equal performance in comparison with TD children or norm values; O, other clinical group (SLI, dyslexia, ADHD, or LD) underperformed significantly compared with TD children; U, both groups underperformed significantly compared with typically developing (TD) children or norm values.

ADHD, attention deficit hyperactivity disorder; APD, auditory processing disorder; TD, typically developing children. F, female; M, male; NR, not reported.

ACPT, Auditory Continuous Performance Test (Keith 1994b); CELF-R, Clinical Evaluation of Language Fundamentals-Revised (Semel et al. 1980); DDT, Dichotic digits test (Musiek, Gollegly, Kibbe & Verkest-Lenz 1991; Tzavaras, Kaprinis & Gatzoyas 1981; Musiek 1983); DPT, Duration Patterns test (Musiek 1994; Pinheiro and Musiek 1985); FPPS, Frequency (Pitch) Pattern Sequence Test (Pinheiro 1977); FPT, Frequency Patterns test (Musiek 1994; Pinheiro and Ptacek 1971); HLD, Humming-Labeling Differential; LPFS, Low Pass Filtered Speech Test (Willeford 1977); PPVT-R, Peabody Picture Vocabulary Test-Revised (Dunn & Dunn 1981); SRT, SSW, Staggered Spondaic Word Test (Katz 2001; 1962); WISC-R, Wechsler Intelligence Scale for Children-Revised (Wechsler 1974); WISC-III, Wechsler Intelligence Scale for Children, third edition (Wechsler 1991).

Table 8. Summary of the participant characteristics, reported measurements, and differences between children diagnosed with APD and children diagnosed with LD.

	Participants/Groups					
Study	Diagnosis reported n; Gender; Age range; Mean age (*M*)	Diagnosis reported n; Gender; Age range; Mean age (*M*)	Measurement instrument	Significance difference between clinical groups	Difference with TD group	Summary of significant differences APD vs. LD
Cameron & Dillon, 2008	APD n = 9 8 M, 1 F 6.6 – 11.2 M = 9.1	LD n = 11 7 M, 4 F 7.2 – 11.8 M = 9.4	LiSN-S: Low-Cue speech reception thresholds High-Cue speech reception thresholds Talker Advantage Spatial Advantage Total Advantage	 o + o + +	 E A E A A	 Poorer performance APD group Worse performance for APD group. Worse performance for APD group.
	Children in the APD group had no ADHD and IQ scores >90.					
Walker et al., 2011	LD + APD n = 10 NR NR	LD n = 28 NR NR	Temporal processing tasks: Auditory: Within-channel gap detection: 3 ms 8 ms 24 ms Between-channel gap detection: 30 ms 80 ms 200 ms	 o o o o o o	 E E E O O E
	Whole sample = LD children (n=38, 11 – 14, M = 12.2). This group is likely to include subjects who have ADD, SLI, dyslexia, and more general developmental learning impairments. Detailed information about additional diagnoses is not available.		Sequential TOJ: 0 ms 84 ms 400 ms Overlapping auditory TOJ: 50 ms 200 ms 614 ms Visual Sequential visual TOJ: 0 ms 5 ms 24 ms Overlapping visual TOJ: 3 ms 12 ms 38ms	 o o o o o o o o o o o o	 A A A E U U E E E E E E

Study	Participants/Groups: Diagnosis reported n; Gender; Age range; Mean age (*M*)	Participants/Groups: Diagnosis reported n; Gender; Age range; Mean age (*M*)	Measurement instrument	Significance difference between clinical groups	Difference with TD group	Summary of significant differences APD vs. LD
			Random dot kinematograms -Coherent motion task:			
			15 ms	o	E	
			25 ms	o	E	
			35 ms	o	E	
			Random dot kinematograms -Transparent motion task:			
			10 ms	o	E	
			20 ms	o	E	
			40 ms	o	E	
			Language / Reading tasks:			
			Phonological Awareness Quotient subtest of the CTOPP	o	U	The mean score for LD + APD was consistently lower than the LD only subjects for the Olson PHONO, Olson ORTHO, CTOPP and WRAT-3.
			Reading subtest of the WRAT-3	o	U	
			Short version of the Olson PHONO and Olson ORTHO subtest	o	U	
			The Token Test	o	E	

Studies are arranged in order of the total quality score. o, no significant difference between clinical groups. +, significant difference between clinical groups. A, APD group underperformed significantly compared with TD children; E, both groups displayed equal performance in comparison with TD children or norm values; O, other clinical group (SLI, dyslexia, ADHD, or LD) underperformed significantly compared with TD children; U, both groups underperformed significantly compared with typically developing (TD) children or norm values.

ADHD, attention deficit hyperactivity disorder; ADD, attention deficit disorder; APD, auditory processing disorder; LD, learning disorder; SLI, specific language impairment; TD, typically developing children. F, female; M, male; NR, not reported.

CTOPP, Comprehensive Test of Phonological Processing (Wagner, Torgesen, & Rashotte 1999); LiSN-S, Listening in Spatialized Noise test-sentences (Cameron & Dillon 2007; 2008); Olson PHONO and ORTHO, short versions of the Olson Phonological and Olson Orthographic subtests (Olson 1985); The Token Test (Boller & Vignolo 1966; Orgass & Poeck 1966); TOJ, temporal order judgment; WRAT-3, Wide Range Achievement Test 3 (Wilkinson 1993).

Children Diagnosed with APD Versus Children Diagnosed with SLI

Table 5 shows the similarities and differences on various measurement instruments between children diagnosed with APD and children diagnosed with SLI. No differences were found on IQ, working memory, language, and reading tests between children diagnosed with APD and children diagnosed with SLI. Most studies also found no difference between these children on behavioral auditory processing tests (Ferguson et al., 2011; Miller & Wagstaff, 2011; Ferguson & Moore, 2014). Both groups experienced difficulties with speech perception. Two studies found comparably poorer performance for children with SLI in the perception of speech (Rocha-Muniz, Befi-Lopes, & Schochat, 2012; Rocha-Muniz et al., 2014). The only study included in this systematic review that used electrophysiological measurements found that the children with SLI had a more impaired brainstem encoding for speech signals than the children

with APD had (Rocha-Muniz, Befi-Lopes, & Schochat, 2012). Also, significance variances were found with the CHAPPS (Smoski, Brunt, & Tannahill, 1998). Parents of children diagnosed with APD rated their children as having poorer listening skills in noisy places, poorer listening skills in multiple input, and poorer attention skills (Ferguson et al., 2011).

Children Diagnosed with APD Versus Children Diagnosed with Dyslexia

Table 6 shows the similarities and differences on various measurement instruments between children diagnosed with APD and children diagnosed with dyslexia. No differences were found on IQ, memory and language tests between children diagnosed with APD and children diagnosed with dyslexia. Children in the dyslexia group performed poorer with reading abilities. Parents of children diagnosed with APD rated significantly more often that their child met characteristics for autism. Furthermore, the CHAPPS total score is worse in children diagnosed with APD (Dawes & Bishop, 201). Children with comorbid APD and dyslexia performed significantly poorer on the duration pattern sequence test (Iliadou et al., 2009).

Children Diagnosed with APD Versus Children Diagnosed with ADHD

Table 7 shows the similarities and differences on various measurement instruments between children diagnosed with APD and children diagnosed with ADHD. No differences were found in performance on intelligence, attention, and language tests between children diagnosed with APD and children diagnosed with ADHD.

