Critical Review: What is the efficacy of auditory training in the treatment of individuals with (Central) Auditory Processing Disorder (CAPD or APD)?

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(Central) auditory processing disorder (C)APD has been defined as a neural deficit in the processing of auditory stimuli and its underlying brain activity (Chermak & Musiek, 2007), although there is no consensus in the field surrounding its definition, diagnosis, assessment or intervention (DeBonis & Moncrieff, 2008; McArthur, 2009). Auditory training is one form of intervention often used to treat (C)APD, yet the studies supporting its efficacy as a legitimate treatment have a number of shortcomings, ultimately leaving the reader with a number of questions regarding the validity of the results.

Introduction

(Central) auditory processing disorder (C)APD is a controversial disorder in a number of respects; it is plagued by a lack of consensus in the field regarding its definition, diagnosis, assessment and intervention (DeBonis & Moncrieff, 2008; McArthur, 2009). Chermak and Musiek (2007) defined (C)APD as a perceptual processing deficiency concerning acoustic stimuli and its underlying brain activity. Furthermore these authors state that while (C)APD can coexist with other disorders, it is not caused by other disorders.

Intervention for individuals with (C)APD is rather eclectic, with no gold standard existing to date (DeBonis & Moncrieff, 2008). Forms of intervention include but are not limited to: environmental modifications, compensatory training, and auditory training (Bellis & Anzalone, 2008). While a wide variety of interventions are currently used, empirical evidence supporting their effectiveness is often lacking. Auditory training is one of the treatments often employed to treat (C)APD, despite limited research supporting its efficacy (DeBonis & Moncrieff, 2008; Musiek, Shinn & Hare, 2002). One definition of auditory training describes it as a collection of acoustic tasks that share the same goal of stimulating auditory and neural pathways, ultimately changing the underlying neural structure and thus the auditory system (Chermak & Musiek, 2007). The literature available on auditory training often uses different methodology, a variety of methods and inconsistent procedures, thus making it difficult for conclusive results to be obtained. Research needs to address the efficacy of using auditory training to treat (C)APD. A critical review in this area of literature is particularly relevant because the controversy surrounding (C)APD requires both authors and readers to use precautions when drawing conclusions from current literature.

Objectives

The primary objective of this paper is to critically evaluate the literature surrounding the efficacy of auditory training as a form of intervention for individuals with (C)APD. The secondary objective is to augment current knowledge regarding auditory training as an intervention for (C)APD in order to enhance evidence based practice in this controversial field.

Methods

Search Strategy

Computerized databases, including SCOPUS, CINAHL, PubMed, Psychinfo and Google Scholar, were explored via the following search strategy:
(central auditory processing disorder) OR (CAPD) OR (auditory processing disorder) OR (APD) AND (intervention) OR (treatment) OR (auditory training) OR (dichotic listening).
The search was limited to articles written in the past 5 years. Two articles were translated from Portuguese.

Selection Criteria

Papers that were included in this critical review addressed the outcomes of auditory training in the treatment of (C)APD. Limits were set to only include the (C)APD as a disorder rather than a feature of a larger disorder (e.g. language impairments). Also, only traditional forms of auditory therapy were evaluated, therefore auditory integration training, auditory stimulation or commercial auditory training programs were not included in this analysis. Participants in all of the studies fell between 7 and 20 years of age.

Data Collection

Proceeding the literature search the following types of articles that adhered to the selection criteria described above were obtained: single group pre-post test design (3) and a between and within case control study (1).

Results

The Schochat, Musiek, Alonso & Ogata (2010) article looked at mid-latency characteristics in children with (C)APD and how these characteristics responded to auditory training. There were 30 participants in the (C)APD group between the ages of 8 and 14, as well as 22 age and gender matched individuals in the control group. The authors implemented an auditory training program lasting 8 weeks, once a week for 50 minutes and 15 minute a day at home. The authors used descriptive and inferential statistics to analyze the data, such as one-way ANOVAs. The authors found that there was a significant wave amplitude difference between the groups prior to the training program that was no longer observed after its completion. In addition to electrophysiologic measures, the (C)APD group displayed significant improvement on all behavioural tests after the auditory training program. The results of this study provide moderate evidence to support the efficacy of auditory training to treat (C)APD.

