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# The development of the Questionnaire of (Central) Auditory Processing: a screening tool of auditory processing

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**Objective:** The aim of this study was to develop a screening questionnaire for auditory processing disorder (APD) targeted for the Maltese pediatric population.

**Method:** The questionnaire consisted of 25 close-ended questions in which parents rated their child's listening skills. The data was collected from 101 typically developing Maltese bilingual children and 30 children forming a clinical group, aged between 7;00 and 9;11 years.

**Results:** The tool was found to be highly reliable with an internal consistency of 0.92 and test-retest reliability of 0.94. Significant differences emerged between normal and clinical groups ( $p = <0.001$ ). Correlational analysis demonstrated a significant correlation between the Questionnaire of (Central) Auditory Processing (QCAP) and the speech-in-noise test, Duration Patterns Test and tests of dichotic listening.

**Conclusion:** The QCAP is potentially an effective screening tool for highlighting listening difficulties in Maltese children at risk of having APD.

## KEYWORDS

auditory processing disorder, listening difficulties, screening tool, questionnaire, children

## 1 Introduction

Auditory processing is the proficiency of the central nervous system to perceptually process information coming from the auditory channels, and incorporates the mechanism of electrophysiological auditory potentials arising from the neurobiological activity responsible for processing this information (Yalçinkaya et al., 2009). The conscious perception of auditory signals occurs in the auditory cortex, with the primary sensory cortical areas being the region where initial perception occurs. This also has been found to be the site where bottom-up and top-down processing come together (Moore and Hunter, 2013).

Auditory processing disorder (APD) has been described as a mixture of unrefined listening skills causing poor speech perception, especially in noisy environments (Rosen et al., 2010). These difficulties are typically evident in the presence of normal hearing (de Wit et al., 2016). Prevalence studies on APD have reported differing results, ranging between 0.2% (Nagao et al., 2016) and 10% (Bamiou et al., 2001) in the pediatric population. When combined with other developmental disorders, the prevalence has been found to increase to between 30 and 50% (King et al., 2002; Ramus, 2003). The most recent definition of APD offered by the British Society of Audiology (2018) provides a broad approach, suggesting that the symptoms occur as a result of impaired neural function

within the afferent and efferent pathways of the central auditory nervous system, along with its related top-down modulation (including vision, cognitive functions of speech and language, attention, executive function, fluid reasoning, memory, and emotion). This definition implies that APD frequently occurs in conjunction with (and could be a contributing factor of) the primary disorders of those systems. The [British Society of Audiology \(2018\)](#) suggest that “APD may thus include both auditory and cognitive elements” (p. 6).

Questionnaires are valuable tools that enable the extrapolation of information using an array of specific questions. It is a useful way of collecting quantitative primary data ([Malhotra, 2006](#)), while exploring respondents’ preferences and drawing out trends in perspectives. Auditory screening questionnaires have the advantage of highlighting auditory behavioral concerns ([O’Hara and Mealings, 2018](#)), which could in turn warrant the necessity of further assessment. They are also easy to administer, cost effective, and gather details that can be provided by different people such as parents and teachers. Their disadvantage, on the other hand, stems from possible biases of the individuals filling out the questionnaire ([Schow et al., 2007](#)). They could also be misleading or unclear at times; and if too long, could result in fatigue or lack of interest, which could in turn produce inaccurate information ([Wilson et al., 2011](#)). In addition, one cannot exclude the fact that the behavioral characteristics of children with APD overlap with those of children having language and learning difficulties ([American Speech-Language-Hearing Association Working Group on Auditory Processing Disorders, 2005](#)).