In two of the three included studies, there was, besides a group of children diagnosed with APD, a group of children with comorbid ADHD and APD included. Only one study included, besides a group of children diagnosed with APD, a group of children with a single diagnosis of ADHD. This one study found that the performance on the auditory and visual duration pattern test (DPT) can possibly distinguish children diagnosed with APD from children diagnosed with ADHD. Children with APD had significantly lower and divergent scores on the auditory and visual DPT (Bellis, Billiet, & Ross, 2011).

Children Diagnosed with APD Versus Children Diagnosed with Learning Disorders

Two studies compared the performance of children diagnosed with APD to the performance of children diagnosed with LD. Table 8 shows the similarities and differences on various measurement instruments between the children in these two groups.

The study of Walker et al. (2011) enrolled no group with children diagnosed with only APD in their study. No differences were found between these two groups on the auditory and visual temporal processing tasks and language and reading tests used in this study. However, according to the authors, it is likely that the included group is very heterogeneous and contains children with ADD, language and reading problems, and more general developmental learning impairments (Walker et al., 2011). Detailed information regarding the problems of these children is missing.

In the study of Cameron and Dillon (2008) the performance on the Listening in Spatialized Noise-Sentences test (LiSN-S; Cameron & Dillon, 2007a) of nine children with suspected APD is compared to the performance of 11 children with various learning disabilities, such as ADHD, dyslexia, memory deficits and visual processing problems. With the LiSN-S the auditory stream segregation skills of a child - one specific part of listening - can be examined (Cameron & Dillon, 2007b). The test assesses of a child is capable to understand speech when noise is coming from different directions. Cameron and Dillon (2008) found that children with suspected APD performed poorer in test conditions where the masker and target were spatially separated.

Overlap Between Groups on the Outcome of Various Tests

To be able to make a comparison between the performance of children diagnosed with APD and children diagnosed with other developmental disorders, the results of the isolated comparisons were analyzed and combined. Because comorbid groups can demonstrate additive effects of both disorders, only the studies in which children with APD were compared with children with a different developmental disorder were used for the overall comparison. Therefore, the four studies in which comorbid groups were enrolled were excluded for this analysis (Riccio et al., 1994, 1996; Iliadou et al., 2009; Walker et al., 2011). Figure 2 illustrates the pair-wise comparisons made in this systematic review and the overlap and differences on the outcomes of various tests used in the included studies for children diagnosed with APD and children diagnosed with SLI, dyslexia, ADHD, and LD. As mentioned earlier, also some children in the studies in which the focus was on the comparison of two different diagnostic groups have multiple diagnoses. This is not taken into account in this equation. The area of the circles is equal to the total number of subjects included in the studies in this analysis. The quantity N identifies the number of studies included (APD vs. SLI, N=5; APD vs. dyslexia, N=2; APD vs. ADHD, N=1; APD vs. LD, N=1). The amount n identifies the number of children included in the studies. All included children from the various studies are added together. This means that some children are counted twice, because in a number of studies the same participants took part in more than one study (e.g., Dawes and Bishop, 2010 and Ferguson and Moore, 2014). No differences (bold and outlined numbers in Figure 2) were found in the performance of children with APD compared with children with a different developmental disorder on the outcome of 85 of the 102 (sub)tests used in the included studies. Significantly poorer performance of children with APD (encircled italic numbers in Figure 2) was found in the case of ten (sub)tests (LiSN-S: High-Cue speech reception threshold, Spatial advantage and Total advantage, Cameron & Dillon, 2008; CHAPPS total score, Dawes & Bishop, 2010; auditory and visual DPT, Bellis, Billiet, & Ross, 2011; CHAPPS total score and noise, multiple input and attention subscales, Ferguson et al., 2011).

For seven (sub)tests, performances in children with SLI or dyslexia were poorer than in children with APD (literacy composite, Dawes & Bishop, 2010; CCC-2 subscale Speech, Ferguson et al., 2011; Speech-evoked auditory brain response: timing-measure E and F peak and spectral encoding measure higher harmonics, Rocha-Muniz, Befi-Lopes, & Schochat, 2012; Speech-in-noise test and Dichotic Digit test, Rocha-Muniz et al., 2014).

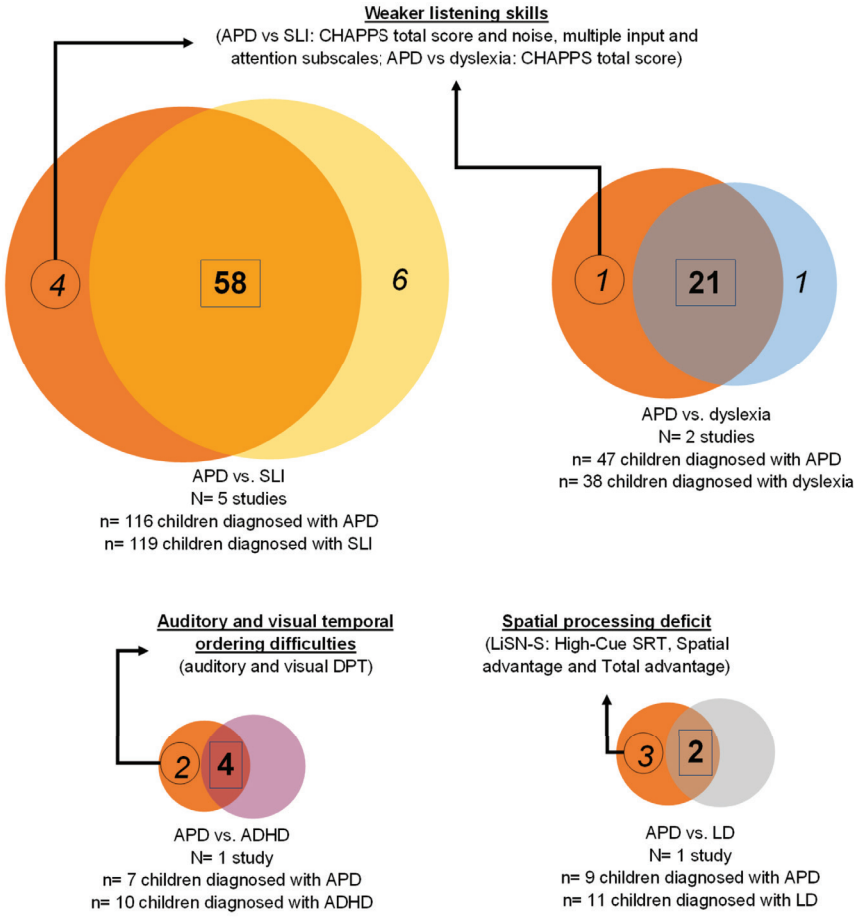

Figure 2. Venn diagram of the comparisons made in this systematic review and the overlap and differences between groups on the outcome of various tests used in the included studies.

The performance of children diagnosed with APD on various tests is compared with the performance of children diagnosed with SLI, dyslexia, ADHD, and LD. N identifies the number of studies included. The area of the circles is equal to the number of subjects included in the studies (n). The bold and the outlined numbers show the overlap (no significant differences) on the outcome of the used measurement instruments. Italic numbers illustrate the significant differences between children diagnosed with APD and children diagnosed with other disorders. The encircled italic numbers show the number of measurement instruments (test and subtest level) whereupon children diagnosed with APD perform significantly poorer in comparison with children diagnosed with other developmental disorders. The studies in which children with comorbid disorders (N=4) were enrolled are not captured in this figure. ADHD, attention-deficit hyperactivity disorder; APD, auditory processing disorder; CHAPPS, Children's Auditory Processing Performance Scale (Smoski et al., 1998); DPT, Duration Pattern Test; LD, learning disorder; LiSN-S, Listening in Spatialized Noise test-Sentence (Cameron & Dillon, 2007, 2008); SLI, specific language impairment, SRT, speech reception threshold.

