NOISE EXCLUSION IN VISUAL AND AUDITORY MODALITIES IN CHILDREN WITH LANGUAGE DISORDER

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Abstract

In order to examine the contribution of noise exclusion ability to language impairment four groups of participants were compared: children with Specific Language Impairment (SLI), children with dyslexia, children with Downs Syndrome (DS) and typically developing children (TD). With the aim of establishing whether noise exclusion is modality specific both visual and auditory modalities were tested – in the visual modality noise exclusion was tested using an apparent motion paradigm while in the auditory modality a spoken word identification task was employed. Analysis revealed that in the visual modality all participants performed equally well in high and low noise conditions. However, children with dyslexia were overall less accurate in identifying motion direction. In the auditory task only children with DS showed difficulties with noise exclusion, although children with SLI were overall less accurate then children with dyslexia and TD children. This leads us to the conclusion that noise exclusion deficits are not a necessary condition for language impairment, and that they are, at least partly, modality specific processes.

Given that the first language is learned through speech perception, difficulties in comprehending and learning language could be associated with deficits in sound perception and processing, for instance, difficulties in auditory perception might result in an incomplete or inaccurate phonological representation (e.g. Boada & Pennington, 2006). Additionally, children who are less able to successfully process acoustic information will have more difficulty extracting statistical regularities from the language input (Coady, Kluender & Evans, 2005). This would again lead to inadequate phonological and higher level language representation. Although there are numerous studies attempting to link language impairment to different aspects of auditory perception the evidence is still inconclusive (see Dawes and Bishop, 2009 for a review).

Recently, there have been several attempts to relate literacy and language disability to noise exclusion ability. For example, using vowel-consonant-vowel (CVC) stimuli, Ziegler et al. (2005) found that under optimal listening conditions language impaired children showed only subtle speech perception deficits, but under conditions of stationary or fluctuating noise, they showed substantial problems identifying CVC patterns. Chiat et al. (2007) also demonstrated noise exclusion deficits using auditory stimuli and showed that individuals with dyslexia took more time than controls to detect tones in background noise. Noise exclusion in children with dyslexia was further examined in the visual modality. Using magnocellular and parvocelular visual stimuli and an apparent motion paradigm Sperling et al. (2005, 2006) showed that children with dyslexia performed as well as TD children under no-noise conditions, but were significantly less successful in identifying target or motion direction in high noise conditions.

In order to gain further insight into the link between noise exclusion ability and language impairments we compared noise exclusion abilities in three groups of children with different aetiologies: SLI, DS and Dyslexia to TD children.

Developmental dyslexia is a specific problem of learning to read, often accompanied by writing and spelling difficulties, despite the presence of normal intelligence, motivation and adequate formal education and in the absence of any obvious physical or psychological problem (Catts & Kamhi, 2005). Dyslexia is frequently associated with additional symptoms such as poor motor coordination, left-right confusion and poor sequencing.

Children with SLI have difficulties with many areas of language, including phonology, morphology and syntax. Furthermore, numerous areas of cognitive processing including problems with attention, memory, and limited general processing capacity have been documented in children with SLI (see Leonard, 1998 for review).

Down syndrome is the most common identified genetic cause of intellectual disability. Individuals with DS show language deficits that are worse than their global delays, and the high incidence of hearing impairment does not adequately account for this. Research on the language development of children with DS shows that intellectual disability is almost universal, and that auditory processing is a relative weakness and visual processing a relative strength (Groen et al., 2008).

Methodology

Participants

Four groups of participants were recruited: typically developing children (TD), children with SLI, children with dyslexia and children with DS. All participants were monolingual English speakers with normal or corrected to normal vision.

Ten children with SLI age 8;0 -11;10 (M=9;1) were recruited. All participants in the SLI group had language test scores of 1.25 standard deviations below the age mean, a non-verbal IQ greater than 85, normal hearing, no recent episodes of otitis media with effusion, and no neurological disorders.

Twelve children classified as dyslexic, age 8;1-9;5 (M=8;7) were selected for participation. Two participants were excluded from the analyses due to their failure to complete the tasks. All participants had normal or correct-to-normal vision and hearing. Parental and teacher reports confirmed that each child had a langauge level sufficient to understand the instructions of the task. Each child also satisfied the following exclusionary criteria: additional neurological impairment; attention deficit hyperactive disorder (ADHD); additional educational needs.

A total of 11 individuals with Down syndrome were recruited from a National Down Syndrome Organisation by means of telephone and letter contact. The participants were assessed using the British Picture Vocabulary Scale (2nd Edition) (Dunn et al., 1997). This was necessary to avoid low receptive vocabulary levels affecting scores, and to match the participants to the chronological age of TD children. One participant did not meet the criterion of age equivalence (8;0 to 9;11) and was excluded from the study. A hearing test screener was also used to rule out hearing impairment using a Kamplex KS8 audiometric screener. The criteria consisted of accurate positive responses at 20dB at 500, 1000, 2000 and 4000 Hz. (Katz, 2002; A.S.H.A., 1997). Two participants were excluded from the study due to hearing difficulties. This resulted in a group of 8 individuals with Down syndrome with a chronological age 10;11-15;7 years (M=13;4).