Various screening questionnaires have been used over the years. Initially, the three most commonly used questionnaires were the Children’s Auditory Processing Performance Scale (CHAPPS), the Screening Instrument for Targeting Educational Risk (SIFTER; [Anderson, 1989](#)), and Fisher’s Auditory Problems Checklist (FAPC; [Fisher, 1976](#); [Emanuel, 2002](#)). Studies have examined the relationship between the screening tools and APD assessments: [Wilson et al. \(2011\)](#) found weak to moderate correlations between the CHAPPS, SIFTER and the Test of Auditory Perceptual Skills—Revised (TAPS-R; [Gardner, 1997](#)) screening tools and diagnostic APD assessments, even when the tools were expected to assess similar auditory skills. The authors also found weak correlations between two screening tests (CHAPPS and SIFTER) indicating that these two tests are screening different sets of skills to a certain extent. These results were consistent with those obtained from previous studies such as [Drake et al. \(2006\)](#) and [Lam and Sanchez \(2007\)](#) who both reported no relationship between screening questionnaires and the diagnosis of APD. Fisher’s checklist has been criticized, on the grounds that it includes a wide range of characteristics with only a small amount linked to listening ([Smoski et al., 1992](#)). Likewise, the SIFTER has been criticized for not being developed specifically to detect the possibility of APD, but rather more general learning difficulties ([Wilson et al., 2011](#)). Despite the pitfalls reported in these auditory screening questionnaires, the CHAPPS seems to be a widely used screening questionnaire of auditory processing. The CHAPPS consists of 36 items all related to a child’s listening skills. The individual filling in this questionnaire scores each item through a seven-point Likert scale and is required to compare the child’s listening behavior

with other children of the same age in relation to quiet, noisy, and ideal situations, auditory memory and attention span, and multiple input situations. In a survey carried out by [Emanuel \(2002\)](#) and [Emanuel et al. \(2011\)](#) it was found that 75% of audiologists use questionnaires as an initial screening of auditory processing skills, out of which a high percentage tend to use the CHAPPS [43% reported by [Emanuel \(2002\)](#) and 51% reported by [Emanuel et al. \(2011\)](#)]. This questionnaire may be effective in detecting the behavioral characteristics salient to APD. Significant differences were reported between clinical and non-clinical APD groups on all CHAPPS subscales ([Iliadou and Bamiou, 2012](#)).

More recently, other questionnaires have been developed which could potentially detect the behavioral characteristics salient to APD. One such questionnaire is the Scale of Auditory Behaviors (SAB; [Schow et al., 2007](#)), which was reported to exhibit strong and significant correlations with tests of speech in noise as well as tests of temporal processing ([Nunes et al., 2013](#)). The Auditory Processing Domains Questionnaire (APDQ; [O’Hara and Mealings, 2018](#)) attempted to bring out differences between the listening difficulties specific to APD when compared with other developmental disorders of attention and language by dividing the questions posed into auditory processing, attention, and language sections. Their results showed contrasting types of auditory difficulties amongst groups.

The goal of this study was to develop a parent screening questionnaire, named the Questionnaire of (Central) Auditory Processing (QCAP), related to how they perceive the listening skills of their children. The aim was to bring out any salient behavioral characteristics which would highlight the need for further assessment of auditory processing skills. The article explains the procedure of the QCAP construction, data collection, results and analysis.

## 2 Methods

### 2.1 Questionnaire development

The *Questionnaire of (Central) Auditory Processing* (QCAP; [Tabone, 2018](#)) was designed and provided in both Maltese and English. The main objective of running this questionnaire was to obtain information regarding the behaviors that may be present in individuals with auditory processing disorder. The aim of developing the QCAP was for use as an informational tool by clinicians, to acquire an understanding of parents’ views about their child’s difficulty with auditory tasks. The information obtained in this questionnaire was valuable in obtaining a behavioral profile of children’s auditory skills, as well as correlating the parents’ perspectives of their child’s auditory skills with the other behavioral tests in the auditory processing assessment battery.

The first draft of this questionnaire was developed by [Causon \(2010\)](#) to target the adult Maltese population. [Causon \(2010\)](#) had based his questions on [Rosenberg’s \(1998\)](#) list of characteristics observed by parents and teachers in children with reported listening difficulties. This study further developed [Causon’s \(2010\)](#) questionnaire to target the pediatric population. While its structure, in terms of five open-ended questions followed by 20 statements

TABLE 1 Auditory skills highlighted in the QCAP.

