USE OF THE VISUAL HABITUATION PARADIGM TO INVESTIGATE SPEECH PERCEPTION IN PREMATURE AND DOWN SYNDROME INFANTS.

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Abstract

Premature (PR) and Down syndrome (DS) infants are prone to developmental delays and could present central auditory processing or a language disorders. The origin of these disorders can be associated to altered mechanisms of learning and perception of speech stimuli already in the first year of life associated to delay in neural development and to conductive haring loss at early ages. Appropriate psychophysical methodology was generated by the adaptation of visual habituation and observer based response procedures, to investigate speech perception by habituation of attention to nonsense disyllabic words in both condition DS and PR, comparing to a control group. Composed the sample: 65 infants with DS, 34 for control group without evidence of developmental delay infants and 11 premature babies, matched by age. Both experimental groups did not show significant differences in the degree of habituation. Differences encountered to control group, in patterns of habituation are discussed.
Key words: Speech perception, Down syndrome, prematurity, neural organization of language.
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Among the various descriptions of the cognitive and behavioural phenotype of individuals with Down syndrome (DS) language problems or understanding and speech production are always singled out as prominent and ubiquitous (Evans & Hampson, 1968; Mahoney, Glover, & Finger, 1981; Miller, 1998; Stoel-Gammon, 2004). Behavioural studies or routine clinical reports tend, however, to emphasize the presence of peripheral damage more obvious, such as hearing problems of driving (e.g. caused by otitis), dysplasia or malformation of the vocal apparatus and articulation, as well as significant differences in standardized measures of development when compared with control groups of individuals with typical development trajectories. When subjected to sophisticated techniques or imaging brain morphometry, the people with SD also show abnormal patterns of neural organization (Pinter *et al.*, 2001).

The linguistic and cognitive development of individuals with DS was traditionally regarded as being essentially a version just slower than normal or typical development, with greater latencies for the appearance of developmental markers (Lenneberg, 1967; Hodapp & Zigler, 1990). Already exist, however, strong evidence in favour of the hypothesis that individuals with DS exhibit unique structural differences in terms of processes and routines cognitive, perceptual mechanisms and control of behaviour (Stoel-Gammon, 2004; Fowler, 1990).

Changes in auditory development and language development in preterm infants also have been reported in the literature pointing to a profile of the immaturity of brainstem pathways and delay in acquisition of language. An increased risk for language deficits in infants born growth restricted has been reported in follow-up studies for more than 20 years, suggesting a relation between foetal auditory system development and later language learning. Work with animal models indicate that there are at least two ways in which growth restriction could affect the development of auditory perception in human foetuses: a delay in myelination or conduction and an increase in sensory-neural threshold. We hypothesize that foetal growth restriction affects auditory system development, resulting in atypical auditory information processing in growth restricted foetuses compared to healthy, appropriately-grown-for-gestational-age foetuses. Speech perception that lays the foundation for later language competence will differ in growth restricted compared to normally grown foetuses and be associated with later language abilities (Kisilevsky & Davies, 2007).

The prevalence of impairments in brain steam evoked responses in premature babies has been of 10.2% of which 5.3% is unilateral and 4.9 % bilateral. The prevalence of hearing impairment among these babies could reach 30% considering also the behavioural audiometry, and it's high (Lima et al, 2006).

Methods

The Eimas (1999) familiarization-preferential looking protocol was applied to assess the capacity of DS and premature infants to form categorical representations of the initial syllables of dissyllabic stimuli. The purpose of this investigation was to examine the speech perception ability of DS infants. The infants' performance in the categorical perception of consonants in initial syllables was compared, as regards the amount of time needed for habituation, and the pattern of sensitization to novel stimuli, following familiarization to exemplars of the phonetic category. The procedure chosen was a combination of the procedures of visual habituation and observer-based response, adapted from a procedure previously used by Eimas (1999). It was hypothesized that if DS infants categorically perceive initial syllables in dissyllabic words in the familiarization and test phases of the procedure, they should display behavioural patterns indicative of habituation to familiar stimuli and sensitization to novel stimuli, compared to infants borned prematurely and normal controls. A total of 108 subjects, 63 of the Down syndrome group, 34 of the control group and 11 in the preterm group underwent measurement of relevant variables.

