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Research paper

THE IMPACT OF SOCIOECONOMIC STATUS ON AUDITORY PROCESSING SKILLS IN MALTESE CHILDREN

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Abstract. Auditory processing skills (APS) may affect the development of language. Understanding the impact that socioeconomic status (SES) has on APS can help to identify individuals at risk of poor auditory processing skills and in turn develop more focused intervention strategies to target these skills before serious repercussions emerge. This study explored the impact of SES on the auditory processing skills of 41 Maltese children aged between 7 and 9 years. A self-devised questionnaire was used to gather information relating to the SES of the children, using maternal education and occupation to categorise SES. Such information was compared with the children's performance on an auditory processing test battery in order to analyse its effect. Results demonstrated a significant correlation between SES groups and performance on the Duration Patterns Test (DPT), an auditory processing subtest which presents tones of varying duration as a stimulus. In addition, overall higher mean scores on almost all the tests were observed for the mid and high-mid socioeconomic groups. This study provides the first preliminary indications that lower SES could be associated with poorer APS in Maltese children.

Keywords: Auditory processing, socioeconomic status, children

1 Introduction

Socioeconomic status (SES) is an area of study that has triggered great interest among researchers. Literature findings have brought out a relationship between SES and various aspects of development in children, such as cognitive skills (Hackman & Farah, 2009), reading and academic achievement (Hansen & Munk, 2012; Teodor, 2012), child vocabulary and language skills (Ensminger et al., 2003; Richels et al., 2013), as well as social and emotional wellbeing (Bradley & Corwyn, 2002).

The lack of general consensus in the measurement of SES poses challenges in defining it. SES has been described broadly in terms of social stratification (Rose & Harrison, 2007). One definition is of a construct reflecting an individual's access to desired resources, such as material items, money, power, educational opportunities, networking, healthcare and leisure time. Without access to such resources, individuals would not thrive in the social world (Oakes & Rossi, 2003). This definition has been adopted in later research where SES has been regarded as a total measure of one's economic and social resources, including prestige and social status (Hackman & Farah, 2009). Measuring SES is more debatable than defining it. While various researchers agree that financial income, education and occupation are used to measure SES (Baydar, Brooks-Gunn & Furstenberg, 1993; Duncan, Brooks-Gunn & Klebanov, 1994; Green, 1970; Hackman & Farah, 2009; Kuppuswami, 1981; Walker et al., 1994), other measures have also been proposed. For example, the Hollingshead four-factor index (Hollingshead, 1975) considers education, occupation, sex and marital status as salient measures of SES, while Duncan's (1961) Socioeconomic Index (SEI) classifies occupations according to education and income. More recently, the combination of parental employment and education levels has been proposed as a determining factor of a child's SES (e.g. Kuriyan et al., 2012; Roy & Chiat, 2013; Stevens et al., 2014), with maternal education considered as the more robust of indicators in child development (e.g. Hoff, Laursen & Bridges, 2012). In Malta, strong links have been found between maternal education and language development (Baldacchino, 2016; Gatt, 2017; O'Toole et al., 2017).

In an extensive study of social class in the United Kingdom based on 161,400 responses to the Great British Class Survey (GBCS) (Savage et al., 2013), seven social classes were quantified: an elite class, an established middle class, a technical middle class, new affluent workers, a traditional working class, emergent service workers and a precariat (Baldacchino, 2013). Some social aspects covered by the GBCS have been found relevant to the local scene, namely

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(1) a strong supply of tertiary education graduates with a strong cultural and social capital, though not necessarily a high economic capital, and (2) the increase of new affluent workers, creating a novel semi-professional and technical category (Baldacchino, 2013).