TD children were aged 8;1-9;6 years (M=8;9), without language impairment, hearing impairments or learning disabilities. In order to control for extraneous variables control group participants were age matched to the participants with SLI and dyslexia.

Visual Task

A customised computer programme was used to assess noise exclusion in the visual modality in children with SLI and TD controls. This method adaptation of the procedure used by Sperling et al. (2006) which was a successful measurement of visual noise exclusion ability for children with dyslexia compared to their TD peers. The tasks were programmed using Matlab 7.1 with Psychtoolbox. Stimuli were presented using a Dell Intell Core^{TM} 2 Duo Laptop (2.00 GHZ) and projected onto a 16” Dell PC monitor with refresh rate of 75 Hz and resolution 640 x 480. Background and dot luminance were set at 12.7 cd/m^2 and 18.3 cd/m^2 respectively. A 6.5° x 6.5° random-dot-kinetics (RDK) display comprised of 300 dots (0.015° x 0.015°) was viewed from a distance of 60 cm. Prior to the motion display, a fixation cross appeared in the centre of the screen for 500 ms and remained throughout the trial. Apparent motion was created by randomly selecting 50% of the dots and re-plotting them 0.06° in a single direction (left or right) after a 67 ms delay. The remaining dots were re-plotted randomly. Each signal/noise dot had a lifetime of only two frames, to prevent tracking. A total of 15 frames generated an apparent velocity of 0.90°/s, for approximately 1000 ms. Participants indicated motion direction by saying ‘left’ or ‘right’ and the researcher pressed the corresponding keyboard button. After each trial participants received feedback.

Two levels of noise level were used in the current study. Low level of noise was created by using red signal dots and grey background dots, which gave strong signal salience; High level noise was created by using both signal and noise of the same colour. Response accuracy to motion detection was recorded for each condition. Prior to each version, participants practiced received 10 practise trials. In order to enter the experiment participants needed to complete practise session achieving at least a 60% correct response rate.

Auditory Task

The standardized auditory test Word Intelligibility by Picture Identification (WIPI) (Ross & Lerman, 1979) was used to assess spoken word perception in high and low background noise. The WIPI test is word recognition assessment by pointing to a picture from a closed-set of pictures that is appropriate for children whose language age is five years and above. Two lists of fifty words stimuli were utilised. Words were controlled for phonetic and phonological characteristics, length and frequency. All stimuli were pre-recorded with one of the two signal-to-noise ratios: (i) SNR = 0dB (high background noise) and (ii) SNR = +10dB (low background noise). The stimuli were amplified through the E-MU Audio Tracker Version 12, and presented through binaural ear-cup Sennheiser HD201 headphones. Participants were asked to listen to the words and identify the word by pointing to one of six pictures printed on an A5 page. The first 10 words of each set constituted the practice trials. The number of correct answers was recorded in each condition.

Results

For all four groups of participants the proportions of correct answers were calculated for low and high noise conditions for both visual and auditory tasks. In order to normalize distributions, these proportions were arc sin transformed and compared in two separate ANOVAs analyzing visual and auditory task performance. In the visual task, the main effect of noise failed to achieve significance: $F(1,34)=0.37$, $p>1$ although there was significant main effect of group: $F(3,34)=3.52$, $p<0.03$: post-hoc analyses indicated that children with SLI and children with DS had similar performance to TD children ($MD=0.04$, $p>1$; $MD=0.06$, $p>1$), while the performance of children with dyslexia was significantly less accurate ($MD=0.41$, $p<0.05$) (see Figure 1). There was no interaction between group and noise indicating that there was no difference in performance under low and high noise condition across the participant groups ($F(3, 34)=0.84$, $p>1$).

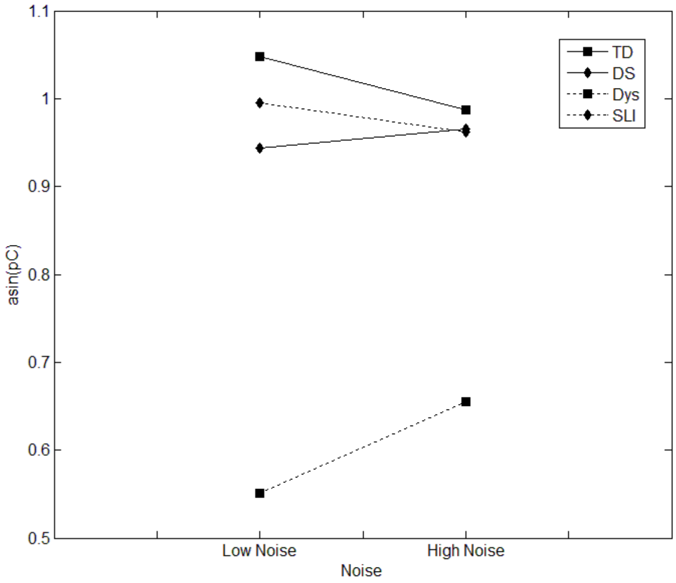

Figure 1: Arc sin transformed proportions of correct responses in TD, DS, D and SLI group in the visual task.