DISCUSSION

The present study was designed (1) to determine which characteristics of APD overlap with the characteristics of SLI, dyslexia, ADHD, LD, and ASD and (2) to examine whether there are characteristics that distinguish children diagnosed with APD from children diagnosed with other developmental disorders. With respect to the first research question, we found that children diagnosed with APD and children diagnosed with SLI, dyslexia, ADHD, and LD have overlapping characteristics of intelligence, memory, attention and language and that the reading skills of children diagnosed with APD overlap with the reading skills of children diagnosed with SLI. No studies were found in which the performance of children diagnosed with APD were compared with children diagnosed with ASD. Compared with TD children, children diagnosed with APD and children diagnosed with other disorders show broadly similar results. Unfortunately, not all studies reported how the performance on several tests of children in the research groups was compared to TD children (for details, see Table 5 – 8). In the case of 57 (sub) tests (45,6%), both groups underperformed significantly compared with TD children or norm values, and in the case of 46 (sub) tests (36,8%), both groups displayed equal performance in comparison with TD children or norm values. With regard to the second research question, possible distinguishing characteristics for children diagnosed with APD were found in only four studies (Cameron & Dillon, 2008; Dawes & Bishop, 2010; Bellis, Billiet, & Ross, 2011; Ferguson et al., 2011). Ferguson et al. (2011) compared the performance of 25 children diagnosed with APD to the performance of 22 children diagnosed with SLI. Dawes and Bishop (2010) also included 25 children diagnosed with APD and compared their performance to that of 19 children diagnosed with dyslexia. Bellis et al. (2011) included 7 children diagnosed with APD and 10 children with an ADHD diagnosis, and Cameron and Dillon (2008) compared the performance of 9 children diagnosed with APD to the performance of 11 children diagnosed with LD. These studies found that children with APD had: (1) auditory and visual temporal ordering difficulties opposed to children diagnosed with ADHD, (2) poorer outcome on subtests of the LiSN-S compared to children diagnosed with LD, and (3) weaker listening skills opposed to children diagnosed with SLI and children diagnosed with dyslexia according to the parental evaluation. These characteristics may suggest a distinction between children diagnosed with APD and children diagnosed with SLI, dyslexia, ADHD, and LD. However, it is important to acknowledge that generalization to a broader population is limited because of the fact that these characteristics were found in single studies with small sample sizes, heterogeneous groups with comorbidity, and moderate methodological quality.

Overlap Between APD and SLI, Dyslexia, and ADHD

In this review, we found that children diagnosed with APD share overlapping intelligence, attention, memory and language characteristics with children diagnosed with other developmental disorders. Executive functions could be a potentially useful construct for understanding the overlapping symptoms observed in different disorders, such as APD, ADHD, SLI, and dyslexia (Chermak, Hall, & Musiek, 1999; Thapar et al., 2015). Executive functions appear to be related to the processing of language. Children diagnosed with SLI have demonstrated deficits in cognitive control related to deficits in language processing (Victorino & Schwartz, 2015). Such deficits are frequently incorporated into the general category of executive functions (Victorino & Schwartz, 2015). The overlapping symptoms of children diagnosed with APD, SLI, ADHD, and dyslexia fits the idea that it is difficult to say that the various psychiatric categories, as stated in the Diagnostic and Statistical Manual of Mental Disorders-V, are separate diagnosis with clear boundaries and a clear underlying cause. Our results support the idea that many of the individual categorical diagnoses are associated with each other in clusters, groups, or on a

spectrum rather than that they are truly distinct disorders (Bishop & Snowling, 2004; Pennington, 2006; Bishop & Rutter, 2008; Pennington & Bishop, 2009; Moore & Hunter, 2013; Bishop, 2015; Vermiglio, 2016). A model that fits this idea is the multiple deficit model proposed by Pennington (2006). The multiple deficit model assumes that a developmental disorder is caused by a combination of underlying specific and shared components (McGrath et al., 2011). Pennington proposes with the model that "the etiology of complex behavioral disorders is multifactorial and involves the interaction of multiple risk factors and protective factors, which can be either genetic or environmental" (Pennington, 2006, p. 404). As a result of the shared etiologic, comorbidity among neurodevelopmental disorders can be expected. Specific components ensure that the various developmental disorders differ slightly from each other on the surface. According to Moore and Hunter (2013), the various psychiatric categories can be conceptualized as a more general neurodevelopmental syndrome, wherein the behavioral difficulties (e.g., auditory, language, and attentional) of children serve as markers that can be expressed along a continuum of severity (Wallach, 2011; Moore et al., 2013; Moore & Hunter, 2013).

Differences Between APD and SLI, Dyslexia, and ADHD

The APD-group demonstrated significantly lower performance on the CHAPPS questionnaire (Dawes & Bishop, 2010; Ferguson et al., 2011) and the subtests of the LiSN-S in which the noise was spatially separated from the target speech (Cameron & Dillon, 2008). This may indicate that difficulties with the ability to listen in noisy conditions in challenging environments is a distinctive characteristic for children with suspected APD. Difficulties in noisy environments are one of the most mentioned symptoms of children with susAPD (Jerger & Musiek, 2000; American Speech-Language-Hearing Association, 2005). However, there are a number of concerns regarding the interpretation of the experimental evidence that children diagnosed with APD experience "difficulties with listening in noise".

Information regarding the validity and reliability of the CHAPPS questionnaire (Smoski, Brunt, & Tannahill, 1998) is lacking, whereby it is not certain what is actually measured (American Academy of Audiology, 2010; Moore et al., 2013; Barry et al., 2015). A number of studies have examined the clinical utility of the CHAPPS (Lam & Sanchez, 2007; Wilson et al., 2011; Iliadou & Bamiou, 2012; Ahmmed & Ahmmed, 2016). Hereby, varying results are reported. Lam and Sanchez (2007) and Wilson et al. (2011) found that the CHAPPS has no significant predictive capability for APD, while others (Iliadou & Bamiou, 2012; Ahmmed & Ahmmed, 2016) reported that a number of subsections (Listening condition: ideal, auditory memory/sequencing, and auditory attention span) of the CHAPPS may be clinically useful for identifying listening difficulties in children; however, further research is needed. The CHAPPS is originally designed to be completed by the teacher of the child (Smoski, Brunt, & Tannahill, 1992). The teacher answers the questions by comparing the listening skills of the individual child with the listening skills of other children of the same age group and background (Smoski, Brunt, & Tannahill, 1998). However, in both studies included in this systematic review, the CHAPPS was completed by parents instead of the teacher. This may plausibly cause a referral bias because parents of children with a diagnosis of APD could complete the questionnaire from a different perspective than parents of children with a diagnosis of SLI or dyslexia (Ferguson et al., 2011). No clear relationship between CHAPPS scores and the diagnosis APD were found in studies in which the CHAPPS questionnaire was completed by the child's teacher (Lam & Sanchez, 2007; Wilson et al., 2011).