The Samelli & del Nero Mecca (2010) article was originally written in Portuguese and was translated. The study addressed the question, "is auditory training an effective way to treat APDs?" The study consisted of 10 participants (2 female and 8 male) ranging from 7 to 20 years of age. The authors implemented an auditory training program lasting 10 sessions, once a week for 50 minutes. The authors used an ANOVA to analyze the data. Results of this study indicated that significant differences were seen on all behavioural tests following auditory training, albeit one test was marginally significant at 0.06. Despite these significant improvements, not all children reached age level performance after the auditory training program. Overall, this article offered moderately suggestive evidence to support the efficacy of auditory training.

Alonso & Schochat (2009) wrote a paper addressing the question, "is auditory training an efficacious treatment for (C)APD?" The participants consisted of 29 individuals (16 male and 13 female) between the ages of 8 and 16. The authors implemented an auditory training program lasting 8 sessions, once a week for 50 minutes. The participants were assessed using both behavioural and electrophysiologic measures. The authors used both parametric (ANOVA and paired student's T-test) and non parametric tests (Wilcoxen and Mann-Whitney) to analyze the data. The use of both parametric and non parametric tests to analyse the same data seems contradictory since the latter assumes non normal distribution of the data while the former assumes a normal distribution of the data. The authors do not explain the rationale underlying these choices or state which results were used when reporting their findings. The authors indicated that P300 latency values significantly decreased after auditory training; although P300 amplitude values also decreased this difference was not significant. The authors noted that significant differences were found in all (C)APD behavioural tests when pre and post scores were compared. In fact, after auditory training 72.4% of the participants exhibited normal auditory processing test results. Overall, this article yielded suggestive evidence to support the efficacy of auditory training.

The Zulcman & Schochat (2007) article was originally written in Portuguese and was translated online. Behavioural tests were used to address the question, "does auditory training enhance the performance of children with (C)APD?" Thirty subjects participated in this study, 12 females and 18 males between the ages of 8 and 16. The authors implemented an auditory training program lasting 8 sessions, once a week for 50 minutes as well as 15 minutes of home training 3-4 times a week. The data was analyzed using the Wilcoxen test. Following the auditory training program all participants displayed improvements in assessment scores on all behavioural tests. Of the 30 participants in this study 19 (63.3%) displayed normal test results after training and the remaining 11 all showed significantly improved scores. Overall, the results of this article provide suggestive evidence to support the efficacy of auditory training in the treatment of (C)APD.

Standard Diagnosis Criteria

As aforementioned, to date there is no standardized method for diagnosing (C)APD, which raises the fundamental question *do the children in these studies have the same underlying auditory deficits*? This is a pertinent issue since it affects the interpretation of the intervention results; if the children do not come from the same population it is irrelevant whether or not the treatment is successful with respect to treatment of (C)APD. All four articles reviewed in this paper included in the description of the diagnostic process: normal tone threshold audiometry and no current or history of ear problems as part of their criteria for (C)APD (Alonso & Schochat, 2009; Samelli & del Nero Mecca, 2010; Schochat, Musiek, Alonso & Ogata, 2010; Zulcman & Schochat, 2007). Alonso & Schochat (2009) also included impedance test results, logoaudiometry, brainstem auditory evoked potential (BAEP), and altered results from at least two (C)APD behavioural assessment tests to confirm a diagnosis of (C)APD. Zulcman & Schochat (2007) also included poor performance on at least 2 auditory processing tests as part of their diagnostic criteria. The study by Schochat, Musiek, Alonso & Ogata (2010) stated that their subjects exhibited poor performance in at least one

ear on at least two out of four tests in the central auditory test battery. The article by Samelli and del Nero Mecca (2010) mentioned where their (C)APD participants were recruited from but did not mention the criteria for this diagnosis. While the aforementioned authors stated that their subjects performed poorly on tests of auditory processing, none explicitly specified what tests were used to make this diagnosis.

While acknowledging the challenges associated with diagnosing individuals with (C)APD, the lack of sufficient descriptions and inconsistency of methods used in these studies brings into question the validity of the subject pool. All four articles provided insufficient information regarding their subjects considering the lack of consensus surrounding this population. For instance, the authors neglect to mention who the referral source(s) were, where their subjects were recruited from, with the exception of except Samelli and del Nero Mecca (2010) and the one control group used, and in two out of four studies which specific tests were used to confirm the diagnosis of (C)APD. Subsequently, whether the subjects are an accurate representation of this population is questionable based on the information provided by the current literature.

