Acoustic, Phonetic and Phonological Mismatch in Adolescents

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Background

Competence in speech processing develops early in life, but the role of specific neuronal processes supporting this development is not yet well understood. Mechanisms to detect changes in trains of regular auditory stimuli such as mismatch negativity (MMN) may play an important role (Naatanen et al., 1978). More recently, a second late discriminative negativity (LDN, with ~300-550 ms latency) following MMN has been described in both children and adults and may reflect more generally cognitive-level deviance processing (Ceponiene et al., 2004). However, further research is needed to clarify the functions of both mismatch responses.

The present experiment disentangles the kind of stimuli used from the kind of contrast incorporated: mismatch responses were evoked by three types of auditory oddball stimuli: (a) sine-wave oddballs with acoustic contrast, (b) CV syllable oddballs differing only in pitch as a phonetic contrast (similar to the acoustic contrast in sine-waves), and (c) different CV syllable oddballs incorporating phonologic contrast.

Methods

Sample

- **27 adolescents** (21 ♂)
- aged 9 to 14 (mean 11.0 ±sd 1.5) years
- IQ above 80 (mean 107.3 ±13.3)
- reading performance within normal range (t > 40, mean 55.8 ±8.4)
- Normal or corrected to normal vision and normal auditory acuity.

Passive Oddball Paradigm

Stimuli **presented binaurally** via headphone at 75 dB SPL in blocks of 610 Standards and 75 Deviants each, with **random ISI** 800 to 1000ms

Conditions: the Acoustic condition consisted of one block, and Phonetic and Phonological conditions consisted of two blocks presented in a pseudo-randomized scheme (see Table 1).

Children were instructed to watch a silent movie and to pay no attention to the auditory stimuli they hear

Table 1: Synopsis of the stimuli used

	Acoustic	Phonetic	Phonological
Standard	1000 Hz sine tone	„ba"	„ba"
Deviant 1	1100 Hz pitch-raised sine tone	"ba", a pitch-raised f0 contrast	"pa", a voice contrast
Deviant 2	1100 to 1000 Hz transient pitch-raised sine tone	"ba", a transient pitch-raised f0 contrast	"ga", a place contrast

ERP recording and processing

Recording: Nose reference, 250Hz sampling-rate, 0.1 to 70Hz filters

Offline processing: filtering (0.5-20Hz, 24db/oct), occular correction (Gratton & Coles, 1983), segmentation of standards followed by deviants, artifact rejection, averages contain > 25 sweeps.

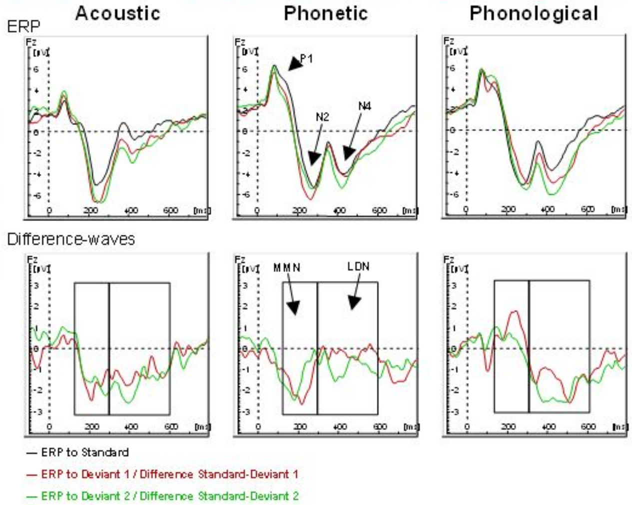
Visual inspection revealed auditory ERP and mismatch components maximal at Fz where peak amplitudes were scored (Figure 1).

Statistics: ANOVAs with factors „Condition" and „Deviant", Greenhouse-Geisser correction where appropriate. Amplitudes of mismatch responses were analysed as means +- 20ms around peak.

Results

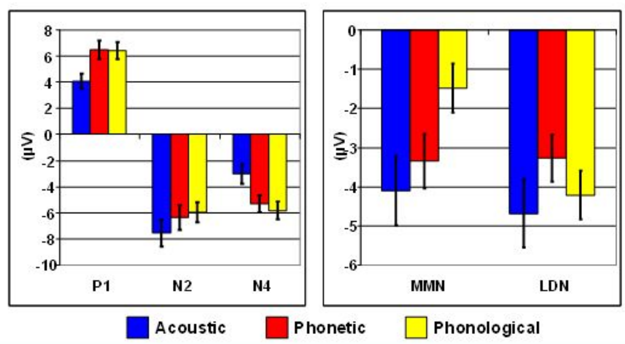
Whilst latency of MMN (mean 215 ±26 ms) and LDN (441 ±45 ms) did not differ between conditions and deviants (all F<2.3, p>.10), clear effects of conditon were found for amplitudes.

Figure 1: Auditory event related potentials and mismatch responses.



The MMN amplitude was reduced in the Phonological condition ($F_{(2, 52)}$=16.3, p<.01) whilst LDN amplitude was reduced in the Phonetic condition (($F_{(2, 52)}$=6.7, p<.01, see Figure 2). LDN amplitude shows a trend towards differences between devinats (($F_{(1, 26)}$=2.8, p=.10, enhanced in the respective Deviants 2), but no other effects on amplitudes of mismatch responses were found (all other F<0.6, p>.42).

Figure 2: Marginal means and confidence intervals (p<.05) of the auditory ERP and mismatch response components .



Conclusions and Conjectures

Mismatch detection comprises a specifiable early and later part. Early mismatch negativity appears to be related to detection of physical f0 deviance for both sine tones and speech sounds (Ceponiene et al., 2004; Cheour et al., 2001). However, for linguistic phonological deviance, we found a diminished and almost positive mismatch response comparable to findings reported by Maurer et al. (2003).

The subsequent LDN is diminished by linguistic congruency despite physical deviance. Thus, LDN may not be specific, but probably a necessary prerequisite for processing of linguistic deviance. These new observations help to better understand neuronal activity associated with auditory mismatch detection in young listeners, and may further be useful to clarify findings from research on dyslexia.

References

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