The results of this systematic review suggest that the LiSN-S (Cameron & Dillon, 2007a) could perhaps be a valuable instrument to differentiate between children diagnosed with APD and children diagnosed with other developmental disorders. The LiSN-S was designed to assess auditory stream segregation

skills in children with susAPD (Cameron & Dillon, 2007b), and can be used to examine spatial processing difficulties (Chermak et al., 2017). With this test, one specific part of the whole range of listening abilities children need to have to be able to pick up information from what they hear, can be examined. The LiSN-S has a high test-retest reliability and normative data are provided for people aged 6 to 60 years (Cameron & Dillon, 2007b; Cameron et al., 2009, 2011). However, the LiSN-S is only used in one of the 14 included studies. In addition, the study group of this one study was very small (9 children diagnosed with APD versus 11 children diagnosed with learning or attention disorders). Studies that previously have used the LiSN-S to examine the differences between children with susAPD and TD children found varying results. Cameron and Dillon (Cameron, Dillon, & Newall, 2006; Cameron & Dillon, 2008) found that the inability to use spatial information may be one important cause of the listening difficulties in children. Others found no differences in spatial processing between children with susAPD and TD children on the LiSN-S Test (Sharma et al., 2014; Barry et al., 2015). As also explained by the authors themselves, it would be beneficial to conduct studies that are more large-scale in the future with the LiSN-S to investigate whether the test can be used to distinguish between children with and without spatial processing difficulties.

The significant underperformance of children diagnosed with APD on the auditory and visual DPT in the study of Bellis et al. (2011) indicates that a nonmodal-specific temporal ordering deficit may also be a possible characteristic that distinguish children diagnosed with APD from children diagnosed with other developmental disorders. Bellis et al. (2011) used an auditory DPT (Pinheiro & Musiek, 1985; Musiek, Baran, & Pinheiro, 1990) in their study with triads of 1000 Hz tone bursts differing in short (250 msec) and long (500 msec) duration. For the auditory DPT (Musiek, 1994), the levels of diagnostic accuracy (sensitivity, 0.86; specificity, 0.92) are known (Friberg & McNamara, 2010; Vermiglio, 2016). The visual DPT (self-developed) consisted of a black rectangle presented on a white screen in short (250 msec) and long (800 msec) triads. Bellis et al. (2011) reported robust effect sizes despite the small number of participants. The differences between children diagnosed with APD and children diagnosed with ADHD in auditory and visual DPT suggest that the deficits of children with listening difficulties are not specific to the auditory modality because children diagnosed with APD underperformed on both the visual and auditory version. Some authors proposed that problems in auditory processing are modality-specific if the problems are only situated in the auditory modality (Cacace & McFarland, 2005; Cacace & McFarland, 2013). When there are also problems in other modalities, such as problems with visual tasks, they would rather not speak of APD. Furthermore, there is no evidence that the DPT also differentiates between children diagnosed with APD and children diagnosed with SLI or dyslexia. In the study of Iliadou et al. (2009), children with a diagnosis of APD and dyslexia scored poorer on the DPT compared with children with a diagnosis of only APD. Also, no differences between children diagnosed with APD and children diagnosed with SLI in performance on the DPT were found by Miller and Wagstaff (2011). Studies in which auditory pattern recognition is examined found similar results, that is, children diagnosed with dyslexia or SLI perform poorer than TD children in the detection of duration patterns (Walker et al., 2002; King et al., 2003; Stollman et al., 2003; Walker et al., 2006). Therefore, it cannot be argued that a temporal ordering deficit is a distinguishing characteristic for APD.

In general, there is substantial overlap between children with various developmental disorders. The performance of children diagnosed with APD on three outcome measurements (CHAPPS, LiSN-S, and DPT) suggested that there are differences between children diagnosed with APD and children diagnosed with other developmental disorders. However, the results are not consistent, and the findings seem insufficiently researched; hence, it remains ambiguous whether these results are replicable. As previously

mentioned by Moore and Hunter (2013), the various developmental disorders could be conceptualized as a general neurodevelopmental syndrome wherein "auditory, speech, language, attention, memory and behavioral difficulties (markers) in children are expressed along a continuum of severity" (Moore & Hunter, 2013, pp. 165). Perhaps it is possible to use the three outcome measurements found in this review to indicate where children are located on this continuum.

Methodological Quality

All included studies in this systematic review had moderate methodological quality because none of the studies used a random sample, because none of the assessors were blinded, and because it was not clear if the participants in the different groups were comparable or not at baseline. In most studies, it was also not evident whether the children in the various groups (APD, SLI, ADHD, and dyslexia) had additional deficits besides the primary diagnosis they had received. The studies did not describe a broad assessment at the beginning in order to: (1) check the specified diagnosis and (2) investigate all important skills covering all developmental areas. It could be that the number of pure cases of children with APD, SLI, ADHD, or dyslexia is negligible if a detailed assessment battery was used at the beginning of the studies (Bishop & Rutter, 2008). The absence of valid auditory processing measurement instruments is another factor that is of influence on the methodological quality of the studies. There are no valid auditory processing tests available because there is no reference standard for the assessment of APD (Vermiglio, 2016).

Clinical Implications and Future Research

Children with various developmental disorders perform similar on the outcome of 85 of the 102 (sub) tests (see Tables 5 – 8 and Fig. 2 for details). No significant differences were found between groups on most auditory tests, and on questionnaires and tests of intelligence, attention, memory, language, and reading. With the current measurement instruments used in clinical practice, it is difficult to distinguish the various disorders from each other. From the results of our previous systematic review (de Wit et al., 2016), we know that children with susAPD perform significantly lower, compared to TD children, on auditory behavioral tests. Clinicians should take into account the fact that, if children have abnormal performance on a test for auditory processing, this does not automatically signify that the child has APD. Otherwise stated, the tests may distinguish abnormal from normal performance, however, they are not able to distinguish the various conditions from each other. It is also known that failure on a specific test, not necessarily mean that the child has a problem (Dillon et al., 2012). Also, TD children show considerable variability on at least some of these measures. From this and our previous review (de Wit et al., 2016), it is evident that listening difficulties experienced by children are multifaceted and that there is substantial overlap between various developmental disorders. As Moore (2016) stated, "Hearing necessarily involves the ear, the central auditory nervous system, and other brain systems, including attention, memory and vision." Therefore, it is crucial that various professions work together and use a multidisciplinary approach not only in the assessment of children with listening complaints but also in the event of children who satisfy the diagnostic standards of SLI, ADHD, and dyslexia. This accords with the latest suggestion of Chermak et al. (2017) who stated that an audiologist, speech-language pathologist, and psychologist must collectively decide whether the listening difficulties arise from an auditory issue, problems with processing language, cognitive deficiencies such as attention, executive function, or working memory, or an aggregation of them. It is important to note that the similarities found in this systematic review between children with various disorders are valid on a group level and does not reveal

individual differences. Audiologists, speech-language pathologists, and psychologists should focus on the performance of the individual child. To apply appropriate treatment, the symptoms and complaints in everyday life of the individual child must be focused on and not necessarily the diagnostic label.

The findings across the 13 studies should be interpreted according to study quality and design characteristics. Heterogeneity of the participants, inadequate reporting of the profile of participants, large variability in the measures and procedures used across studies, and a minimal number of studies with sometimes a small sample size should be taken into account when making comparisons between studies. There is a clear need for higher quality, well-designed studies in which a comparison is made between different groups of children with various disorders. We recommend that these studies include multiple groups of children with different diagnoses and the use of a detailed assessment battery incorporating the entire range of symptoms of neurodevelopmental disorders so that not only the performance of children diagnosed with APD is compared to the performance of children diagnosed with some other disorder but that the performance of children with all various developmental disorders can be compared with each other and that the entire continuum of developmental disorders can be identified.

Limitations of the Current Review

The limitations of this systematic review are the same as the restrictions listed in our previous study (de Wit et al. 2016), specifically (1) only articles written in English were included; (2) case studies were excluded; (3) studies in which auditory processing or one of the used synonyms was not mentioned in the title were excluded; and (4) another way of classifying the methodological quality of the studies could lead to other studies included or excluded in this review. Unfortunately, conducting a meta-analysis was not possible because of the diversity among outcome measures and the wide variation in the descriptive of participants.