SES has been associated with various neurocognitive functions of language, memory and executive functioning, with outcomes pointing to variances in the neural structure and functioning of children coming from different SES backgrounds (Noble et al., 2012; Ursache & Noble, 2016). This has been linked with evidence that children from poorer SES environments are exposed less to cognitive and linguistic stimuli (Cartmill et al., 2013) and exhibit weaker language and cognition (Ursache & Noble, 2016). The effect of SES on auditory processing skills (APS) has also been documented. Auditory processing refers to the ability of the central nervous system to perceptually process information coming from the ear. It includes skills such as the ability to discriminate between sounds, to localise sounds and to identify acoustic signals in the presence of background noise, as well as the rate at which sound is processed (Geffner & Ross-Swain, 2013). Children raised in low SES environments have been found to show an overall disadvantage in APS when compared to children raised in higher SES environments, affecting early vocabulary acquisition and the processing speed of receptive language (Kraus & Anderson, 2015). These children tend to be exposed to environments with increased noise (Kohlhuber et al., 2006). Outcomes of electrophysiological studies suggest that children from a low SES background find it harder to suppress irrelevant auditory input during active listening tasks (auditory selective attention (ASA))[1] (e.g. D'Angiulli et al., 2008a, 2008b). Findings from these studies demonstrated a significant difference in event-related potential (ERP)[2] waveforms between attended and unattended auditory stimuli in children coming from a high SES. Differences in children of low SES were not significant. Similar findings were also reported through other studies (e.g. D'Angiulli et al., 2012; Jones, Moore & Amitay, 2015; Stevens, Lauigner & Neville, 2009). The opposite emerged in children coming from a high SES environment, with stronger attentional skills being reported (Ison et al., 2015). Evidence from recent research has shown that the automatic processing of sound in individuals from a disadvantaged social background is also affected, with weaker and noisier neural responses to speech stimuli (Skoe, Krizman & Kraus, 2013).

The influence of SES on the understanding of speech in the presence of background noise is an area which is attracting research and investigation. SES effects on speech recognition performance through a sentence imitation task (SIT) in quiet and in noise have also been researched (e.g. Becker, Costa & Lessa, 2013), showing a similar performance in children of low and high SES for the SIT in quiet. Differences were found in noise, with the lower SES group performing worse than the higher SES group. This was attributed to noisy environments where the lower SES groups commonly reside in and possible lack of auditory stimulation present in their lives. It was suggested that such factors tamper with neurocognitive systems needed for proper speech perception. This decreased ability to perceive speech in noise can affect learning, since noise in classrooms and other settings is a very common scenario (Becker, Costa & Lessa, 2013).

Auditory function in children with high and low SES has also been investigated through the implementation of temporal processing (TP) tests (e.g. Balen, Boeno & Liebel, 2010; Maamor, 2010). Findings suggested that weaker TP skills are more common in areas of low SES. This was potentially attributed to: (1) behaviour issues being more commonly seen in children from low SES environments; (2) differences in the integrity of the children's auditory system, impeding their ability to process auditory information (Maamor, 2010).

In light of the reported weaker APS evident in children of a low SES, the following research questions have emerged.

- What is the relationship between SES and APS in a Maltese paediatric population?
- Are there any particular APS which are more affected by SES than others?
- Are language differences as a consequence of SES present?

2 Method

2.1 Questionnaire development

The telephone-based questionnaire (Appendix 1) was developed as part of a previous project (Said, 2016). It was initially compiled in English and translated into Maltese. The questionnaire design required that SES information be obtained via close-ended questions. Close-ended questions provide the advantage of ease of analysis in comparison to open-ended questions (Robson, 2011).

The approach adopted was to construct the children's SES on the basis of maternal information. The questionnaire was devised to obtain information regarding the respondents' age, highest educational attainment and current occupation.

2.2 Pilot study

A pilot study was carried out to measure the effectiveness of the questionnaire. Ten mothers, chosen separately from the potential participants, were given a recruitment letter for them to understand the objectives of the study. After signing a consent form, the SES questionnaire was conducted via telephone in the subjects' preferred language. Participants were then asked to answer a number of questions related to their general experience of having participated in the study. This feedback sheet contained five statements (Figure 1), to which the participants were to state their level of agreement ranging from *strongly agree* to *strongly disagree*. Responses were directly noted and audio recorded. The same participants

1 the ability of the central nervous system to focus on a specific sound source

2 a measure of the brain's response to cognitive, motor or sensory events

were again contacted two weeks later and the entire procedure was repeated in order to measure for test-retest reliability of their feedback. The responses obtained from time 1 and time 2 were compared and analysed for consistency.

