Altered tactile spatial attention in the early blind

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Accepted 1 November 2006. Available online 14 December 2006.

Introduction

• Blind individuals utilize tactile and auditory cues for information and orientation

• Increased reliance on touch and audition is reflected in better performance of blind relative to sighted participants in tactile or auditory discrimination tasks.

Introduction

• For example.
  - Early blind individuals perform better than sighted people in tactile tasks measuring two-point thresholds.
  - Electrophysiological studies have shown changes in the latency and topographic distribution of Event Related Potential (ERP) components.

  Such findings are interpreted as evidence for compensatory plasticity based on reorganization of cortical functions

Experimental procedures

• Event-related potential
  - electrophysiological response to an internal or external stimulus.
  - measured using electroencephalography (EEG),
  - individual presentations are averaged

Experimental procedures

• However, enhanced performance in the blind could be due to modulations at low-level sensory stages or improved attentional selectivity developed through continuous practice.

• Support comes from an ERP study
  - the superior spatial selection of tones presented in peripheral space in the blind is linked to a better spatial tuning of early auditory attention
Introduction

• However, there is as yet no evidence for similar compensatory changes of tactile attention in the blind.

• Two previous studies have failed to find evidence for differences in the spatial tuning of tactile attention between blind and sighted participants.

• This is surprising, given that the ability to allocate attention to specific regions of the hand and fingers is essential for the blind when relying on touch.

Introduction

• The tactile attention tasks used in previous investigations were easy.
  – In a previous study with sighted participants although only when attended and ignored locations were located on different fingers.

• Importantly, this effect disappeared when both locations were on the same finger, indicating limitations to the spatial tuning of early tactile attention for sighted people.

Introduction

• The present study investigated whether tactile attentional selectivity is more finely tuned in the early blind, when focused on those parts of the finger that are used during Braille reading.

• In the present experiment, a difficult spatial selection task, which also relates to everyday activities of the blind, was used to uncover altered tactile attention mechanisms in the early blind.

Experimental procedures

• 20 volunteers participated in the experiment.

  10 participants (blind from infancy)
  10 participants (sighted)

*regular Braille readers from an early age (5 years or below).

All participants gave their informed consent prior to the testing.

Experimental procedures

• Participants sat in an experimental chamber
**Experimental procedures**

**Vibratory tactile stimulus**

- Two stimulus intensities:
  - Weak vibrations, contact time was set to 2 ms, followed by a 15 ms interpulse interval.
  - Strong vibrations, contact time was set to 3 ms, followed by a 14 ms interpulse interval.

**Participants**

- 5 blind participants (left - right)
- 5 sighted participants (left - right)

**Experimental procedures**

- Each block consisted of 140 trials.
  - 140 trials non-target stimuli (strong vibrations)
  - 20 trials (weak vibratory stimuli)
  - 12 trials attended
  - 8 trials ignored

**Stimulating (Example)**

- Electroencephalography:
  - Linked-earlobe reference from midline electrodes (FP2, Cz, Pz and O2) and hemisphere electrodes (F3, F7, FC5, T7, C3, CP5, P3, P7 and O1).

- Measurement:
  - The latency of the somatosensory P100 and N140 components and for a 200–300 ms post-stimulus interval.

**P100 is a modality-specific somatosensory component that is assumed to be generated within secondary somatosensory cortex (S2).**
Experimental procedures

- Statistical analyses
  - latencies for early somatosensory components (P100 and N140)
  - mean amplitude values
- subject factor and attention
  - stimulus at attended/unattended location
  - stimulus location (1/2/3)
  - stimulated hand (left/right)
  - electrode site and hemisphere

Horizontal electro-occulogram (HEOG)

Results

<table>
<thead>
<tr>
<th>Behavioral result</th>
<th>Average reaction times (ms)</th>
<th>% Missed targets</th>
<th>% False alarms to targets at unattended locations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sighted participants</td>
<td>637.5 ms *(SE 20.3)</td>
<td>2.3 % *(SE 0.5)</td>
<td>2.8 % *(SE 1.1)</td>
</tr>
<tr>
<td>Blind participants</td>
<td>560.8 ms *(SE 36.1)</td>
<td>1.3 % *(SE 0.5)</td>
<td>2.4 % *(SE 0.8)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ERP results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
</tr>
<tr>
<td>----</td>
</tr>
<tr>
<td>Overall</td>
</tr>
<tr>
<td>Group</td>
</tr>
<tr>
<td>Group × attention</td>
</tr>
<tr>
<td>Group × electrode × attention</td>
</tr>
<tr>
<td>Group × hand × attention</td>
</tr>
<tr>
<td>Group × hemisphere × hand × attention</td>
</tr>
</tbody>
</table>
**Results**

<table>
<thead>
<tr>
<th></th>
<th>50–115 ms</th>
<th>120–145 ms</th>
<th>200–300 ms</th>
<th>50–115 ms</th>
<th>120–145 ms</th>
<th>200–300 ms</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F-value</td>
<td>P-value</td>
<td>F-value</td>
<td>P-value</td>
<td>F-value</td>
<td>P-value</td>
</tr>
<tr>
<td>Sighted</td>
<td>1.54</td>
<td>0.25</td>
<td>0.87</td>
<td>0.38</td>
<td>8.95</td>
<td>0.02*</td>
</tr>
<tr>
<td>Attention</td>
<td>0.57</td>
<td>0.57</td>
<td>0.29</td>
<td>0.73</td>
<td>5.15</td>
<td>0.02*</td>
</tr>
<tr>
<td>Attention × electrode</td>
<td>1.25</td>
<td>0.29</td>
<td>3.87</td>
<td>0.08</td>
<td>21.82</td>
<td>0.01*</td>
</tr>
<tr>
<td>Attention × hemisphere</td>
<td>0.02</td>
<td>0.88</td>
<td>1.68</td>
<td>0.23</td>
<td>0.02</td>
<td>0.88</td>
</tr>
<tr>
<td>Attention × hand</td>
<td>1.24</td>
<td>0.29</td>
<td>0.97</td>
<td>0.35</td>
<td>1.65</td>
<td>0.26</td>
</tr>
</tbody>
</table>

**Discussion**

- **Our results,**
  - tactile attention is more precise in early blind than in sighted participants when the area used by the blind during Braille reading is stimulated.
  - P100 occurred earlier and was enhanced by spatial attention for the early blind,
  - indicates that compensatory enhancements of spatial selectivity within somatosensory cortical areas.

- **Discussion**
  - The blind participants all reported reading Braille characters with one index finger while using the other index finger,
  - involving both hands in Braille reading.
  - This may explain why the compensatory enhancement of attentional selectivity for the early blind was present regardless of which hand was stimulated, and was unaffected by hand dominance.

- **Discussion**
  - Alternatively,
    - the early attentional modulations present in the blind are independent of Braille reading,
    - instead reflect a general enhancement of discriminating fine spatial patterns.

- **Discussion**
  - These two alternatives could be tested in future experiments by measuring the spatial tuning of tactile attention in the blind for fingers not involved in Braille reading.

- **Discussion**
  - This conclusion
    - visual deprivation from a very early age,
    - resulting increased usage and dependence on the tactile sense,
    - alter and improve tactile attention sensory-specific somatosensory cortex.
THANK YOU