The psychophysical procedure was structured in two phases: familiarization and test. From a set of 18 stimuli, 6 stimuli started by [da] ou [ba] were selected for each subject to be used in the familiarization phase. Two of the remaining pseudo-word stimuli, one starting with [da] and the other with [ba], the final syllable remaining constant, were used in the test phase. This distribution resulted in a set of four basic conditions of stimulus presentation: (1) BABA condition, where stimuli in the familiarization phase started with [ba], and stimuli in the first block of the test phase also started with [ba]; (2) BADA condition, where stimuli in the familiarization phase started with [ba], and stimuli in the first block of the test phase started with [da]; DADA condition, where stimuli in the familiarization phase started with [da], and stimuli in the first block of the test phase also started with [da]; and (4) DABA condition, where stimuli in the familiarization phase started with [da], and stimuli in the first block of the test phase started with [ba]. With such a design, subjects of each group were organized in two main subgroups, one in which the first block of the test phase consisted of stimuli starting with a familiar syllable, and another in which the initial syllable was novel. Therefore, there were two conditions in the test phase: familiar and novel initial syllable. In the familiarization phase six stimuli starting with [b] or [d] were arranged in six blocks with 200ms inter-stimulus and inter-block intervals. In the test phase two new stimuli were presented, each one repeated six times within a block; the two blocks were alternated, each being presented three times, at the same inter-stimulus and inter-block intervals.

Once the infant was accommodated in the testing environment, the experimental session was started as the infant directed its visual attention to a photo positioned in front of him (her). Briefly, the onset of this visual attention behaviour was recorded and prompted the presentation of the auditory stimuli. The offset of the attention behaviour was also recorded and prompted the termination of the auditory stimuli. A trial was defined as the observation of the photo stimulus for at least 4 accumulated seconds. Once the 4s minimum duration criterion was reached, a deviation of gaze by more than one second ended the trial. During a single trial a single block was presented. Once the trial was completed, the remaining stimuli in the block were presented and the program was prompted to start a new trial. The criteria for completion of the familiarization phase was the occurrence of at least 6 trials and the reduction to at least 75% in the duration of the last three trials as compared to the first three. The test phase was programmed not to exceed 20m.

Developmental and audiological assessment

Following the experimental session infants were assessed using the Bayley Scales of Infant Development, the BSID-III version (Bayley, 2006). These scales evaluate mental as well as psychomotor development. They also allow a general evaluation of attention, orientation and engagement, emotional control, motor quality. Besides indexes of mental (MDI) and psychomotor (PDI) development, they also provide indexes of age for cognitive development, language, social and motor behaviour. All groups were also evaluated in an audiological test battery: behavioural audiometry and physiological audiometry (BERA), and immitanciometry.

Results

For the speech test variables of speech perception, no significant correlation with measures of development was found, regardless the group factor. When comparing the scores of the control subjects, infants and SD, we found a negative correlation between prematurity and the difference between the average time to look at the last three attempts Phase 1 and family block from staging ($r = -0.30$, $p = 0.029$). This indicates that prematurity contributes to a longer time for habituation, i.e., the maintenance for a longer time than average time to look at he stimulus. There was no significant influence of prematurity on the performance of subjects in the testing phase (Phase 2) of the speech perception test. There was no significant interference of gender of the subject in the experiment dependent measures of speech. Was seen only a weak tendency for female subjects take more time in phase 2 ($r = 0{,}26$; $p = 0{,}05$).

An ANOVA including premature and control subjects in one group compared with the SD subjects demonstrated a significant difference between groups according to the variable difference between the average of the last three attempts and the average block 1 of phase 2 ($F (4{,}6)$, $P = 0.04$). No significant correlation between the variables of speech perception in phase 2 and group variable was found, despite a significant correlation between the group variable (with the exclusion of premature infants) and the difference between the average of the last three attempts and the average family block ($r = -0{,}42$; $p < 0.004$). This indicates that individuals with Down syndrome need more time to adjust and maintain a longer look at the average characteristic of the criterion of familiarization.

Through the analysis of variance (ANOVA) and Bonferroni’s Post-Hoc test, there were significant differences between the control and Down syndrome in the light of development measures (MDI: $F (78)$, $p < 0.000$; PDI: $F (85)$, $p < 0.000$). Similar results are obtained when the preterm and control are jointly compared to individuals in the SD group: MDI: $F (78)$, $p < 0.000$; PDI: $F (86)$, $p < 0.000$. Correlations also pointed to a decrement in the values of MDI and PDI to the SD group compared to the control group (MDI: r = -0,67, p< 0,01; PDI: r = -0, 69, p< 0,01).