2.3 Participants

The parents of 101 typically developing (TD) children (42 boys, 59 girls) aged between 7;00 and 9;11 years who underwent testing in an assessment of APS as part of another study (Tabone, in progress), were contacted to take part in this study. They were recruited from the same database to obtain further information on their SES. The participant selection criteria adopted in Tabone's study are shown in Table 1.

Table 1. TD participants: selection criteria

Selection criteria
Maltese citizen
Aged between 7;0 and 9;11 years
Bilingual: Maltese/English
Normal hearing thresholds and tympanometric results
No history of hearing impairment / chronic ear infections
No diagnosed • speech and language impairment • cognitive impairment • attention difficulties • neurological pathology • behaviour problems
No reported long-term medication

A recruitment letter and consent form was sent to the parents of the potential participants on inviting them to take part study. A reminder letter was sent one month later, resulting in a final number of 41 participants.

2.4 Procedure

The data related to the subjects' SES was collected via a telephone questionnaire. Although other modes of data collection, specifically face-to-face interviews, may offer more opportunities for building a rapport and encourage naturalness (Irvine, Drew & Sainsbury, 2013), telephone interviews are many times faster and of a lower cost (Szolnoki & Hoffmann, 2013). Given the limited time frame and funds allocated for this study, data collection via telephone was most practical.

2.5 Socioeconomic status

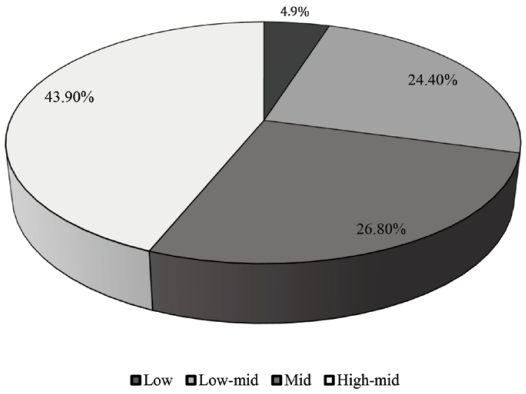
The SES of the 41 children was obtained from the results of the telephone questionnaire. Children were categorised into such groups based on their maternal occupation and highest maternal educational attainment as shown in Table 2.

Table 2. Explanation of each SES category

SES category	Requirement
low	Mother's highest educational attainment was primary school; mother was currently unemployed or held an insecure or part-time employment.
low-mid	Mother's highest educational level was secondary; mother owned a traditional working class occupation.
mid	Mothers had a post-secondary level of education and engaged in technical work.
high-mid	Mothers had a tertiary level of education and held a steady occupation, such as teaching and middle management.

In this sample, there were no mothers with a tertiary level of education and engaged in a professional or senior managerial work, hence no high SES group emerged. A low SES characterised 4.9% of the sample, while 24.4% had a low-mid SES, 26.8% had a mid SES and 43.9% had a high-mid SES. Figure 1 illustrates the SES distribution of the sample.

Figure 1. SES distribution of the participant group



2.6 Statistical analysis

Since this study incorporates a relatively small sample, the Shapiro-Wilk (S-W) test was used to assess normality in the distribution of the data. A S-W p-value of < 0.05 is considered significantly different from normal (Peat & Barton, 2005). Table 3 demonstrates that scores on the vast majority of the APS tests had a non-normal distribution.

The questionnaire responses obtained during time 1 and time 2 of the pilot study were assessed for reliability using the Spearman correlation in the Statistical Package for Social Sciences (SPSS) version 20. SES groups were compared on their performance of the APS assessment battery (Tabone, in progress), which consisted of dichotic digits tasks[3] (Musiek, 1983), speech recognition in noise[4],

3 Assess selective attention in the auditory system.

4 Assess the ability of an individual to understand speech which has been degraded by noise.

English nonword repetition in noise (eNWRTn) and Maltese nonword repetition in noise (mNWRTn)) (Calleja, Grech & Bamiou, 2012) and tests of temporal processing[5], assessed through the Duration Patterns Test (DPT) (Musiek, Baran & Pinheiro, 1990), Frequency Patterns Test (Musiek, 1994) and the Gaps in Noise (GIN) test (Musiek, 2003). The Kruskall-Wallis test was used to carry out statistical comparisons across SES groups' performance.

