Early Language Predictors: Behavioural and ERP Measures of Gap Detection in Infants and Adults

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The resolution of fine temporal details is critical for processing speech sounds. This has led researchers to propose a link between deficits in temporal processing and language impairment (Farmer & Klein, 1995; Tallal, Starks & Mellits, 1985). One common way of measuring temporal resolution is to use a gap detection task.

In a within-channel gap detection task (containing 500 Hz markers) Trehub, Schneider and Henderson (1995) found thresholds of 11 ms and 5.2 ms for 6-month-olds and adults, respectively. In a follow-up study examining the infants' subsequent language development at 16 to 30 months of age, Trehub and Henderson (1996) found that infants with above-median gap performance showed higher scores on the MacArthur Communicative Development Inventory than those below the median. Electrophysiological studies tracing the development of within-channel gap detection (2000 Hz markers) have revealed that infants' within-channel resolution matures quickly, reaching adult levels by 6 months of age (Trainor et al., 2001, 2003; Werner et al., 2001).

The present study extends this work to a between-channel task in which gaps are defined by markers of different frequencies. This task is thought to depend on more central processes that integrate temporal information across frequency channels, and may therefore better reflect abilities essential to the processing of speech and language.

Subjects

- 30 infants, 6–7.5 months of age (26 Behavioural, 4 ERP)
- 38 adults (30 Behavioural, 8 ERP)

Stimuli

•1 and 4 kHz Gaussian-enveloped tone pips
•No Gap stimuli contained an imperceptible 2 ms gap
•Gap stimuli had gaps between 10 and 70 ms
•Gap and No Gap stimuli were matched in terms of total power and duration

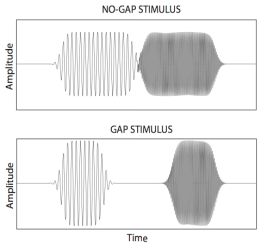

Figure 1: No Gap and Gap stimuli

Procedure

Behavioural

Conditioned head turn procedure
•Infants were rewarded for head turns in response to an occasional Gap stimulus within a series of No Gap stimuli (hits)
•No reward for turning on control trials (false alarms)
Adults raised their hand rather than turned their head to respond

Table 1: Gap durations tested with infants

	Block 1	Block 2
N=10	50 ms	20 ms
N=8	50 ms	30 ms
N=8	50 ms	40 ms

Table 2: Gap durations tested with adults

	Block 1	Block 2
N=10	50 ms	10 ms
N=10	50 ms	20 ms
N=10	50 ms	30 ms

ERP

•Oddball paradigm: random series of "standard" No Gap stimuli (80%) and "deviant" Gap stimuli (20%)
•ERPs recorded from 128 sites using an EGI system and a common-average reference.
•ERPs to Gap stimuli were subtracted from those to No Gap stimuli to produce difference waves. The mismatch negativity (MMN) and P3a components of these difference waves were analyzed.

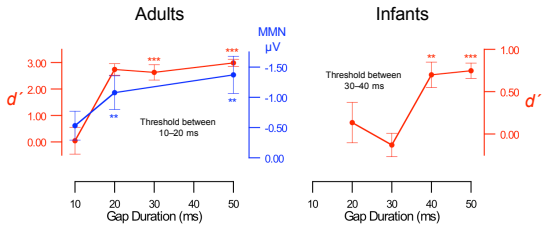

Figure 2: Behavioural discrimination levels (*d´* in red) show that gap detection thresholds are higher for infants than adults. Adults' MMN amplitude (in blue) mirrors their behavioural theshold.

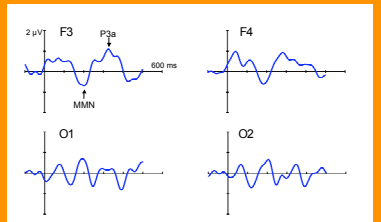

Figure 3: Grand average difference waves for infant listeners with 50 ms Gap stimuli.

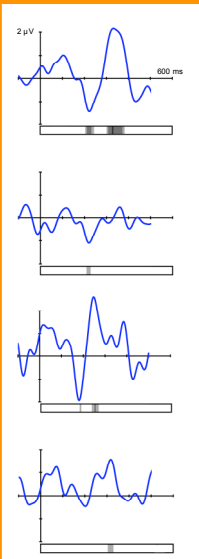

Figure 4: Difference waves for individual infant listeners (at electrode F3) for the 50 ms gap condition. Gray bars beneath the waveforms indicate periods for which Gap and No Gap stimuli produced significantly different responses.

Conclusions

•Between-channel gap thresholds are considerably greater than the within-channel thresholds reported by Trehub et al. (1995) and Trainor et al. (2001, 2003).
•ERP thresholds mirror behavioural thresholds.
•Infants' between-channel gap thresholds are more than twice as great as those of adults, suggesting that the central perceptual processes used for between-channel gap detection follow a prolonged developmental trajectory.

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