Auditory skill	Question numbers
1: Auditory attention and memory	6, 13, 14, 15, 18, 20, 22, 24, 25
2: Following conversations	9, 16, 19, 23
3: Listening in noisy situations	7, 8
4: Sensory stimulation	10, 12
5: Social aspects	17, 21

using a 5-point Likert scale was retained, the instructions were modified to target parents and the statements were linked to typical pediatric situations such as the school environment. An extensive literature search was carried out to strengthen its content validity (Iliadou and Bamiou, 2012; Moore et al., 2010; Rosen et al., 2010; Scheich et al., 2011; Umat et al., 2011). Two experts on child language vetted the adapted questionnaire and their feedback was noted. It was also given to the parents of five children for their feedback on its readability and presentation. A complete revision of the previous literature was conducted and published in 2018 (Tabone, 2018).

## 2.2 Questions

This research opted to use a structured, close-ended questionnaire, with the intention of analyzing responses quantitatively. The QCAP consists of a total of 25 close-ended questions. The first five questions were created to obtain parental report of their child's developmental history concerning ear infections, hearing loss, and related neurodevelopmental disorders that have been found to cause similar behavioral characteristics as those observed in individuals with auditory processing difficulties, such as Attention Deficit Hyperactivity Disorder (ADHD), characterized by poor attention, impulsivity, and hyperactivity (Kim et al., 2024), and Developmental Language Disorder (DLD; Tabone et al., 2020), an impairment affecting primarily the development of language in children (Lai et al., 2024). In these five questions carers were required to reply by simply indicating "yes" or "no" below the statement. The following 20 questions targeted various auditory skills. An exploratory factor analysis, as reported in Tabone et al. (2016) was carried out to determine the number of underlying dimensions that make up the tool. The outcome indicated that there was one strong component which alone accounted for 42.28% of the variance, but a total of five components above the eigenvalue of 1. Hence, the questions were grouped in accordance with the five components as shown in Table 1.

Throughout this part of the questionnaire, carers were required to answer each statement by choosing a score between 1 and 5, according to the level of agreement with it. A score of 1 indicated that the statement was not relevant to their child, whilst a score of 5 indicated the highest level of relevance. The questions and scoring were posed in a way that the lower the score of each question, and in turn the lower the overall score, the less difficulties were perceived.

## 2.3 Data collection

Research ethics approval was obtained in 2011 from the University Research Ethics Committee (UREC) at the University of Malta (reference number 023/2011). The questionnaire was completed by the parents of 101 typically developing Maltese bilingual children, 42 male and 59 female, and 30 children forming a clinical group, holding a diagnosis of DLD, ADHD, or a combination of both. In contrast to the TD sample there were more males in the clinical group (60%). All participants underwent pure tone audiometry and tympanometry. They exhibited normal hearing thresholds and middle ear function. The Maltese educational system comprises three school-types, being state, church and independent schools. Overall, most children attended mainly state or church schools, with the amount attending state schools being slightly more than church schools. Fewer children were reported to attend independent schools. The primary language was found to vary between schools. In state schools more children spoke Maltese. Similarly, most children attending church schools used Maltese as their primary language. However, this was less than in state schools. The language use of children who attended independent schools portrayed a different picture, with the vast majority using English as their primary language.

## 2.4 Statistical analysis

The data was analyzed using Statistical Package for Social Sciences (SPSS) software, version 22. The tool was assessed for reliability and validity using the Cronbach alpha and Spearman correlations. The data was found to be of a non-normal distribution, hence to evaluate the differences between groups on the questionnaire responses the Mann-Whitney test was used. Correlation analysis using all the participants in this study was carried out between the QCAP and various APD subtests to determine the extent with which they agree.

## 3 Results

### 3.1 Reliability and validity measures

The Cronbach's alpha was used to measure how closely related the items in the QCAP are as an evaluation of auditory processing skills. The internal consistency was found to be highly reliable (Cronbach alpha = 0.92).

The parents 10% of the sample were asked to complete the QCAP at the initial assessment date and again following a 2 week interval in order to assess the test-retest reliability of the questionnaire. Spearman's rank correlation of the total scores obtained on the two occasions revealed a positive and high correlation,  $r_s = 0.94$ ,  $p = 0.000$ , indicating that the questionnaire outcomes should not change significantly over a specific amount of time between administrations.