Single Group Pre-Post Test Design

A single group pre-post test design is considered level 3 experimental evidence (OCEBM Table of Evidence Working Group*). It measures a single group of subjects before and after an experimental manipulation (Archibald, 2010). This allows the author to measure the change allegedly resulting from the experimental manipulation by gathering both baseline and post-experimental data. While this type of study offers a good starting point, limitations of this design include no control groups to document that the change was only in the experimental condition. The Alonso & Schochat (2009), Samelli & del Nero Mecca (2010), and Zulcman & Schochat (2007) articles all used a single group pre-post test design. While this choice of design did address the articles objectives, it appears to have been dictated by the resources available (e.g. small group of children with (C)APD available for the study may have not permitted the inclusion of a (C)APD control group), and therefore has the potential to be improved by increasing the number of subjects and therefore the power of the experiment, as well as adding a control group of matched peers. See discussion of control groups below.

Case Control Study

A case control study is considered level 2b experimental evidence (OCEBM Table of Evidence Working Group*). It consists of at least one experimental group that has a matched control group and is quasi-experimental since the groups are not fully randomized (Archibald, 2010). Generally, it is considered a higher level of evidence compared to the single group pre-post test design since it includes a matched control group. The Schochat, Musiek, Alonso & Ogata (2010) article used a mixed case control study design, which consisted of a 'within groups' component (performance of the experimental group before and after an auditory training program), as well as a between groups component (differences between the control and experimental groups). This design was appropriate for this study and offered a more comprehensive measurement of the effectiveness of auditory training; a suggestion to further improve this study would be the addition of a second control group of matched individuals with (C)APD who did not receive auditory training or received a different type of training. See below for further discussion of the advantages of including a control group in an experimental study.

Size of the Experimental Group

Ideally a study will recruit a large number of subjects which gives the experiment more power, since testing a large number of people gives a more accurate picture of what is really happening. Conversely, a relatively small number of subjects are less likely to capture an accurate picture of the target event and therefore it has less power (Archibald, 2010). All four articles use relatively small experimental groups (30 subjects or less) and therefore the results must be interpreted carefully since they may not be an accurate representation of the entire (C)APD population based on the small samples.

Control Group

The use of a control group is the gold standard for empirical research because it supports the hypothesis that without the experimental manipulation the hypothesized change is not seen. A control group can either be normal matched peers or individuals in the same population who are not exposed to the experimental manipulation; the ideal study would include both of these control groups (Archibald, 2010). There are inherent issues that surround the use of control groups from the target population; such as small target populations or ethical dilemmas like withholding treatment. None of the articles address the use of including a control group of matched peers with (C)APD who do not receive auditory training; this would have added increased validity to the claim that auditory training is an effective intervention for (C)APD. Only one article used a control group of normal matched peers who did not have (C)APD as a baseline to compare with their experimental group (Schochat, Musiek, Alonso & Ogata, 2010). While the inclusion of a control group was an improvement, this

control group was comprised of relatives and acquaintances of the (C)APD group and were thus not randomly selected; also the authors mention that not all of the control group could be post tested however the exact number of subjects was not stated.

Long Term Follow Up

Only the Alonso and Schochat (2010) article somewhat addressed the lasting effects of the results obtained in the study by waiting one month between the end of the program and reassessment. The Schochat, Musiek, Alonso & Ogata (2010) article did not mention long term follow up in their study but stated that it would be addressed in the future. The purpose of an experimental study is to see if a manipulation leads to a hypothesized change; however an important factor that should not be overlooked is follow up to see if that change is maintained. This issue is relevant to transferring what is learned through research into clinical practice.

Addressing Reliability and Validity

The results of a study are only relevant if they are reliable and valid. Steps can be made during the research process to increase the reliability and validity of the study. One of these precautions is blinding the researchers/participants from the experimental conditions to eliminate bias, for example finding what they expect to find (Archibald, 2010). Only the Alonso & Schochat (2009) article address this important issue in one of their measurements. Not blinding subjects or participants may adversely affect the interpretation of the results; thus the findings of the three articles that did not address this should be interpreted with caution. Additionally, the authors claim that the positive results are directly attributable to the training program that was implemented; however variables that may have affected the results were not addressed. For instance, was the child receiving any other type of therapy? Interfering variables should be identified/discussed so the reader can have a more comprehensive picture of the results.