Table 3. Normality testing results of APS tests

Test	Shapiro-Wilk (*p*-value)	
	Right ear	Left ear
Dichotic digits (free recall) (DDFR)	<.001	.013
Dichotic digits (focused attention) (DDFA)	<.001	<.001
English nonword repetition in noise (eNWRTn)	.007	
Maltese nonword repetition in noise (mNWRTn)	<.001	
Gaps in Noise (GIN)	.322	<.001
Duration Patterns test (DPT)	<.001	<.001
Frequency Patterns test (FPT)	<.001	<.001

2.7 Ethical Considerations

This study was approved by the Faculty Research Ethics Committee (FREC) and the University Research Ethics Committee (UREC) at the Faculty of Health Sciences, University of Malta (Reference number: FHS137/2015)

3 Results

3.1 Pilot study

Results for test-retest reliability obtained from the feedback form in the pilot study revealed a high correlation between the responses given at time 1 and time 2 (r^s = .909, p < .001). This provides indication of good test-retest reliability. The results of the feedback form revealed that the respondents considered the questions to be appropriate and adequate for correct SES categorisation. It also emerged that the questions posed did not make the respondents feel uncomfortable in any way. Hence, the likelihood that information given is correct was increased. The feelings of the respondents to each feedback question in response to the SES questionnaire are presented in Figures 2a to 2e.

3.2 Comparisons between groups

The mean scores for each of the APS subtests are displayed in Table 4. The Kruskal-Wallis test was used to examine whether the observed difference between SES groups was statistically significant for the participants in this study. In all tests of temporal processing, the two higher SES groups obtained better scores than the two lower SES groups, with statistically significant differences evident in the DPT for both right (p = .027) and left (p = .017) ears. The Spearman's correlation test revealed a moderate positive correlation between SES and the DPT which was statistically significant (Table 5). This shows that the higher the SES, the better the subjects' performance on the DPT. The mean scores for the DDFR in the right ear were marginally higher in the 'mid' group than the rest of the groups while the highest score in the left ear was achieved by the 'high-mid' group. This was not the case for the DDFA, where mean scores revealed a more or less similar performance in both ears across all groups. The same can be said for the eNWRTn, where all groups obtained very similar percentage error scores. The opposite emerged in the mNWRTn, as the 'low' category group had higher percentage error scores than the other groups. These differences were not found to be statistically significant.

Table 5. Correlation between SES and the DPT

			SES	DPT (right)	DPT (left)
Spearman's rho	SES	Correlation coefficient	1.00	.452**	.374**
		Sig. (2-tailed)		.003	.016
		N	41	41	41

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

4 Discussion

The main aim of this study was to examine the impact of SES on the APS of 41 TD children aged 7;00 – 9;11 years. The findings from this study revealed that 37.0% of the mothers had a white-collar job[6]. This corroborates with the Programme for International Student Assessment (PISA) report (The Organisation for Economic Co-operation and Development [OECD], 2010), which revealed that the proportion of mothers in Malta engaged in a white-collar job is 38.6%. This report also stated that 55.3% of Maltese parents have an education attainment of upper-secondary or higher. In the current study, 70.0% of the mothers had a post-secondary level of education or higher. A possible reason for the higher percentage in the latter could be the small sample size of interested participants and greater interest shown by mothers of a higher level of education to participate in this research. This hypothesis has already been investigated in previous studies, with lower participation in clinical research from individuals of a lower SES being reported (e.g. Pandya, 2014).