In order to examine equivalence reliability, the parents of 30 children (20 TD and 10 clinical group) were requested to complete both the QCAP and an already established and widely used questionnaire developed to assess auditory processing skills:

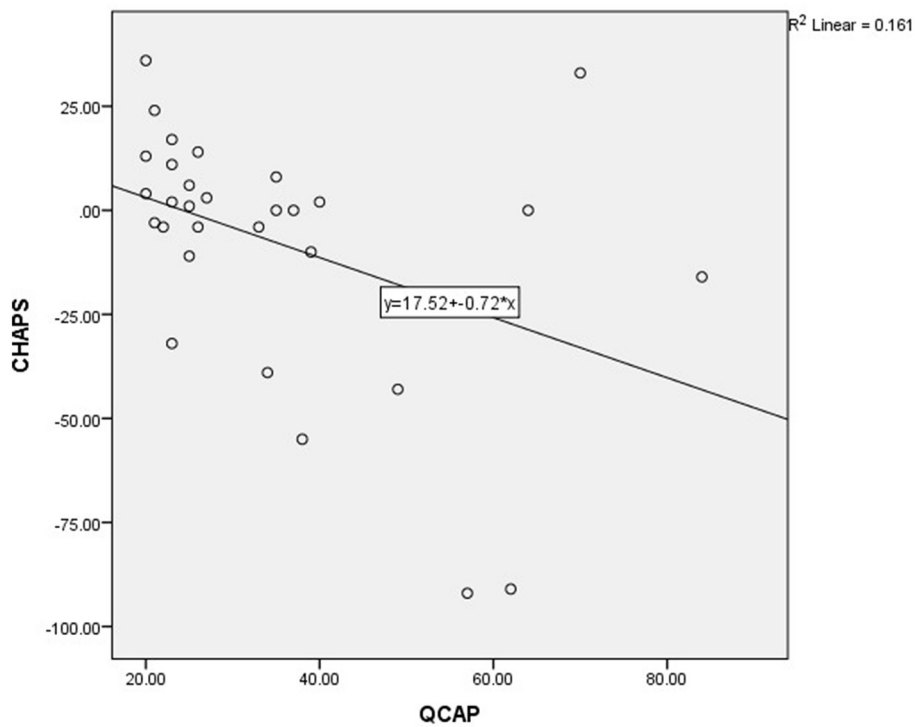


FIGURE 1  
Correlation between the QCAP and the CHAPPS.

