RESULTS: HABITUATION EFFECTS

1. HABITUATION EFFECTS

The development of speech perception, including speech discrimination, depends partially on the development of quality sound access. 

Participants

N = 40
Age (VRISD): 8.3 (1.6) mo
Age (MMR): 3.3 (1.1) mo

Normal Listeners (NL)

N = 47
Age (MMR): 3.3 (1.1) mo
Age (VRISD): 8.3 (1.6) mo

Stimulus parameters

Two stimulus contrasts: /a-i/ and /ba-da/
P(deviant) = 0.15
0.5s duration per sound
Pitch matched at 204 Hz
Equated for loudness
70dB in sound field

Electroencephalography

Continuous EEG was recorded during sleep throughout the session
11 electrode montage
Nasion (Nz) reference during acquisition
Ocular activity (E0S) was monitored for wakefulness & REM state

EEG was re-referenced to the linked mastoid channels after artifact rejection.

Final ERPs analyzed from Cz
ERPs transformed to a frequency via CWT (64 log-spaced scales, 1-18 Hz)

METHODS

1. HABITUATION EFFECTS

Effects of habituation on the TF-MMR

1a. Trial selection

To examine the effects of habituation on the TF-MMR, ERP trials were binned into three groups based on the number of standard trials that had elapsed since the previous deviant stimulus. The three habituation groups are labeled as short, medium, and long, referring to the number of elapsed standard trials:

- Short (S): 2 - 4 trials
- Medium (M): 5 - 7 trials
- Long (L): 8 - 11 trials

Trial bins were created separately for standard and deviant trials. After binning the trials, we computed the mean TF Coherence response for each set of bins.

1b. Analysis

We used an extension of classical multidimensional scaling known as DISTATIS to test for generalized effects of habituation on all responses (i.e., irrespective of hemisphere or contrast type). Each of the retained relationships was transformed into a grammian, or "gram" matrix, which is a normalized representation of the spectral-temporal covariances in the TF response. A principal component analysis (PCA) of the mean grammian was used to identify three eigenvectors that, together, explained 82.7% of the total variance amongst all responses. These three eigenvectors were computed as weighted scores for each response, which were then treated as dependent variables for group comparison.

Figure 1 (left) shows a schematic illustration of the DISTATIS approach for analysis.

2. PREDICTING DISCRIMINATION OUTCOMES

Predicting behavioral discrimination outcomes

To examine whether scaled TF-MMR responses might be predictive of later behavioral performance, each subject was administered the Visual Reinforcement Infant Speech Discrimination test (VRISD) approximately 6 months after EEG testing. The VRISD PC Max score for each subject and contrast was treated as the dependent variable in a path classification analysis. VRISD scores were grouped into six based on the PC Max scores (see Figure 5). The goal of the classification algorithm was to predict individual VRISD scores from the corresponding TF-MMR grammian matrix.

Figure 2 (above) shows the weighted scores for each selected eigenvector, E1, E2, and E3. Each panel depicts two trial groups: standard trials (left column group), deviant trials (center column group), and their differences (deviant minus standard, right column group). Each column group depicts the weighted score for each of three habituation groups: short (blue bars), medium (red bars), and long (gold bars). The arrows over each of the standard groups are schematic and are plotted to highlight the observed habituation effects. Note that while E1 and E3 clearly demonstrate habituation of the standard trials, the effect in E2 appears to be driven by the deviant trials.

Figure 3. Spectral and temporal projections for each selected eigenvector, E1, E2, and E3. Each panel depicts two trial groups: standard trials (top row) and deviant trials (bottom row), and each habituation group (short (blue lines), medium (red lines), and long (gold lines)).

Figure 4. Time-frequency (TF) component projections for each selected eigenvector, E1, E2, and E3. Each panel depicts two trial groups: standard trials (top row), deviant trials (middle row), and their differences (deviant minus standard, bottom row) for each habituation group (short (left column), medium (center column), and long (right column)).

CONCLUSIONS

These results revealed a habituation effect corresponding with the time elapsed from the last deviant trial and changes in the frequency and magnitude of the TF-MMR. These results also revealed a significant correlation between the TF-MMR response and later VRISD scores. Taken together, these results suggest that acoustic loudness and salience are both necessary but not sufficient for speech discrimination and that discrimination is dependent on the brain’s ability to recognize and adapt to complex stimulus patterns.

REFERENCES


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