5 Assess how sounds are processed over time.

6 A job performed in an office or an administrative setting

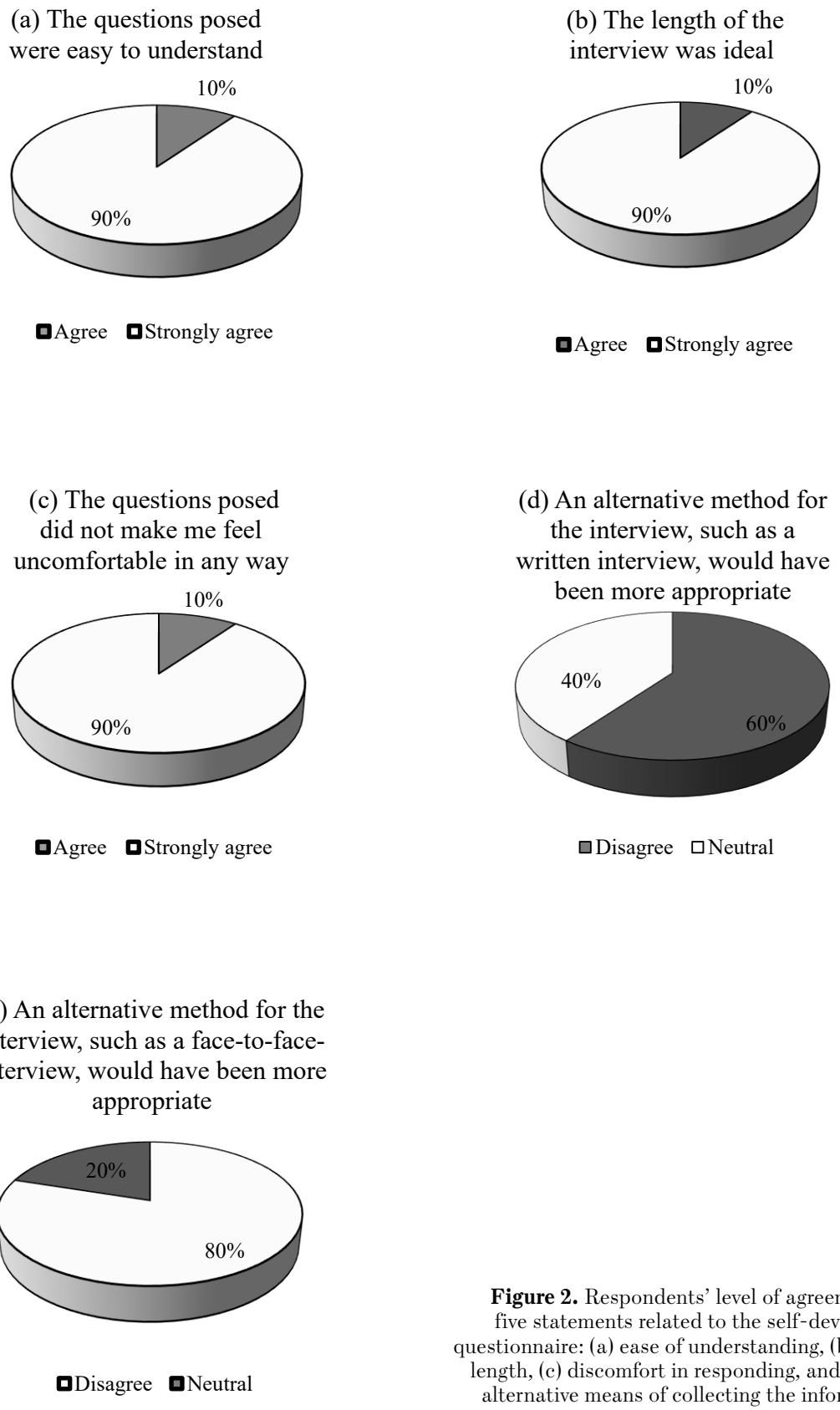


Figure 2. Respondents' level of agreement to five statements related to the self-developed questionnaire: (a) ease of understanding, (b) interview length, (c) discomfort in responding, and (d and e) alternative means of collecting the information.