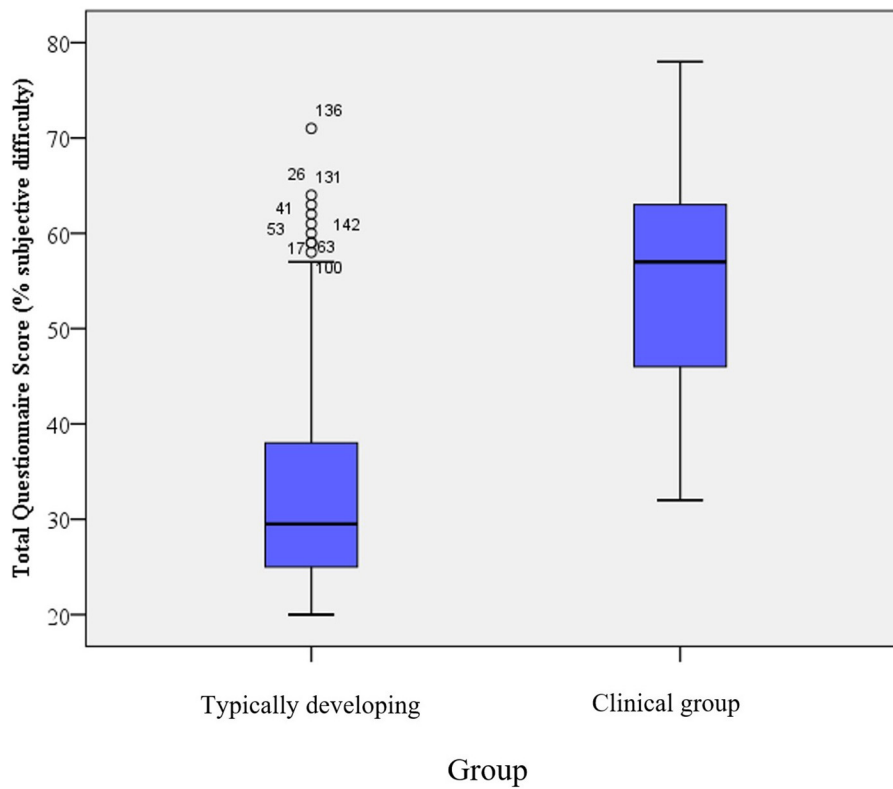
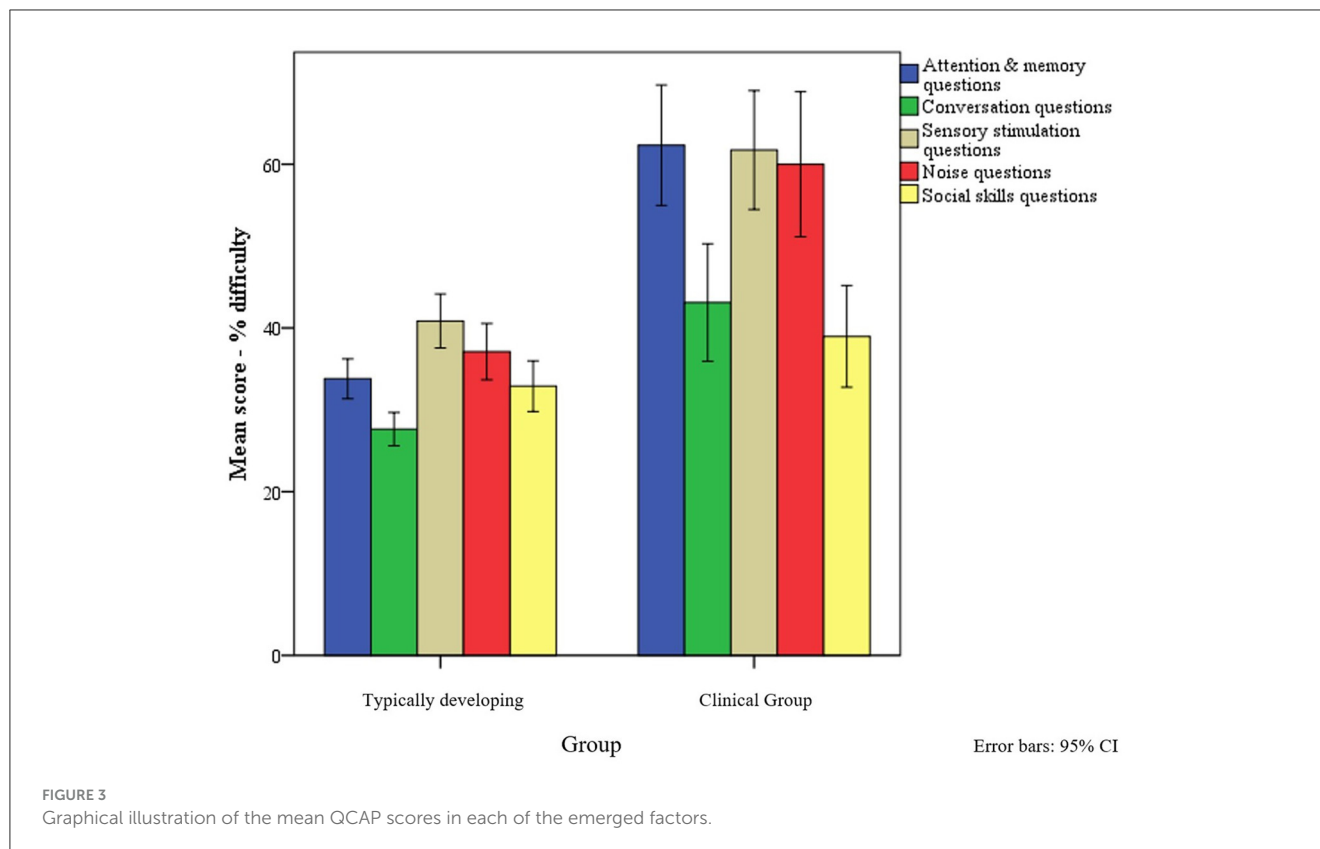


FIGURE 2  
Graphical illustration of the median QCAP scores.



the CHAPPS (Smoski et al., 1998). The Spearman correlation was administered to investigate relations between the total scores in the QCAP and the CHAPPS. It was expected that a negative correlation would emerge since the scoring methods of the two questionnaires were inverse to each other.