CONCLUSION

Only marginal differences were found between children diagnosed with APD and children diagnosed with a different developmental disorder. Children diagnosed with APD and children diagnosed with SLI, dyslexia, ADHD, and LD have overlapping characteristics in terms of intelligence, memory, attention, and language. The reading skills of children diagnosed with APD overlap with the reading skills of children diagnosed with SLI. The results suggest that the CHAPPS questionnaire and the subtests of the LiSN-S in which noise is spatially separated from target sentences could possibly differentiate between children with difficulties in auditory functioning and children with language, reading, and attention disorders. However, this result is possibly confounded by the generally poor quality of the research studies included in this review and the quality of the used outcome measures. Additional research is required to better understand the different profiles of children with various complaints or disorders.

ACKNOWLEDGEMENTS

This research was funded by the Netherlands Organisation for Scientific Research (NWO). Preliminary results of this study were presented by poster presentation on the British Society of Audiology, Annual Conference 2016 and by oral presentation on the 30th World Congress of the International Association of Logopedics and Phoniatrics (I.A.L.P.) 2016. The authors declare no conflict of interest.

REFERENCES

References marked with an asterisk (*) indicate studies included in the systematic review.

Ahmmed, A. U., & Ahmmed, A. A. (2016). Setting appropriate pass or fail cut-off criteria for tests to reflect real life listening difficulties in children with suspected auditory processing disorder. *International Journal of Pediatric Otorhinolaryngology, 84,* 166-173. doi:10.1016/j.ijporl.2016.03.014.

American Academy of Audiology. (2010). *Clinical practice guidelines. Diagnosis, treatment and management of children and adults with central auditory processing disorders*. Retrieved from http://audiology-web.s3.amazonaws.com/migrated/CAPD%20Guidelines%208-2010.pdf_539952af956c79.73897613.pdf.

American Psychiatric Association. (1980). *Diagnostic and Statistical Manual of Mental Disorders (DSM-III)* (3rd ed.). Washington, DC: American Psychiatric Association.

American Psychiatric Association. (1999). *Diagnostic and Statistical Manual of Mental Disorders (DSM-IV)* (4th ed.). Washington, DC: American Psychiatric Association.

American Psychiatric Association. (2014). *Handboek voor de classificatie van psychische stoornissen (DSM-5)* [Dutch version of the Diagnostic and Statistical Manual of Mental Disorders, 5th Edition]. Amsterdam: Boom.

American Speech-Language-Hearing Association. (2005). *(Central) auditory processing disorders [Technical report]*. doi:10.1044/policy.PS2005-00114. Retrieved from http://www.asha.org/policy/TR2005-00043/.

Bamiou, D. E., Musiek, F. E., & Luxon, L. M. (2001). Aetiology and clinical presentations of auditory processing disorders - a review. *Archives of Disease in child, 85*(5), 361-365.

Barry, J. G., Ferguson, M. A., & Moore, D. R. (2010). Making sense of listening: the IMAP test battery. *Journal of visualized experiments : JoVE,* (44), e2139. doi:10.3791/2139

Barry, J. G., Tomlin, D., Moore, D. R. et al. (2015). Use of questionnaire-based measures in the assessment of listening difficulties in school-aged children. *Ear and Hearing, 36*(6), e300-e313. doi:10.1097/AUD.0000000000000180.

Bellis, T. J. (2003). *Assessment & Management of Central Auditory Processing Disorders in the Educational Setting: From Science to Practice* (2nd ed.). San Diego, CA: Plural Publishing.

Bellis, T. J. (2007). Historical foundations and the nature of (central) auditory processing disorder. In F. E. Musiek, & G. D. Chermak (Eds.), *Handbook of (Central) Auditory Processing Disorder. Volume 1: Auditory Neuroscience and Diagnosis.* (1st ed., pp. 119-136). San Diego: Plural Publishing.

*Bellis, T. J., Billiet, C., & Ross, J. (2011). The utility of visual analogs of central auditory tests in the differential diagnosis of (central) auditory processing disorder and attention deficit hyperactivity disorder. *Journal of the American Academy of Audiology, 22*(8), 501-514. doi:10.3766/jaaa.22.8.3.

Bench, J., Kowal, Å, & Bamford, J. (1979). The BKB (Bamford-Kowal-Bench) sentence lists for partially-hearing children. *British Journal of Audiology, 13*(3), 108-112.

Bishop, D. V. M. (2003). *The Children's Communication Checklist: CCC-2* (2nd ed.). London, UK: Pearson Assessment.

Bishop, D. V. M. (2004). *Expression, Reception and Recall of Narrative Instrument (ERRNI)*. Oxford, UK: Pearson assessment.

Bishop, D. V. M. (2005). *Test for Reception of Grammar, Version 2—Electronic (TROGE).* London, UK: Psychological Corporation.

Bishop, D. V. M. (2015). The interface between genetics and psychology: lessons from developmental dyslexia. *Proceedings. Biological sciences, 282*(1806), 20143139. doi:10.1098/rspb.2014.3139

Bishop, D. V. M., & Rutter, M. (2008). Neurodevelopmental disorders: conceptual issues. In M. Rutter, D. V. M. Bishop, D. S. Pine et al. (Eds.), *Rutter's Child and Adolescent Psychiatry* (5th ed., pp. 32-41). Oxford, UK: Blackwell Publishing. doi: 10.1002/9781444300895.fmatter.

Bishop, D. V. M., & Snowling, M. J. (2004). Developmental dyslexia and specific language impairment: same or different? *Psychological Bulletin, 130*(6), 858-886. doi:10.1037/0033-2909.130.6.858.

Boller, F., & Vignolo, L. A. (1966). Latent sensory aphasia in hemisphere-damaged patients: an experimental study with the Token Test. *Brain, 89*(4), 815-830.

Bracken, B. A., & McCallum, R. S. (1998). *Universal Nonverbal Intelligence Test*. Itasca, IL: Riverside.

British Society of Audiology. (2011). *Position statement on auditory processing disorder. Auditory Processing Disorder (APD) Steering Committee*. Retrieved from ftp://ftp.phon.ucl.ac.uk/pub/andyf/BSA_APD_Position_Consultation.pdf.

Cacace, A. T., & McFarland, D. J. (2005). The importance of modality specificity in diagnosing central auditory processing disorder. *American Journal of Audiology, 14*(2), 112-123.

Cacace, A. T., & McFarland, D. J. (2009). *Current Controversies in Central Auditory Processing Disorder (CAPD).* San Diego, CA, US: Plural Publishing.

Cacace, A. T., & McFarland, D. J. (2013). Factors influencing tests of auditory processing: A perspective on current issues and relevant concerns. *Journal of the American Academy of Audiology, 24*(7), 572-589.

Cameron, S., Brown, D., Keith, R. et al. (2009). Development of the Nort American Listening in Spatialized Noise-Sentences Test (NA LiSN-S): Sentence Equivalence, Normative Data, and Test-Retest reliability studies. *Journal of the American Academy of Audiology, 20*, 128-146. doi:10.3766/jaaa.20.2.6.

Cameron, S., & Dillon, H. (2007a). Development of the Listening in Spatialized Noise Sentences Test (LiSN-S). *Ear and Hearing, 28*(2), 196-211. doi:10.1097/AUD.0b013e318031267f.

Cameron, S., & Dillon, H. (2007b). The listening in spatialized noise-sentences test (LiSNS): test-retest reliability study. *Int J Adiol, 46*, 145-153. doi:10.1080/14992020601164170.