Table 4. Comparison of scores across SES groups

Test	SES group	Mean score (right)	SD	*p-value*	Mean score (left)	SD	*p-*value
DDFR (% correct)	low	91.25	1.77	.639	87.50	7.07	.213
	low-mid	92.22	9.85		88.33	10.82	
	mid	95.00	6.02		90.23	6.84	
	high-mid	94.31	6.23		91.94	5.52	
DDFA (% correct)	low	97.22	3.93	.801	94.44	3.93	.683
	low-mid	97.53	4.03		88.36	4.03	
	mid	91.00	11.78		93.95	7.12	
	high-mid	95.06	7.35		91.65	7.90	
GIN (smallest gap detection (Ath)*/ms)	low	--**		.491	--		.380
	low-mid	6.60	4.85		5.60	3.67	
	mid	5.29	0.91		4.00	1.53	
	high-mid	5.40	2.38		4.93	2.46	
GIN (% correct)	low	--		.383	--		.380
	low-mid	63.60	18.04		65.40	24.92	
	mid	69.62	13.49		76.24	14.25	
	high-mid	71.80	13.48		77.04	13.46	
DPT (% correct)	low	50.00	28.28	**.027**	56.67	14.14	**.017**
	low-mid	50.67	23.40		47.33	21.78	
	mid	67.88	21.25		76.97	23.16	
	high-mid	78.15	17.68		75.18	19.78	
FPT (% correct)	low	54.87	14.14	.078	56.67	18.86	.079
	low-mid	79.34	21.27		75.33	27.07	
	mid	90.30	13.45		93.33	21.25	
	high-mid	90.56	14.47		92.96	17.68	
NWRTn (% error)		English			Maltese		
	low	10.94	0.44	.749	12.26	4.56	.414
	low-mid	11.04	2.75		9.97	1.58	
	mid	10.62	3.31		9.03	2.97	
	high-mid	11.10	4.76		9.82	4.63	

*The GIN test is composed of a series noise bursts containing various intervals of silence (gaps) between 2 to 20 ms.
**From the small number of subjects that formed the low SES group, no results were obtained on the GIN.

Differences between SES groups in APS were observed in tests using non-linguistic[7] content: those assessing TP. TP skills play a role in the identification of the subtle differences involved in the formation of speech sounds, specifically speech perception and phoneme recognition (Balen, Boeno & Liebel, 2010). The results which emerged from this study suggest poorer TP skills in children of a lower SES. This result might also explain the poorer performance of the children forming the 'low' SES group in this study on the Maltese NWRTn, since such a test is heavily dependent on speech perception. The FPT and the DPT assess one's ability to discriminate between sound stimuli based on sequencing (FPT) and ordering (DPT). The difficulty to recognise temporal patterns can reflect in a weakness to extract and interpret prosodic characteristics of speech like rhythm, stress and intonation, which in turn facilitate the interpretation of emphases and sarcasm (Onoda, Pereira & Guilherme, 2006). Statistically significant differences in mean scores across SES groups emerged in the DPT, with the 'high-mid' and 'mid' groups obtaining the highest percentage correct scores. This result confirmed that the children of a lower SES in this study performed more poorly in temporal tests, specifically temporal ordering. The mean scores obtained by the participants on the FPT also revealed differences amongst SES groups, where the 'high-mid' and 'mid' groups obtained the higher mean score. This was found

7 The AP assessment battery was divided into two sections: subtests using linguistic stimuli (specifically nonwords and digits) and those using non-linguistic stimuli (pure tones and white noise). These sections emerged following an exploratory factor analysis of the assessment battery (Tabone, Grech & Bamiou, 2016).

to decrease substantially in the lower SES groups. This outcome is consistent with previous studies investigating the relation between temporal skills and SES (e.g. Balen, Boeno, & Liebel, 2010; Maamor, 2010; Rezende, Lemos & Medeiros, 2016; Ribas et al., 2015). Ear differences on this test demonstrated generally better scores in the left ear. This left ear advantage (LEA) for processing tonal stimuli has also been reported by Sininger and Bhatara (2012). These authors suggest that the LEA reflects right hemisphere dominance in the brain since the right auditory cortex is responsible for tonal processing.