A moderate and (as expected) negative correlation (Figure 1) was obtained, which was statistically significant at the 0.05 level ( $r_s = -0.401$ ,  $p = 0.028$ ). This result was satisfactory, considering the limitation in obtaining equivalence reliability through parallel forms due to the difficulty in finding two assessments to investigate the same behavior (Miller, 2008).

Internal validity was assessed through a principal component analysis with Oblimin rotation and Kaiser Normalization. The results revealed a Kaiser-Meyer-Olkin score above 0.7 and low probability value. The Barlett's test of Sphericity was significant ( $p = 0.000$ ), therefore supporting the use of factor analysis. The reader is referred to Tabone et al. (2016) and Tabone (2018) for an in-depth explanation of this analysis.

### 3.2 Performance of the TD and clinical group on the QCAP

Figure 2 illustrates the scores obtained by the two groups on the QCAP. It clearly indicates a substantial difference between the questionnaire scores of the two groups. While the TD subjects obtained a mean score of 32.95 (SD = 11.36), the clinical group presented with a mean score of 54.45 (SD = 12.81) indicating parental perceptions of greater listening difficulties.

The Mann-Whitney test was used to analyze the difference between groups since data did not fit a normal distribution curve. A statistically significant difference was found between the two groups:  $U = 431.5$ ,  $p = <0.001$  between the TD (Mdn = 29.5) and the clinical (Mdn = 57.0) groups.

Further analysis was carried out to investigate whether the difference between the groups is evident in all the emerged factors (Table 1). Figure 3 reveals a substantial difference in scores between groups related to "attention and memory," "conversation skills," "sensory stimulation," and "noise," indicating that the children forming the clinical group were reported to exhibit greater difficulties in these areas. A difference, but to a lesser extent, was also evident in the questions related to "social skills." These results are further explained in Table 2.

Through the Mann-Whitney test, it emerged that the differences between groups in all subtests was statistically significant (Table 3).

### 3.3 Correlational analysis

The Spearman's rho correlating the QCAP with subtests investigating the different auditory processing skills, including speech-in-noise tests (Maltese and English Nonword repetition tests in noise; Tabone, 2018), the Duration Patterns Test (Musiek, 1994), the Frequency Patterns Test (Musiek and Pinheiro, 1987), the Dichotic Digits Tests (Musiek, 1983), and the Gaps in Noise Test (Musiek, 2003) are presented in Table 4. A statistically significant correlation emerged between the QCAP and the Maltese

speech-in-noise test, Duration Patterns Test (DPT) and tests of dichotic listening. In these tests there was a statistically significant difference between the TD and clinical groups, where the latter performed significantly poorer as detailed below:

- QCAP:  $U = 431.5, p = <0.001$  between the TD (Mdn = 29.5) and the clinical (Mdn = 57.0) groups.
- Speech in noise (Maltese; mNWRtn): TD group ( $M = 9.47, SD = 3.31$ ) and clinical group ( $M = 14.19, SD = 6.72$ ) groups:  $t_{(121)} = -4.674, p = <0.001$ .
- DPT, right:  $U = 835.5, p = 0.002$  between the TD (Mdn = 66.67) and the clinical (Mdn = 46.67) groups.
- DPT, left:  $U = 757.5, p = < 0.001$  between the “TD group” (Mdn = 66.67) and the “clinical group” (Mdn = 46.67) groups.
- Dichotic Digits test, right:  $U = 1,013, p = 0.005$  between the TD (Mdn = 95.0) and the clinical (Mdn = 95.0) groups; Dichotic Digits test, left:  $U = 710.5, p < 0.001$  between the TD (Mdn = 95.0) and the clinical (Mdn = 95.0) groups.

## 4 Discussion

The main aim of this research was to devise a questionnaire that identifies listening difficulties in children at risk of APD, warranting the need for further assessment. With only 20 5-point Likert scale items forming the test, the QCAP could be a quick and attractive tool to quantify the perceived listening difficulties across different situations.