*Cameron, S., & Dillon, H. (2008). The Listening in Spatialized Noise-Sentences Test (LiSN-S): comparison to the prototype LISN and results from children with either a suspected (central) auditory processing disorder or a confirmed language disorder. *Journal of the American Academy of Audiology, 19*(5), 377-391.

Cameron, S., Dillon, H., & Newall, P. (2006). The Listening in Spatialized Noise Test: An auditory processing disorder study. *Journal of the American Academy of Audiology, 17*, 306-320.

Cameron, S., Glyde, H., & Dillon, H. (2011). Listening in Spatialized Noise – Sentences Test (LiSN-S): normative and retest reliability data for adolescents and adults up to 60 years of age. *Journal of the American Academy of Audiology, 22*, 697-709. doi:10.3766/jaaa.22.10.7.

Chermak, G.D., Bamiou, D-E., Iliadou, V. et al. (2017). Practical guidelines to minimize language and cognitive confounds in the diagnosis of CAPD: a brief tutorial. *International Journal of Audiology*, 1-8, published online: http://dx.doi.org/10.1080/14992027.2017.1284351.

Chermak, G. D., Hall, J. W., & Musiek, F. E. (1999). Differential diagnosis and management of central auditory processing disorder and attention deficit hyperactivity disorder. *Journal of the American Academy of Audiology, 10*, 289-303.

Chermak, G. D., & Musiek, F. (1997). *Central Auditory Processing Disorders*: New Perspectives. San Diego, CA, US: Singular Publishing Group.

Conners, C. K. (1996). *Conners' Rating Scales-Revised (CRS-R).* London, UK: Psychological Assessment Resources.

Conner, C.K. (1999). *Conners' Attention Deficit Scale - Parent Version*. North Tonawanda, NY: Multi-Health Systems.

Dawes, P., & Bishop, D. V. (2009). Auditory processing disorder in relation to developmental disorders of language, communication and attention: a review and critique. *International Journal of Language & Communication Disorders, 44*(4), 440-465. doi:10.1080/13682820902929073.

*Dawes, P., & Bishop, D. V. (2010). Psychometric profile of children with auditory processing disorder and children with dyslexia. *Archives of Disease in Childhood, 95*(6), 432-436.

*Dawes, P., Sirimanna, T., Burton, M. et al. (2009). Temporal auditory and visual motion processing of children diagnosed with auditory processing disorder and dyslexia. *Ear and Hearing, 30*(6), 675-686. doi:10.1097/AUD.0b013e3181b34cc5.

DeBonis, D. A. (2015). It is time to rethink central auditory processing disorder protocols for school-aged children. *American Journal of Audiology, 24,* 124-136. doi:10.1044/2015_AJA-14-0037.

Dillon H., Cameron S., Glyde H., Wilson W. et al. (2012). An opinion on the assessment of people who may have an auditory processing disorder. *Journal of the American Academy of Audiology, 23*(2), 97-105. doi: 10.3766/jaaa.23.2.4.

Dollaghan, C., & Campbell, T. F. (1998). Nonword repetition and child language impairment. *Journal of Speech, Language, and Hearing Research, 41*(5), 1136-1146.

Dunn, L. M., & Dunn, L. M. (1981). *Manual for the Peabody Picture Vocabulary Test Revised.* Circle Pines, MN: American Guidance Service.

Dunn, L. M., & Dunn, L. M. (1997). *Peabody Picture Vocabulary Test (PPVT-III)* (3rd ed.). Circle Pines, MN: American Guidance Service.

Ellis Weismer, S. (2008). Living on the edge of communicative competence: Processing capacity limitations. *Annual Meeting of the American Speech-Language-Hearing Association*, Chicago, IL.

Ferguson, M. A., Hall, R. L., Riley, A. et al. (2011). Communication, listening, cognitive and speech perception skills in children with auditory processing disorder (APD) or Specific Language Impairment (SLI). Journal of Speech, Language, and Hearing Research, 54*(1), 211-227. doi:10.1044/1092-4388(2010/09-0167).

*Ferguson, M., A., & Moore, D. R. (2014). Auditory Processing Performance and Nonsensory Factors in Children with Specific Language Impairment or Auditory Processing Disorder. *Seminars in Hearing, 35*(1), 1-14. doi:10.1055/s-0033-1363520.ISSN 0734-0451.

Frederickson, N., Frith, U., & Reason, R. (1997). *Phonological Assessment Battery (Manual and Test Materials).* Windsor, UK: NFER-Nelson.

Friberg, J. C., & McNamara, T. L. (2010). Evaluating the reliability and validity of (central) auditory processing tests: a preliminary investigation. *Journal of Educational Audiology, 16*, 4-17.

Gaulin, C. A., & Campbell, T. F. (1994). Procedure for assessing verbal working memory in normal school-age children: Some preliminary data. *Perceptual and Motor Skills, 79*(1 Pt 1), 55-64.

Geffner, D., & Ross-Swain, D. (2013). In Geffner D., & Ross-Swain D. (Eds.), *Auditory Processing Disorders: Assessment, Management, and Treatment* (2nd ed.). San Diego, CA, US: Plural Publishing.

Gyorkos, T. W., Tannenbaum, T. N., Abrahamowicz, M., et al. (1994). An approach to the development of practice guidelines for community health interventions. *Canadian Journal of Public Health, 85*(suppl 1), S8-S13.

Hind, S. E., Haines-Bazrafshan, R., Benton, C. L. et al. (2011). Prevalence of clinical referrals having hearing thresholds within normal limits. *International Journal of Audiology, 50*(10), 708-716. doi:10.3109/14992027.2011.582049.

Iliadou, V., & Bamiou, D. E. (2012). Psychometric evaluation of children with auditory processing disorder (APD): comparison to a normal and a clinical non APD groups. *Journal of Speech, Language, and Hearing Research, 55*, 791-799. doi:10.1044/1092-4388(2011/11-0035).

*Iliadou, V., Bamiou, D. E., Kaprinis, S., et al. (2009). Auditory Processing Disorders in children suspected of Learning Disabilities--a need for screening? *International Journal of Pediatric Otorhinolaryngology, 73*(7), 1029-1034. doi:10.1016/j.ijporl.2009.04.004.

Iliadou, V., Fourakis, M., Vakalos, A., et al. (2006). Bi-syllabic, Modern Greek word lists for use in word recognition tests: Listas de palabras bisilábicas del Griego moderno para uso en pruebas de discriminación. *International Journal of Audiology, 45*(2), 74-82.

Jerger, J. F. (2009). The concept of auditory processing disorder. A Brief History. In A. T. Cacace, & D. J. McFarland (Eds.), *Controversies in Central Auditory Processing Disorder (CAPD)* (pp. 1-14). San Diego, CA, US: Plural Publishing.

Jerger, J., & Musiek, F. (2000). Report of the Consensus Conference on the Diagnosis of Auditory Processing. *Journal of the American Academy of Audiology, 11*(9), 467-474.

Kamhi, A. G. (2011). What speech-language pathologists need to know about auditory processing disorder. *Language, Speech, and Hearing Services in Schools, 42(*3), 265-272. doi:10.1044/0161-1461(2010/10-0004).

Katz, J. (1962). The Use of Staggered Spondaic Words for Assessing the Integrity of the Central Auditory Nervous-System. *The Journal of Auditory Research, 2,* 327-337.

Katz, J. (2001). *Central Test Battery*. Vancouver, WA: Precision Acoustics.

Keith, R. W. (1994a). SCAN-A: A *Test for Auditory Processing Disorders in Adolescents and Adults.* San Antonio, TX: Psychological Corporation.