Temporal resolution, as assessed through the GIN test, investigates the capability of extracting differences in duration of sounds within specific time intervals arising between the stimuli over time (John, Hall & Kreisman, 2012). This skill highlights transitions between phonemes, voicing and prosody (Pichora-Fuller & Singh, 2006). The participants forming the 'high-mid' group achieved best mean scores in the GIN test, while the 'low-mid' group attained the lowest. These findings corroborate with previous studies (e.g. Balen et al., 2010) reporting a weaker performance in this test from children of lower SES backgrounds.

Although the results of this study showed no significant differences between SES and any of the APS subtests of dichotic listening, the mean scores in the DDFR tests show that the 'high-mid' group obtained the highest mean scores and the 'low' group obtained the lowest mean scores. This result seems to be consistent with previous literature. Given that dichotic digit tests depend heavily on attention (Alho et al., 2012; D'Anselmo, Marzoli & Brancucci, 2016), differences in performance could be explained by variances in the ASA of children from different SES. Children from a low SES have in fact been described as having different neural mechanisms, exhibiting weaker ASA abilities (e.g. D'Angiulli et al., 2008a, 2008b; Isbell, 2015; Stevens et al., 2009; Stevens et al., 2014). The mean scores obtained by the participants in the DDFA task revealed differences in SES groups which are opposite to those seen in the DDFR. The 'low' and 'low-mid' groups obtained the best scores on average out of all the groups in the right ear, with the 'mid' group achieving the lowest mean score (91.0%). In contrast, the 'mid' group obtained the best mean score in the left ear, while the lowest mean score emerged from the 'low-mid' group. While these outcomes were not expected and do not seem to conform to studies proposing links between selective attention and SES, the results that emerged from this research did not actually demonstrate group differences that were statistically significant. Furthermore, the number of participants in each group was far from equal, with much fewer participants in the 'low-mid' and 'low' SES groups. It is of interest to carry out further research on this population addressing this limitation.

The mNWRTn mean scores also indicated differences in performance across SES groups, where the 'low' SES group obtained the highest percentage incorrect score, as opposed to the 'mid' and 'high-mid' groups, which obtained a lower percentage incorrect score. Differences in the performance of SES groups in this study could be attributed to noisy environments in which children from low SES environments are often brought up (Hackman & Farah, 2009). These environments have been found to affect children's ability to discriminate between speech sounds in the presence of background noise (e.g. Buss, Hall & Grose, 2009; Stimley, 2008). This finding could also be a result of possible stronger language processing skills in the higher SES groups, following reports that children born to mothers of a higher level of education tend to receive more language stimulation and in turn possess stronger language **s**kills (Bornstein & Bradley, 2014; Stimley, 2008).

Each group performed worse in the eNWRTn subtest in comparison to the Maltese equivalent test. This could be attributable to the fact that Maltese was the preferred language of more than half of the participants (62.5%). However, a similar and stronger pattern has also been reported in a previous study (Calleja & Grech, 2014), where Maltese bilingual children performed significantly better ($p < .001$) on a Maltese-based NWRT, irrespective of their primary language. Interestingly, the participants in Calleja and Grech's study were younger (aged 5;00 to 5;11 years). The results that emerged from the present study might suggest that as Maltese children grow older, their proficiency in Maltese- and English-based NWR levels out.

5 Conclusion

This study provides preliminary indications that lower SES could be associated with poorer AP since children from a higher SES fared better on almost all the tests of APS. Such findings highlight the potential risk of speech, language and communication difficulties as a consequence of disadvantaged environments. More awareness about the importance of a rich and stimulating environment not only contributes to the possibility of early intervention but also increases parental knowledge about child development (Leffel & Suskind, 2013).

This study is limited in that it is not representative of the Maltese population due to the small sample size and distribution of the SES groups. However, given these preliminary results it is of importance for future research to replicate this study using a much larger sample in order to obtain clearer and stronger results. This might be especially applicable to further explore the possible correlation between SES and tasks of TP. Future larger-scale studies could also investigate whether SES actually influences TP. For this purpose, tests incorporating a variety of other possible influencing factors, such as noise and attention levels, would also need to be employed.

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8 Conflicts of interest

The authors report no conflicts of interest.

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