Perhaps the greatest challenge in determining the reliability and validity of this tool stems from the great variability across audiology centers in the assessment of auditory processing disorders. If one were to follow [Ferguson and Moore \(2014\)](#) suggestions in establishing a strong test, then the tool is to have good construct validity and test-retest reliability, as well as a high sensitivity and specificity in a specific population. However, achieving high sensitivity and specificity in a tool could be problematic when one is to consider the reported high comorbidity of children reported to present with a profile of APD as well as having a diagnosis of some other developmental disorder. For this reason it might make more sense take an approach of examining the reliability and validity of tools assessing the different skills that have been reported to underlie auditory processing disorders, such as understanding speech in noise, temporal processing and dichotic listening.

The inter-item (0.92) and split-half (0.86) reliability outcomes indicate very good homogeneity (internal consistency) of the tool, suggesting that all the items on a scale seem to measure one construct ([Heale and Twycross, 2015](#)); that of listening difficulties across an array of situations, and the possible consequences

of these difficulties. The stability of the QCAP was tested through test-retest and equivalence reliability. Through test-retest, there was a positive and high correlation between the results obtained on the two occasions, indicating that the questionnaire outcomes should not change over a specific amount of time between administrations. Test-retest reliability of the QCAP has already been previously investigated. [Cassar \(2014\)](#) reported a very good test-retest reliability with a Cronbach's Alpha score of 0.997. Equivalence reliability for the QCAP was attempted as a means of analyzing the reliability of the new questionnaire with an already established questionnaire found to conceptualize behavioral findings related to APD. In light of the previous findings related to screening questionnaires, the researcher has opted to devise this questionnaire as an aid to highlight auditory behavioral concerns in Maltese children rather than as a screening tool of APD. The moderate and significant correlation between the two questionnaires suggests that the QCAP might measure the same behavioral characteristics reported in the CHAPPS. However, this result needs to be interpreted with caution due to the differences evident between the two tools.

A validated questionnaire would be useful in picking up the listening difficulties widely reported in children diagnosed with, or suspected of having APD ([Moore et al., 2012](#)). Attempting to extract validity measures for this questionnaire was of importance to this study, especially in light of reports that many questionnaires used to screen APD in general have not been validated ([American Academy of Audiology, 2010; Moore, 2012; Moore et al., 2012](#)). On the other hand, the validation of a questionnaire investigating behaviors commonly linked with auditory processing is also complicated due to the lack of consensus about the construct to be investigated ([de Wit et al., 2016](#)). The QCAP results compared with the CHAPPS gave rise to a significant moderate correlation in this sample. Although there seems to be little known validity data on the CHAPPS, studies have shown poorer scores from children with

TABLE 3 Comparison of means between the two groups categorized by “group.”

% difficulty	Mann-Whitney test			
	<i>U</i>	<i>W</i>	<i>z</i>	<i>p</i>
Auditory attention and memory	480.5	10,633.5	-6.512	<0.001
Following conversations	943.5	11,096.5	-4.826	<0.001
Listening in noisy situations	887.0	11,040	-4.891	<0.001
Sensory stimulation	921.5	11,074.5	-4.843	<0.001
Social skills	1,470	11,623	-2.572	0.010

TABLE 2 Group score means and standard deviations for the TD and clinical groups.

Group	Score mean (and SD)				
	Auditory attention and memory	Following conversations	Listening in noisy situations	Sensory stimulation	Social aspects
TD	33.8 (14.7)	27.6 (12.3)	37.1 (20.8)	40.1 (19.8)	32.9 (18.6)
Clinical	62.3 (19.3)	43.1 (19.7)	60.0 (23.3)	61.7 (19.1)	39.0 (16.3)

TABLE 4 Spearman's correlations between subtests.

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	QCAP Score	1	0.239**	0.178	-0.315**	-0.254**	0.117	0.115	-0.248**	-0.361**	-0.113	-0.294**	0.043	-0.013	0.087	-0.083
2	mNVRT(n)															
3	eNVRT(n)															
4	DPT (right)															
5	DPT (left)															
6	FPT (right)															
7	FPT (left)															
8	DD(FA) (right)															
9	DD(FA) (left)															
10	DD(FR) (right)															
11	DD(FR) (left)															
12	GIN Ath (right)															
13	GIN % (right)															
14	GIN Ath (left)															
15	GIN % (left)															

\*\*Correlation is significant at the 0.01 level (2-tailed).