Keith, R. W. (1994b). *The Auditory Continuous Performance Test*. San Antonio, TX: Psychological Corporation.

Keith, R. W. (2000a). *SCAN-C: Test for Auditory Processing Disorders in Children Revised.* San Antonio, TX: Psychological Corporation.

Keith, R. W. (2000b). *Random Gap Detection Test,* AUDiTEC, St. Louis, MO.

King, W. M., Lombardino, L. J., Crandell, C. C., et al. (2003). Comorbid auditory processing disorder in developmental dyslexia. *Ear and Hearing, 24*(5), 448-456.

Korkman, M., Kirk, U., & Kemp, S. (1997). *NEPSY. Neuropsychological Assessment of Children.* Oxford, UK: Pearson Assessment.

Korkman, M., Kirk, U., & Kemp, S. (1998). *NEPSY: A Developmental Neuropsychological Assessment.* San Antonio, TX: Psychological Corporation.

Lam, E., & Sanchez, L. (2007). Evaluation of screening instruments for auditory processing disorder (APD) in a samle of referred children. *Australian and New Zealand Journal of Audiology, 29*(1), 26-39.

Leonard, L. B. (1998). *Children with Specific Language Impairment.* Cambridge, MA: MIT Press.

Levy, S., & Parkin, C. M. (2003). Are We Yet Able to Hear the Signal Through the Noise? A Comprehensive Review of Central Auditory Processing Disorders: Issues of Research and Practice. *Canadian Journal of School Psychology, 18*(1-2), 153-182. doi:10.1177/082957350301800108.

Lucker, J. R. (2013). The history of auditory processing disorders in children. In D. Geffner, & D. Ross-Swain (Eds.), *Auditory Processing Disorders: Assessment, Management, and Treatment* (2nd ed., pp. 33-58). San Diego, CA, US: Plural Publishing.

MacLeod, A., & Summerfield, Q. (1990). A procedure for measuring auditory and audiovisual speech-reception thresholds for sentences in noise: Rationale, evaluation, and recommendations for use. *British Journal of Audiology, 24*(1), 29-43.

McArthur, G. M. (2009). Auditory processing disorders: can they be treated? *Current Opinion in Neurology, 22*(2), 137-143. doi:10.1097/WCO.0b013e328326f6b1.

McFarland, D. J., & Cacace, A. T. (2006). Current Controversies in CAPD: From Procrustes' Bed to Pandora's Box. In T. K. Parthasarathy (Ed.), *An Introduction to Auditory Processing Disorders in Children* (pp. 247-263). Mahwah, NJ US: Lawrence Erlbaum Associates Publishers.

McGrath, L. M., Pennington, B. F., Shanahan, M. A. et al. (2011). A multiple deficit model of reading disability and attention-deficit/hyperactivity disorder: searching for shared cognitive deficits. *Journal of Child Psychology and Psychiatry, 52*(5), 547-557.

Medwetsky, L. (2011). Spoken Language Processing Model: Bridging Auditory and Language Processing to Guide Assessment and Intervention, *Language, Speech, and Hearing Services in Schools, 42*, 286-296. doi:10.1044/0161-1461.

Miller, C. A. (2011). Auditory processing theories of language disorders: Past, present, and future. *Language, Speech, and Hearing Services in Schools, 42*(3), 309-319. doi:10.1044.0161-1461.

*Miller, C. A., & Wagstaff, D. A. (2011). Behavioral profiles associated with auditory processing disorder and specific language impairment. *Journal of Communication Disorders, 44(*6), 745-763. doi:10.1016/j.jcomdis.2011.04.001.

Moher, D., Liberati, A., Tetzlaff, J., et al. PRISMA Group. (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. *PLoS Medicine, 6*(7), e1000097. doi:10.1371/journal.pmed1000097.

Moore, D. R. (2016). What's new in auditory processing? *ENT & Audiolgoy News, 25*(2), 2-3.

Moore, D. R., & Hunter, L. L. (2013). Auditory processing disorder (APD) in children: a marker of neurodevelopmental syndrome. *Hearing, Balance and Communication, 11*, 160-167. Doi:10.3109/21695717.2013.821756.

Moore, J. K., & Linthicum, F. H. (2007). The human auditory system: a timeline of development. *International Journal of Audiology, 46*, 460-478.

Moore, D. R., Rosen, S., Bamiou, D. et al. (2013). Evolving concepts of developmental auditory processing disorder (APD): A British Society of Audiology APD Special Interest Group 'white paper'. *International Journal of Audiology, 52*(1), 3-13. doi:10.3109/14992027.2012.723143.

Mullen, R. (2007). The state of the evidence: ASHA develops levels of evidence for communication sciences and disorders. *ASHA Lead, 12*(3), 8-9, 24,25.

Musiek, F. E. (1983). Assessment of central auditory dysfunction: the dichotic digit test revisited. *Ear and Hearing, 4*(2), 79-83.

Musiek, F. E. (1994). Frequency (pitch) and duration pattern tests. *Journal of the American Academy of Audiology, 5*, 265-268.

Musiek, F. E., Baran, J. A., & Pinheiro, M. L. (1990). Duration pattern recognition in normal subjects and patients with cerebral and cochlear lesions. *Audiology, 29*, 304-313.

Musiek, F. E., Gollegly, K. M., Kibbe, K. S. et al. (1991). Proposed screening test for central auditory disorders: Follow-up on the Dichotic Digits Test. *American Journal of Otolaryngology, 12*(2), 109-113.

Neijenhuis, K., Snik, A., & van den Broek P. (2003). Auditory processing disorders in adults and children: evaluation of a test battery. *International Journal of Audiology, 42(7*), 391-400.

O'Connor, K. (2012). Auditory processing in autism spectrum disorder: a review. *Neuroscience & Biobehavioral Reviews, 36*, 836-854. doi:10.1016/j.neubiorev.2011.11.008.

Olson, R. K. (1985). Disabled reading processes and cognitive profiles. In U. B. Gray, & J. Kavangh (Eds.), *Behavioural Measures of Dyslexia* (pp. 215-244). Parkton, MD: York Press.

Orgass, B., & Poeck, K. (1966). Ein neuer Aphasic-Test zur Diagnose von Sprachverstandnisstorungen [A new aphasia-test for the diagnosis of speech comprehension disorders]. *Nervenarzt, 37*(3), 124-126.

Pennington, B. F. (2006). From single to multiple deficit models of developmental disorders. *Cognition, 101*, 385-413. doi:10.1016/j.cognition.2006.04.008.

Pennington, B. F., & Bishop, D. V. M. (2009). Relations among speech, language, and reading disorders. *Annual Review Psychology, 60*(1), 283-306. doi:10.1146/annurev.psych.60.110707.163548.

Pinheiro, M. (1977). Tests of central auditory function in children with learning disabilities. In R. W. Keith (Ed.), *Central Auditory Dysfunction* (pp. 223-256). New York: Grune & Stratton.

Pinheiro, M. L., & Musiek, F. E. (1985). Sequencing and temporal ordering in the auditory system. In M. L. Pinheiro, & F. E. Musiek (Eds.), *Assessment of Central Auditory Dysfunction: Foundations and Clinical Correlates* (pp. 219-238). Baltimore: Williams and Wilkins.

Pinheiro, M. L., & Ptacek, P. H. (1971). Reversals in the perception of noise and tone patterns. *The Journal of the Acoustical Society of America, 49*(6B), 1778-1782.

*Riccio, C. A., Cohen, M. J., Hynd, G. W., et al. (1996). Validity of the Auditory Continuous Performance Test in differentiating central processing auditory disorders with and without ADHD. *Journal of Learning Disabilities, 29*(5), 561-566.

