Supplemental Digital Content 1: *Protocol Systematic review*

**Title**

Same or different: the overlap between characteristics of children with APD and children with other developmental disorders (SLI, Dyslexia, ADHD, Autism): a Systematic Review

**Context and conceptual issues**

Aim of review

To determine the differences and similarities between the characteristics of children diagnosed with Auditory Processing Disorders (APD) with the characteristics of children diagnosed with specific language impairment (SLI), reading disorders (Dyslexia), attention deficit hyperactivity disorders (ADHD), autism spectrum disorders (ASD), and learning disorders (LD) and to provide a summary of the differences and similarities in performance between children with APD and children with a different developmental disorder on behavioral, physiological, and brain measurements.

**Stage 1: Identification**

*Stage 1 and 2 are identical to the method as described in the article of De Wit et al. (2016).*

Search strategy

The following databases will be searched:

Pubmed;

Ebscohost:

PsycINFO;

Cumulative Index to Nursing and Allied Health Literature (CINAHL);

Educational Resources Information Center (ERIC);

Communication & Mass Media Complete;

Excerpta Medica database (EMBASE).

Studies published from 1954 (studies of auditory processing began in 1954 (Myklebust in Cacace & McFarland 2009) and 1955 (Bocca, Calearo, Cassinari & Migliavacca in Cacace & McFarland 2009)), written in English and published in a peer-reviewed journal, containing primary research were initially considered for the review.

Results will be incorporated in a Prisma flow chart (Moher, Liberati, Tetzlaff, Altman, The PRISMA Group 2009).   
Keywords:

*Pubmed:*

("Auditory Diseases, Central"[Mesh] OR auditory processing[tiab] OR auditory perceptual[tiab]) AND (child[tiab] OR children[tiab] OR adolescent\*[tiab])

* We decide to use the MeSH-term one above in hierarchy (MeSH-term “Auditory diseases, central” instead of “Auditory Perceptual Disorders”). Search on the broader term will retrieve articles with that heading as well as all of the narrower terms indented below.

*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.

* Import all possibly eligible studies in Refworks in a separate folder (“Total search”).
* Assess exact duplicates and close duplicates in Refworks and remove exact duplicates.

**Stage 2: Screening**

*Stage 1 and 2 are identical to the method as described in the article of De Wit et al. (2016).*

Step 1) Screening of titles

The titles of studies located and stored in Refworks are screened against the inclusion/exclusion criteria by two researchers (EW & MV).

* Indicate, based on the title per Refworks page (in written form on paper), per reference if the study should be included (+) or excluded (-) in the review.

The selection of both reviewers will be compared. When both reviewers have assessed a reference with the symbol “-“, the study is stored in a folder “Out”. When both reviewers have assessed a reference with the symbol “+”, the reference will be stored in the Refworks folder “In on title”. When the reviewers have no consensus, the abstract will be opened and reviewed and discussed between the two reviewers. After reaching agreement, the reference is stored in the “in on title” or “out” folder.

*Inclusion criteria title*

1. Published in English
2. Addressed factors in title about:

* Auditory Processing in combination with deficit(s), impairment(s), problem(s), difficulties, or disorder(s)

The following terms are also considered for inclusion:

* Auditory problem(s)
* Auditory perceptual or auditory perception
* Auditory (dys)function
* Auditory abilities
* Listen(ing)
* Speech perception or processing

Step 2) Screening of abstracts

The abstracts of the studies stored in the Refworks folder “In on title” will be screened against the eight inclusion/exclusion criteria by two of the three researchers (EW and MV or EW and ML).

* Indicate, based on the abstract (in written form on paper), per reference if the study should be included (+) or excluded (-) in the review. In the event of exclusion, state the reason of exclusion by writing down the number corresponding with the inclusion/exclusion criteria (1-8) where the study does not met the inclusion criteria.

Abstracts that satisfy the inclusion criteria will be moved to the Refworks folder “In on abstract”. Where there is uncertainty, the abstract will be reviewed and discussed between the three reviewers. As it is not always obvious from the abstract whether the study satisfied the inclusion criteria, remaining studies are read more extensively for eligibility (Step 3) by one of the three reviewers (EW, MV, and ML).

*Inclusion/exclusion criteria abstract*

1. Published in English
2. Addressed factors in abstract about:

* Characteristics of APD, susAPD or children at risk for APD, in the presence of normal hearing.

The following terms for APD are also considered for inclusion:

* (Central) auditory processing disorder(s)
* Auditory processing deficit
* Auditory processing disease
* Auditory perceptual disorder(s)
* Auditory perception disorder(s)
* Acoustic perceptual disorder(s)
* Auditory listening problems
* Central auditory dysfunction
* Listening disorder(s)
* Listening difficulties
* Speech perception problem(s)
* Speech perception disorder(s)

1. Participants must be under the age of 18 years because the final step in structural maturation of the auditory cortex occurs in later childhood between the ages of six and 12 years of age (Moore & Linthicum 2007).
2. Studies in which participants with brain damage or other deficit(s) participate will be excluded (neuropathy, children with cochlear implants, children with Down Syndrome or another syndrome, neonatal children, children with peripheral hearing loss, children with chronic otitis media, children with brain damage).
3. Primary research (randomized controlled trials, experiments, quasi-experiments, Meta-analyses, cohort studies, case-control).
4. Published in peer-reviewed journal.
5. Books, book chapters, dissertations, or case studies or case-series will be excluded.