Description of Methods

It is important that an experiment's method section is clearly described in enough detail for replication to be easily achieved. The Schochat, Musiek, Alonso, & Ogata, 2010 and Samelli & del Nero Mecca (2010) articles provided detailed descriptions of their respective auditory training programs that were used in their experiments. These articles offer well documented method sections that both named and explained the tasks included in the training program. On the other hand, a large flaw in two of the four articles was insufficient description of the auditory training program that was implemented. Both the Alonso & Schochat (2009) and the Zulcman & Schochat (2007) articles alluded to the tasks that comprised their respective auditory training programs, stating that the tasks were compiled from the work of other authors and validated, however they did not provide any further detail. The four articles exhibit a wide range of detail provided by the authors. Since there are no standard procedures for auditory training as an intervention for (C)APD it is imperative that researchers in this field provide clear, replicable accounts of what has been done.

All four articles provided complete descriptions of tasks used to measure patient performance pre/post training. Overall, this description of measurement procedures strengthens the validity of the articles.

Discussion

The authors of all four of the current studies concluded that auditory training appeared to be an effective form of treatment for (C)APD based on their findings. Only the article by Schochat, Musiek, Alonso & Ogata, (2010) added the caveat that their findings supported emerging evidence, however further research was needed to confirm these claims. In general, these conclusions seem to overstate the results considering that (C)APD is an area where caution should be exercised. The critical review of these articles contains a more guarded interpretation of their findings. While the current articles offer a good starting point with regards to addressing the efficacy of auditory training, further research attempts should focus on improving the design and attention to detail in order to enhance the efficacy of the results. In particular, authors should focus on:

1.) Detailed diagnosis criteria.
    - *a. How are the clients/controls selected?*
    - *b. What procedures were used to diagnose?*
2.) Consideration of type of design.
    - *a. Randomized control study possible?*
    - *b. Can control groups be included?*
    - *c. What is the experimental/control group size?*
3.) Detailed methods section.
    - *a. Sufficient description of procedure?*
4.) Clearly describe measurement tools.
    - *a. Is the description/rationale for tests stated?*
    - *b. Easily replicable?*
5.) Adequately addressed reliability and validity.
    - *a. Blind participants/experimenters?*
    - *b. Are confounding factors identified?*
6.) Long term follow up.

The current studies all provide a respectable attempt at answering the question of whether auditory training is an efficacious form of treatment for (C)APD. A key suggestion to improve the quality of this research is to make the studies easier to replicate. This is essential to produce conclusive results, thus leaving less uncertainty regarding procedures and the significance of the results.

A subsequent area of study, which may enhance the efficacy of research findings, is the use of electrophysiological measures to assess the performance of an individual with (C)APD prior to and following auditory training, in conjunction with behavioural measures. Plasticity of the nervous system seems to underlie auditory training and these changes can be monitored through electrophysiological measures, such as the P300 wave latency and mid latency response (MLR) amplitude as exemplified by the Alonso & Schochat (2009) and Schochat, Musiek, Alonso & Ogata (2010) studies. These results offer support to the efficacy of auditory training in the treatment of (C)APD and future research may benefit from including this additional type of measurement.

Considering the state of the current literature, clinicians should be cautious if inclined to use auditory training alone to treat (C)APD. A more conservative option may be to assume an eclectic approach (Bellis & Anzalone, 2008). In using this approach auditory training may still be included in the treatment process, however it would only be one part of the intervention battery.

Conclusion and Clinical Implications

Based on a critical review of the current literature, auditory training appears to be a promising form of (C)APD intervention, however further research in this area is still required before definite conclusions can be drawn. The *quality* of future studies is an important issue since (C)APD is a controversial disorder that has a number of unresolved issues; special attention to subject selection, test selection, measurement tools, procedures and details are essential for gaining accurate insight to the efficacy of auditory training as a form of treatment for (C)APD. It has been suggested that an eclectic approach to (C)APD therapy which tailors treatment to a child's specific deficits is currently the best option for (C)APD intervention (Bellis & Anzalone, 2008). Until further research has been conducted, the use of auditory training as a form of (C)APD treatment should be used with caution. Including auditory training as part of the treatment battery, rather than the only form of intervention, may serve as a relatively safe option for clinicians until more conclusive research is available.

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