*Riccio, C. A., Hynd, G. W., Cohen, M. J., et al. (1994). Comorbidity of central auditory processing disorder and attention-deficit hyperactivity disorder. *Journal of the American Academy of Child & Adolescent Psychiatry, 33*(6), 849-857. doi:10.1097/00004583-199407000-00011

*Rocha-Muniz, C. N., Befi-Lopes, D. M., & Schochat, E. (2012). Investigation of auditory processing disorder and language impairment using the speech-evoked auditory brainstem response. *Hearing Research, 294*(1-2), 143-152. doi:10.1016/j.heares.2012.08.008.

*Rocha-Muniz, C. N., Zachi, E. C., Teixeira, R. A., et al. (2014). Association between language development and auditory processing disorders. *Brazilian Journal of Otorhinolaryngology, 80*(3), 231-236. doi:S1808-86942014000300231 [pii].

Rutter, M. & Pine, D. S. (2015). Diagnosis, diagnostic formulations, and classification. In A. Thapar, D. S. Pine, J. F. Leckman et al. (Eds.), *Rutter's Child and Adolescent Psychiatry* (6th ed., pp. 17-30). Oxford, UK: Wiley Blackwell.

Seashore, C. E., Lewis, D., & Saetveit, J. G. (1960). *Seashore Measures of Musical Talents.* New York: Psychological Corporation.

Semel, E., Wiig, E., & Secord, W. (1980). *Clinical Evaluation of Language Fundamentals*—Revised (CELF-R). New York: Psychological Corporation.

Semel, E. M., Wiig, E. H., & Secord, W. (2003). *Clinical Evaluation of Language Fundamentals (CELF-4) Observational Rating Scale* (4th ed.). San Antonio, TX: Psychological Corporation, Harcourt Brace.

Sharma, M., Dhamani, I., Leung, J. et al. (2014). Attention, memory, and auditory processing in 10- to 15- year-old children with listening difficulties. *Journal of Speech, Language, and Hearing Research, 57*, 2308-2321. doi:10.1044/2014_JSLHR-H-13-0226.

Sharma, M., Purdy, S. C., & Kelly, A. S. (2009). Comorbidity of auditory processing, language, and reading disorders. *Journal of Speech, Language, and Hearing Research, 52*(3), 706-722. doi:10.1044/1092-4388(2008/07-0226).

Simões, M. B., & Schochat, E. (2010). (Central) auditory processing disorders in individuals with and without dyslexia. *Pró-Fono Revista de Atualização Científica, 22*(4), 521-524.

Smoski, W. J., Brunt, M. A., & Tannahill, J. C. (1992). Listening characteristics of children with central auditory processing disorders. *Language, Speech, and Hearing Services in Schools, 23*(2), 145-152.

Smoski, W. J., Brunt, M. A., & Tannahill, J. C. (1998). *Children's Auditory Processing Performance Scale (CHAPPS).* Tampa Florida: The Educational Audiology Association.

Stollman, M. H., van Velzen, E. C., Simkens, H. M., et al. (2003). Assessment of auditory processing in 6-year-old language-impaired children. *International Journal of Audiology, 42*(6), 303-311.

Thapar, A., Pine, D. S., Leckman, J. F., et al. (Eds.). (2015). *Rutter's Child and Adolescent Psychiatry* (6th ed.). Oxford, UK: Wiley Blackwell.

Torgesen, J. K., Wagner, R. K., & Rashotte, C. A. (1999). *Test of Word Reading Efficiency.* London, UK: Psychological Corporation.

Tzavaras, A., Kaprinis, G., & Gatzoyas, A. (1981). Literacy and hemispheric specialization for language: Digit dichotic listening in illiterates. *Neuropsychologia, 19*(4), 565-570.

Vermiglio, A. J. (2016). On diagnostic accuracy in audiology: central site of lesion and central auditory processing disorder studies. *Journal of the American Academy of Audiology*, *27*, 141-156. doi:10.3766/jaaa.15079.

Victorino, K. R., & Schwartz, R. G. (2015). Control of auditory attention in children with specific language impairment. *Journal of Speech, Language, and Hearing Research, 58,* 1245-1257. doi:10.1044/2015_JSLHR-L-14-0181.

Wagner, R., Torgesen, J., & Rashotte, C. (1999). *Comprehensive Test of Phonological Processes (CTOPP).* Austin, TX: Pro-Ed.

*Walker, K. M. M., Brown, D. K., Scarff, C., et al. (2011). Temporal processing performance, reading performance, and auditory processing disorder in learning-impaired children and controls. *Canadian Journal of Speech-Language Pathology and Audiology, 35*(1), 6-17.

Walker, M. M., Givens, G. D., Cranford, J. L., et al. (2006). Auditory pattern recognition and brief tone discrimination of children with reading disorders. *Journal of Communication Disorders, 39*(6), 442-455.

Walker, M. M., Shinn, J. B., Cranford, J. L., et al. (2002). Auditory temporal processing performance of young adults with reading disorders. *Journal of Speech, Language, and Hearing Research, 45*(3), 598-605.

Wallach, G. P. (2011). Peeling the onion of auditory processing disorder: a language/curricular-based perspective. *Language, Speech, and Hearing Services in Schools, 42,* 273-285. doi:10.1044/0161-1461(2010/10-0008).

Walton, D., & Brooks, P. (1995). The Spoonerism Test. *Educational and Child Psychology, 12*, 50-52.

Wechsler, D. (1974). *Wechsler Intelligence Scale for Children-Revised*. New York: Psychological Corporation.

Wechsler, D. (1991). *Wechsler Intelligence Scale for Children (WISC-III)* (3rd ed.). San Antonio, TX: Psychological Corporation.

Wechsler, D. (1999). *Manual for the Wechsler Abbreviated Intelligence Scale (WASI).* San Antonio, TX: Psychological Corporation.

Wiederholt, J., & Bryant, B. (2001). *Gray Oral Reading Test (GORT-4)* (4th ed.). Austin, TX: Pro-Ed.

Wilkinson, G. S. (1993). *WRAT-3 Wide Range Achievement Test, administration manual.* Wilmington, DE: Wide Range.

Willeford, J. (1977). Assessing central auditory behavior in children: A test battery approach. In R. Keith (Ed.), *Central Auditory Dysfunction* (pp. 43-72). New York: Grune and Stratton.

Williams, J., Scott, F., Stott, C. et al. (2005). The CAST (Childhood Asperger Syndrome Test): test accuracy. *Autism, 9*(1), 45-68.

Wilson, W. J., & Arnott, W. (2013). Using different criteria to diagnose (central) auditory processing disorder: how big a difference does it make*? Journal of Speech, Language, and Hearing Research, 56*(1), 63-70. doi:10.1044/1092-4388(2012/11-0352); 10.1044/1092-4388(2012/11-0352).

Wilson, W. J., Jackson, A., Pender, A., et al. (2011). The CHAPS, SIFTER, and TAPS-R as predictors of (C)AP skills and (C)APD. *Journal of Speech, Language, and Hearing Research, 54*, 278-291.

Wit, de, E., Visser-Bochane, M. I., Steenbergen, B. et al. (2016). Characteristics of Auditory Processing Disorders: A Systematic Review. *Journal of Speech, Language, and Hearing Research, 59*, 384-413. doi:10.1044/2015_JSLHR-H-15-0118.

Woodcock, R. W., McGrew, K. S., Mather, N. et al. (2001). *Woodcock-Johnson III Tests of Achievement*. Itasca, IL: Riverside Publishing.