Negative correlation was found between MDI and age in the group SD (r= -0,43, p<0.000) and MDI and age by semester (r =- 0.41, p = 0.001). In the control group there was a significant positive correlation between MDI and age (r = 0.53, p = 0.002) and between MDI and age by semester (r = 0.51, p = 0.02). In none of the groups were significant correlations between age and PDI real or per semester, although in both groups to observe a positive correlation between MDI and PDI (SD: r = 0,64, p<0,000; Control: r=0,53, p=0,001).

Physiological latencies of the BERA indicated a significant differentiation between the control and SD: the right ear wave V F (4,4), P<0.04; Interpeak I-V (F (4,6), p < 0.04; F (4,3), p < 0.04). The average behavioural threshold also indicated significant difference (F (7,3), P < 0.009) beyond the physiological threshold of the right ear (F (5,8), p<0.019).

Behavioural auditory threshold average showed a positive correlation with the variable group (r = 0.37, p = 0.009) indicating an increase in behavioural thresholds in subjects SD. The pattern persists even when considering only individuals with less than a year and a half (r = 0.46, p = 0.02), but it is significant when including only individuals with less than one year. Among subjects of the control group and SD up to one year of age, a significant positive correlation between the values of immitanciometry and gender was found: RE (r = 0.62, p = 0.01), LE (r = 0.66, p = 0.007).

Discussion

The dependent variables of the speech perception test indicated that both individuals premature and SD take longer to reach the criterion of familiarization and keeps for a longer period the average time for setting characteristic look of the criterion of familiarization. In conjunction with the absence of significant differences between SD and control groups in terms of number of trials in the familiarization phase, it was found a similar pattern to that presented by persons with DS in tasks that require habituation to visual stimuli (Cohen, 1981).

As might be expected, relations with the data of visual tasks are not convergent in all aspects. Lewis & Brooks-Gunn (1984) found significant correlations between measures of habituation and development measures of the Bayley Scales and with chronological age, in groups of subjects with SD, cerebral palsy and developmental delays of differing aetiologies. Similar effects were not found in our study. The absence of similar patterns for visual and auditory tasks in subjects SD is provided also by the evidence pointing to greater difficulty of these subjects in auditory tasks than in equivalent visual tasks (Marcell & Armstrong, 1982; Burr & Rohr, 1978).

In short, the evidence of this speech perception test complement the broader set of data pointing to distinct patterns of habituation in subjects with SD (Wagner, Ganiban & Cicchetti, 1990), that can be observed even in fetuses with SD of habituation to the acoustic stimuli (Hepper & Shahidullah, 1992).

The fact that there were no significant correlations between the dependent variables for the test phase and the variable group may indicate that the experimental design chosen to be sensitive to the responses of habituation, but not to the sensitization, at the age range considered in our study (0-12 months). In the original study design, only individuals of 3 and 4 months of age were considered (Eimas, 1999).

Significant differences were found between SD and control groups in terms of MDI and PDI. With increasing age there is a significant growth in the values of MDI in the control group and a significant decrement in MDI in the group SD. The same pattern of development was observed for the PDI, but without reaching significance. Within each group the values of MDI and PDI are positively correlated significantly. The development data come to corroborate what is perhaps the most robust generalization about the development of individuals with DS that their mental and psychomotor development suffers significant declines with advancing age of the individual (Zeaman & House, 1962).

Electrophysiological data of impulse conduction in the auditory pathways and nuclei of the brainstem proved interesting in several respects. In particular, demonstrating a significant differentiation of SD and control groups to measure the physiologic threshold and latency of wave V, both for the right ear. The I-V interpeak latency was significantly different for both ears, besides the average behavioural threshold. The correlations indicated that the difference in physiological thresholds shows the SD group having lower thresholds.

When considered the SD and others groups together was found a significant correlation indicating the greater presence of non-optimal tympanometric curves in female subjects. It wasn't found reports of similar evidence in the literature (e.g., Shanks, 2004). There were also significant negative correlations between the latencies of some physiological measures of BERA and acoustic immittance measures, indicating an increase in latencies of waves correlated with greater tympanometric curves.

Conclusion

This paper wish to fill a gap and make the understanding of evidence on speech processing and language development in Down syndrome and in premature infants in the light of current models and assumptions about the neuro-functional organization of language. It's suggested that the relations between the different types of auditory evoked potentials disorders at the level of the brainstem (Kraus & Nicol, 2005) should be better understood in heartening to a better understanding of the problems with speech perception that affect people with Down syndrome and children borned prematurely.

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