Anticipatory Eye Movements:
a technique for assessing auditory categorization in infants

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Overview

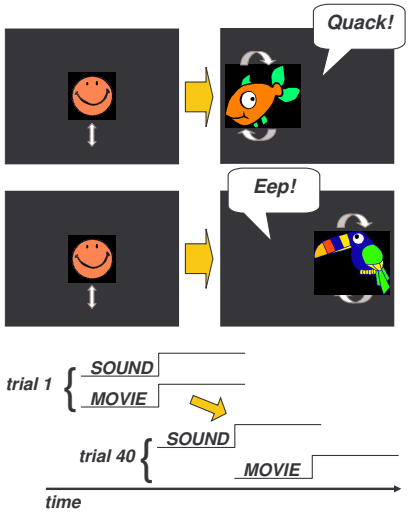
A variety of techniques have been developed to assess auditory discrimination and preferences in infants. However, none of these techniques has been able to provide a measure commonly obtained from adults: labeling or categorization data. In a typical adult study, two stimuli serve as the labels during training, and each participant must exceed some minimal level of performance on these endpoints before a number of generalization stimuli are presented during a two-alternative forced-choice testing phase.

Existing habituation and high amplitude sucking methodologies rely on the infant's response to changes in a stimulus after multiple repetitions of a familiarization stimulus. This leaves open the possibility of adaptation effects and reliance on acoustic representations that are not available during on-line (single-presentation) speech processing. Moreover, these methodologies only permit assessments of discrimination.

We describe a new technique that employs anticipatory eye-movements after a brief training session to measure speech categorization in 4 and 5 month old infants.

Methods

The infant is seated on a parent's lap and views a series of movies. Each trial begins with a vertically moving 'smiley face' to orient the infant's gaze to the center of the screen. The face is removed and one of two randomly selected sounds is presented simultaneously with a short animation on one side of the screen. The sound is consistently paired with the side on which the animation is presented.



Methods (cont)

During training the time interval between the presentation of the sound and the presentation of the movie is gradually increased to a maximum delay of 1800 ms. If infants have learned which side of the screen is associated with each sound, they will make eye-movements toward that side *before* the presentation of the visual stimulus (Haith et al., 1993).

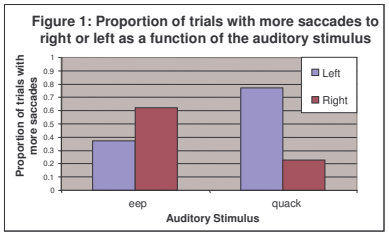
After ~40 training trials, the infant is tested on new sounds that are not followed by the visual reinforcer. Eye-movements are recorded on video tape to assess generalization.

Experiment 1: Quack vs. Eep

To evaluate the effectiveness of the anticipatory eye-movement methodology, 4-month-old infants were initially trained and tested on easily discriminated sounds: the Macintosh "Quack" and "Eep" sounds. Close-up videos of the infant's face were coded by trained observers for gaze direction.

After 36 training trials, performance was quite good:
Eye movements were made to one or both stimulus locations on 70% of the trials
• Of those eye-movement trials, gaze was directed to the correct location 85% of the time
• None of the infants scored lower than chance (50%)

Figure 1: Proportion of trials with more saccades to right or left as a function of the auditory stimulus



Experiment 2: A Voicing Continuum

Subjects were trained on the endpoints of a voice onset time continuum (VOT=0 and 40ms). Early in training, F_0 of the voiced sound was 80% that of normal (100 Hz). F_0 of the voiceless sound was 120% that of normal. As training progressed, F_0 was gradually brought to normal levels.

Figure 2: Frequency Distribution of Accuracy on Endpoints

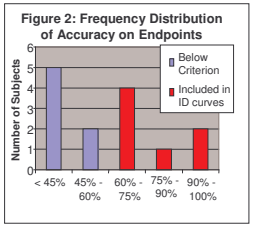
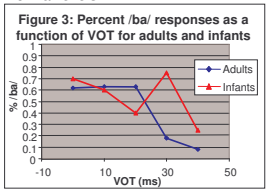


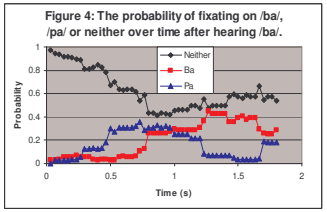
Figure 3: Percent /ba/ responses as a function of VOT for adults and infants



For each trial, a criterion response was the R/L direction with the longer duration of fixation. By averaging across all subjects who scored better than 60% on the endpoints (8/14 subjects), identification curves were created.

Eye-tracking methodologies have also been useful in capturing the detailed time-course of perceptual judgments. McMurray and Spivey (1999) have used the probability of looking to one of two visual stimuli to assess voicing perception in adults, and Swingley and Aslin (2000) have used a similar eye-tracking method to explore the time course of word recognition in eighteen-month-olds. The use of anticipatory eye-movements allows us to generate the same kinds of results (see Figure 4).

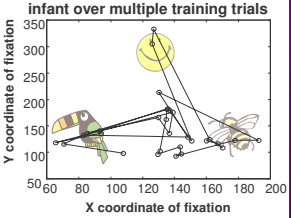
Figure 4: The probability of fixating on /ba/, /pa/ or neither over time after hearing /ba/.



What's Next?

The use of new computerized eye-tracking technologies offers several improvements to video-coding, including: 1) greater temporal accuracy, 2) greater spatial accuracy, and 3) more efficient data coding. However, infants tend to move, making existing table-mounted systems inadequate. By adding a magnetic head- tracking system to a table-mounted eye-tracking system, the eye-tracker can follow the baby's head-movements and maintain a more constant data stream. The greater accuracy resulting from this improvement will increase the power of the anticipatory eye-movement methodology.

Figure 5: Actual scan-path of infant over multiple training trials



Conclusions

• Anticipatory Eye-Movements are a useful tool for assessing auditory categorization in infants. Only 40 training trials are needed to establish reliable responding to two endpoint stimuli. Responses are elicited by a single stimulus presentation. Computer-based eye-tracking techniques hold the promise of fast data acquisition and can provide information about the time-course of perception.
• Although the methodology depends on training, infants are trained on the endpoints only. Anticipatory Eye-Movements then tell us which stimuli they *naturally* group together into categories.

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