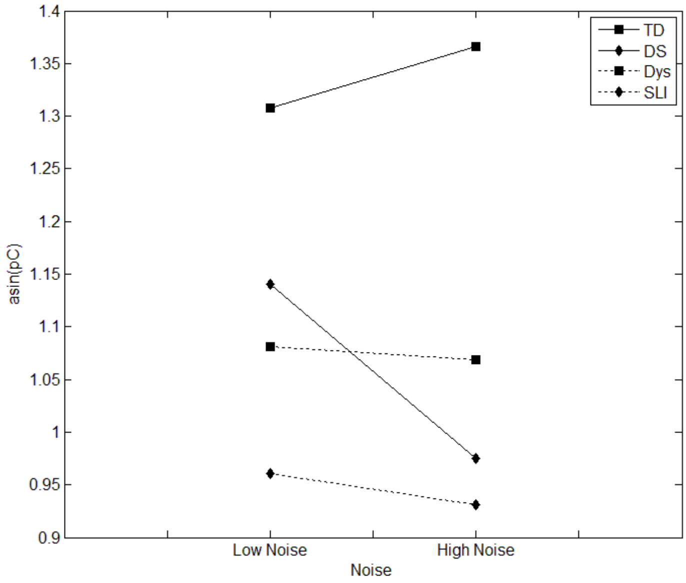

Figure 2: Arc sin transformed proportions of correct responses in TD, DS, D and SLI group in the auditory task.

Similarly, the main effect of noise failed to achieve significance in the auditory task: F(1,34)=2.15, p>1 although there was significant interaction between the level of noise and group (F(3,34)=3.083, p<0.05). This was due to an effect of noise only for children with DS (F(1,7)=34.13, p<0.001) while no difference in performance was observed for TD children (F(1,9)=1.29, p>1), children with dyslexia (F(1,9)=0.47, p>1) or children with SLI (F(1,9)=0.31, p>1) as a function of noise level (See Figure 2). Inspection of Figure 2 shows that children with DS performed significantly less well given increased noise than in the low noise condition. In addition, there was a significant main effect of group: F(3,34)=25.74, p<0.01 and although all three groups of children with language impairment performed significantly less accurately then TD children (DS: MS=0.28, p<0.001; Dyslexia: MS=0.26, p<0.001; SLI: MS=0.39, p<0.001), children with Dyslexia performed marginally better then children with SLI (MS=0.13, p<0.05).

Discussion

The aim of the current study was to compare noise exclusion ability in 3 groups of language impaired children with different aetiologies (SLI, Dyslexia, DS) to TD children. In order to test whether noise exclusion ability is modality specific the same children were tested in analogous visual and auditory tasks. Comparison of the results across the two tasks revealed that clear effect of noise exclusion was present only in the auditory task and only in children with DS. On the basis of this finding we may be able conclude only that noise exclusion influences language acquisition in children with DS and this is in line with previous studies which have identified weakness in auditory processing in individuals with DS. The current study did not manage to replicate other studies that found noise exclusion problems in children with SLI in audition (Zigler et al., 2005) and in children with dyslexia in vision (Sperling et al., 2005; 2006). In both cases this could be due to differences in tasks. In study conducted by Zigler et al. participants were asked to identify consonant-vowel-consonant (CVC) formations while the current study used real words. In addition, Zigler et al. asked participants to identify target stimuli out of 16 different CVC structures on the computer screen while in the current study participants were asked to point to one of 6 pictures. Both differences could have caused higher information load in the study conducted by Zigler et al. and this factor is known to influence performance of children with SLI.

The study conducted by Sperling et al. (2006) included much larger range of signal-to-noise ratios (SNR) and compared thresholds at 75% correct answers for children with dyslexia and TD children. Given the vulnerability of some children in the current study we were not able to use this extended range of stimuli. Consequently, it is possible that due to a restricted SNR the current study failed to observe an effect of noise on identification of the direction of apparent motion. Although, instead, the current study revealed overall less accurate performance of children with Dyslexia in the same type of visual task.

In the auditory task, all three groups of children with language impairment performed less accurately then TD children irrespective to the noise condition. This supports the idea that children with language impairment have impaired or incomplete phonological representations (Boada & Pennington, 2006). In addition, children with dyslexia performed better then children with SLI in the auditory task. Taken together with their poor performance in the visual task and the fact that children with dyslexia were not categorized into surface or phonological dyslexia it is possible that some of the children in this group had difficulties only in visual processing while some had difficulties in both modalities. In order to clarify this issue further research is needed in which children with surface and phonological dyslexia will be examined separately.

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