**Stage 3: Eligibility**

Step 1) Full-text articles assessed for eligibility

The references in the Refworks folder “In on abstract” will be divided between the three researchers (EW, MV, and ML). They will individually read and review the papers and accurately check them against the criteria for inclusion. Each researcher indicates if the study meets the inclusion criteria of the first systematic review (De Wit et al. 2016) or the second systematic review (current one). Subsequently, the first reviewer (EW) will check the eligibility of the second reviewer (MV) and third reviewer (ML) and vice versa. All reviews will be discussed in a consensus meeting and any uncertainty about a reference will be discussed among the three researchers. All studies that meet inclusion will be stored in the folder “Systematic Review: final search”.

*Procedure*The following should be present in the study:

1. Description of the study design and research method.
2. The focus of the study needs to be on the comparison of the behaviors and/or performance on various measurements of children with (sus)APD and children diagnosed with a different developmental disorder (SLI, Dyslexia, ADHD, ASD or LD).
3. Description of the study population: a group of children with (sus)APD and a group of children with a different developmental disorder such as SLI, Dyslexia, ADHD, ASD, or LD.
4. Description of the tests used in the study to determine if there were differences between children with (sus)APD and other developmental disorders.
5. Study meets the research question: contains information about characteristics or performance of children with (sus)APD on behavioral, physiological, or brain measurements in comparison with children diagnosed with a different developmental disorder.
6. In the results section, the following must be indicated: a comparison between the performance of children with (sus)APD and children with a different developmental disorder.
7. The study meets all of the criteria described at Stage 2: screening of abstracts

Step 2: Full-text assessed for methodological quality

Each included study will be independently reviewed and evaluated for methodological quality by two reviewers (EW and SH or EW and ML) with the ASHA’s levels-of-evidence (ASHA’s LOE) scheme (Mullen 2007). The two reviewers, blinded to each other’s results, appraised each study on the basis of the quality indicators: study design, blinding, sampling/allocation, group/participant comparability, outcomes, significance, and precision (see Supplementary Table 1).

*Explanation ASHA’s LOE system* (adapted from Mullen 2007 & Fey et al. 2011)

Study design: design of the study is reported or a description of the design is described in detail. Studies with more than one experimental group and a control group and studies with normative groups will be regarded as a cross-sectional study.

Blinding: researcher, testers (observers), and/or test scores were masked with respect to the child’s group assignment. The tester/researcher does not know in which group the child participated.

Sampling / allocation: participants were selected at random or were assigned randomly to groups. The recruitment and selection procedure of participants was descripted in detail. The main characteristics of the groups are described in detail; the study contained a table with a clear description of the demographic characteristics of the children in the different groups (e.g., gender, age range, mean age, socioeconomic status, type of school, language abilities).

Group / participant comparability: appropriate comparison between groups; homogeneous group at the beginning of the study (between-subject design) or well-described subjects (within-subject design). Inclusion and exclusion criteria of the study population are well described. Matching is described. Differences between subjects are described in detail. Only yes when the subjects within groups are well described (with participant information in a table) and are comparable to the following factors: hearing; language, intelligence and reading abilities, and the presence of comorbid disorders.

Outcomes: clearly defined how primary outcomes will be measured. The used measurements were clearly described and explained. Information about reliability and validity is included in the description of the measurements or reference to information about reliability and validity is included. The validity and reliability is reasonable when the used measurement is described in detail and when there are no concerns about the reliability of the measurement.

Significance: a statistical test was reported and p-values are reported or calculable.

Precision: an effect size, such as *d*, is reported along with confidence limits surrounding *d*. When effect size and confidence intervals were not reported, the study provides sufficient descriptive statistics (sample size of each group, means, and standard deviations (SD)) to calculate *d* and confidence limits around it.

The quality assessment must be saved per study in a standard formatted Excel file (available on request from the first author). All discrepancies between the reviewers will be discussed and resolved by consensus between the three reviewers in a consensus meeting.

**Stage 4: Included**

Data extraction and analysis

Data will be extracted from the included studies by two reviewers (EW and SH or EW and ML). From the included papers, details of participants, experimental group, control group, used measures, and outcomes will be extracted and compiled in the standard formatted Excel file.

**References**

Bocca, E., Calearo, C., Cassinari, V., & Migliavacca, F. (1955). Testing “cortical” hearing in

temporal lobe tumors. *Acta Otolaryngolgica, 45*, 289-304.

Cacace, A. T., & McFarland, D. J. (2009). *Current controversies in central auditory*

*processing disorder (CAPD)*. San Diego, CA US: Plural Publishing.

Fey, M. E., Richard, G. J., Geffner, D., Kamhi, A. G., Medwetsky, L., Paul, D., … Schooling, T. (2011). Auditory processing disorder and auditory/language interventions: An evidence-based systematic review. *Language, Speech, and Hearing Services in Schools, 42*(3), 246-264. doi:10.1044/0161-1461(2010/10-0013).

Moher D., Liberati A., Tetzlaff J., & Altman D. G., The 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, J. K., & Linthicum, F. H. (2007). The human auditory system: a timeline of development. International Journal of Audiology, 46: 460-478.

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

Myklebust, H. (1954). Auditory disorders in children. New York: Grune & Stratton.

Wit, de, E., Visser-Bochane, M.I., Steenbergen, B., Dijk, van, P., Schans, van der, C.P., &

Luinge, M.R. (2016). Characteristics of Auditory Processing Disorders: A Systematic

Review, Journal of Speech, Language, and Hearing Research, 59(2), 384-413.