APD in this questionnaire (Ferguson et al., 2011; Iliadou and Bamiou, 2012). This demonstrates the possibility of the QCAP extracting similar findings to the CHAPPS. One area that warrants further investigation for the QCAP is the influence or relation with cognitive factors. For example, Barry et al. (2015) examined four questionnaires used in the assessment of auditory processing, and their ability at detecting the presence of listening difficulties. While the authors reported all questionnaires to be sensitive to listening difficulties, they also correlated with measures of cognition used in the study. The effect of cognition has also been examined in relation to the CHAPPS (Moore et al., 2010), with similar outcomes to the Barry et al. (2015) study. Moore et al. (2010) found that in 1,469 mainstream school children aged between 6 and 11 years, the variance in the CHAPPS was primarily accounted for by factors of cognition and attention. These findings thus elicit queries as to which construct the questionnaires are tapping into listening, cognition, or perhaps an amalgamation of the two.

There were significant correlations between the QCAP and tests of dichotic listening. Dichotic listening requires working memory in order to execute them as a task. Working memory has been described as a multifaceted system. It is linked to the execution of complex tasks such as those involving attentional control to suppress less important information, or tasks that involve storage and processing (Engle, 2002; Riches, 2012). Accordingly, a good working memory capacity is linked to better ability to use attention to avert distraction (Engle, 2002). This correlation result was expected since, on examination of the rotated component matrix for the QCAP, the largest component is made up of questions related to auditory attention and memory. So if a child is to score poorly in the questionnaire, there is an increased chance that a high proportion of the weak scores fall within “component 1.” In this case the child may also score poorly on the tests of dichotic listening.

Temporal processing skills are essential for the perception of speech in noise, since they are reported to support auditory stream segmentation (Anderson et al., 2010). The DPT also poses a cognitive load, in which an individual must pay attention to, and store the sequence of tones in short-term auditory memory (Iliadou and Bamiou, 2012). With components of “auditory memory and attention” and “listening in noisy environments,” this may explain the significant correlations that emerged between the QCAP and both tests of speech in noise as well as tests of temporal processing.

When the questionnaire scores between the two groups were analyzed, a statistically significant difference emerged overall and across all components. The aim of the QCAP development and use was to extract any listening difficulties that the children might have, warranting the need for further assessment of auditory processing skills. This corroborates with other research findings of greater reported listening difficulties in children with DLD (Azzopardi, 2015; Ferguson et al., 2011; Tabone et al., 2016), literacy difficulties and ADHD (Tabone et al., 2016). The clinical group in this study also performed significantly worse than the TD cohort on tests of dichotic listening and speech in noise (Tabone, 2018), suggesting that the listening difficulties which emerged in the QCAP also surfaced in these subtests. This might not be surprising when considering that several questions in the QCAP targeted difficulties with

understanding longer and more complex sentences, and speech in noisy environments.

## 5 Conclusion

In this study, the Questionnaire of (Central) Auditory Processing (QCAP) was developed as a screening tool for APD in the Maltese population. It aimed to bring out the listening difficulties, as perceived by parents, in children aged between 7 and 9 years. The QCAP shows evidence of strong reliability and validity, giving it the potential to be an effective screening tool for highlighting listening difficulties in Maltese children at risk of having APD, in turn warranting the need for further assessment.

## Data availability statement

The datasets presented in this article are not readily available because the data is available only to the primary author. The co-authors may have access to the anonymized data. Requests to access the datasets should be directed to: [nadine.tabone@um.edu.mt](mailto:nadine.tabone@um.edu.mt).

## Ethics statement

The studies involving humans were approved by Faculty of Health Sciences Research Ethics Committee (FREC), University of Malta. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants’ legal guardians/next of kin.

## Author contributions

NT: Writing – original draft, Methodology, Investigation, Formal analysis, Conceptualization. HG: Writing – review & editing, Supervision. D-EB: Writing – review & editing, Supervision.

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## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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