Response-related patterns in discrimination of FM narrowband noise

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Introduction

- Theories accounting for mechanisms of frequency change detection
  - **Pitch-sampling theory** (Hartmann and Klein, 1980; Demany and Semal, 1989)
  - **Dynamic channel theory** (Green and Kay, 1973; Regan and Tansley, 1979; Dooley and Moore, 1988)
  - **Combination of pitch-sampling and dynamic channel theories** (Sek and Moore, 1999; Lyzenga et al., 2004)
Current study

- Investigate the auditory mechanism for frequency glide detection

- Derive temporal weights using a linear classification model (Ahumada, 2002)

- Stimuli: 50-Hz BW
  - Fixed: $f_c = 1000$ Hz
  - Random: $800$ Hz < $f_c$ < $1200$ Hz
Stimuli

- 50-Hz narrow bands of noise
  - Fixed: \( f_c = 1000 \text{ Hz} \)
  - Random: \( 800 \text{ Hz} < f_c < 1200 \text{ Hz} \)
Procedure

- 3 young adults with normal hearing
- Fixed $\Delta f$ Y/N task, 57 dB SPL
- Proper stimulus level ($\Delta f$) to ensure 75~80% correct responses
- 1250 trials for each of the four conditions
  - 1) SS-fixed, 2) SS-random
  - 3) GO-fixed and 4) GO-random
Data Analysis

IF: Instantaneous Freq
DIF: Deviation of Instantaneous Freq
SEWDIF: Squared- Envelope-Weighted- Deviation-of-Instantaneous-Freq

<table>
<thead>
<tr>
<th></th>
<th>IF</th>
<th>DIF</th>
<th>SEWDIF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signal</td>
<td>1000 Hz</td>
<td>0 Hz</td>
<td>0</td>
</tr>
<tr>
<td>No-Signal</td>
<td>1000 Hz</td>
<td>0 Hz</td>
<td>0</td>
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</tbody>
</table>
Data Analysis

Signal

No-Signal

IF: Instantaneous Freq
DIF: Deviation of Instantaneous Freq
SEWDIF: Squared-Envelop-Weighted-Deviation-of-Instantaneous-Freq

“Yes” Pattern

“No” Pattern

Weighting Pattern

m “Yes” trials

IF<sub>y1</sub> → DIF<sub>y1</sub> → SEWDIF<sub>y1</sub>

IF<sub>ym</sub> → DIF<sub>ym</sub> → SEWDIF<sub>ym</sub>

n “No” trials

IF<sub>n1</sub> → DIF<sub>n1</sub> → SEWDIF<sub>n1</sub>

IF<sub>nn</sub> → DIF<sub>nn</sub> → SEWDIF<sub>nn</sub>
Results: Psychophysical Data

Frequency extents ($\Delta f$ in Hz) and $d$’s in four conditions

<table>
<thead>
<tr>
<th>Conditions</th>
<th>GO</th>
<th></th>
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<tbody>
<tr>
<td></td>
<td>CK</td>
<td>RK</td>
<td>MD</td>
<td>CK</td>
<td>RK</td>
<td>MD</td>
<td></td>
</tr>
<tr>
<td>Fixed-center-frequency</td>
<td>$\Delta f$</td>
<td>46</td>
<td>44</td>
<td>42</td>
<td>16</td>
<td>18</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>$d'$</td>
<td>1.52</td>
<td>1.38</td>
<td>1.51</td>
<td>1.76</td>
<td>1.72</td>
<td>1.62</td>
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<tr>
<td>Random-center-frequency</td>
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<td>64</td>
<td>60</td>
<td>24</td>
<td>18</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>$d'$</td>
<td>1.60</td>
<td>1.42</td>
<td>1.72</td>
<td>1.76</td>
<td>1.49</td>
<td>1.52</td>
</tr>
</tbody>
</table>
Results: Temporal weighting patterns

Patterns derived based on subjects' responses

96% confidence interval of null hypothesis
d’ based on relative weights

- Evaluate the degree to which derived weight pattern captures a subject’s decision process.

- Compare d’ based on weights (d’\textsubscript{wgt}) and d’ based on subjects’ performance (d’\textsubscript{obs}).

- Estimate d’\textsubscript{wgt}

1. Decision variable: $\beta(i) = W \cdot S(i)$
   - $\beta$: decision variable, $i$: ith trial, $W$: temporal weighting pattern vector, $S(i)$: ith squared-envelop-weighted-instantaneous carrier (SEWIC), also a vector.

2. d’\textsubscript{wgt} based on $\beta_{sig}$ and $\beta_{nos}$
$d'_{\text{wgt}}$ and $d'_{\text{obs}}$
Conclusions

- Linear model successfully accounted for the decision process in 3 out of 4 conditions.
- Larger magnitude of weights in the second half of TWPs than in the first half suggest more attention at the end of the stimulus.
- $d'$ analysis in the SS-fixed condition supports the idea that both static and dynamic frequency information is integrated into decision process.
- Differences of TWPs in GO and SS conditions suggest different decision process in these conditions.
Acknowledgements

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