The level of prepulse inhibition in healthy individuals may index cortical modulation of early information processing

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Abstract

This study examined whether baseline PPI levels reflect individual efficiency in tasks associated with routine versus supervisory attentional systems (SAS). PPI and neuropsychological data were collected from 30 healthy male subjects. High PPI was associated with shorter movement times on the 5-choice Reaction Time and shorter Subsequent Thinking Times in the Stockings of Cambridge test. These data suggest that high-PPI status reflects greater efficiency in tasks that engage SAS.

Prepulse inhibition (PPI) of the acoustic startle response measures the inhibition of the startle response to a sudden intense stimulus (pulse) by a weak sensory stimulus (the prepulse) preceding the pulse by 30–500ms. PPI is considered a measure of “sensorimotor gating”, which involves the ability to filter out irrelevant information in the early stages of processing so that attention can be directed to more salient environmental features (Braff and Geyer, 1990; Braff et al., 1978). However, as elegantly shown in previous studies, inhibition at this early stage of information processing is modulated by the cortex in a “top-down” fashion (Hazlett et al., 1998; Neumann, 2002). An additional and important characteristic of PPI is that it shows significant inter-individual variability (Hamm et al., 2001). The significance of such variability has been examined in connection to personality dimensions such as social anxiety and extraversion (Blumenthal et al., 1995), psychosis proneness (Cadenhead et al., 1996), novelty seeking (Hutchison et al., 1999), smoking habits (Kumari et al., 1998) and schizotypy (Abel et al., 2004). Perhaps a more pertinent question is whether PPI differences reflect individual variability in efficiency of attentional processing. In the present study, we explored this possibility within the theoretical framework of the control-to-action model developed by Norman and Shallice (1980). This model distinguishes 2 control mechanisms; one involved in routine situations where actions are triggered automatically while the second, the Supervisory Attentional System (SAS), is engaged in situations that require planning and willed actions (Shallice, 1994).

The study was approved by the Ethics Committee of the University of Crete, and all participants gave their written informed consent. Participants were selected using the following criteria: male gender, right-handed, general intellectual ability above 90 as estimated using Raven’s Standard Progressive Matrices, no history of any major medical or neurological disorders, no personal or family history of major DSM-IV axis I disorders, no history of head trauma, no use of prescribed or recreational drugs, hearing threshold of 1kHz > 20dB and a “responder criterion” of 50 units (122μV).
starlike reactivity. All participants underwent physical and psychiatric assessment using the Mini-International Neuropsychiatric Interview (M.I.N.I.) (Sheehan et al., 1998), urine toxicology screening and a hearing test.

A commercially available electromyographic startle system (EMG SR-LAB, San Diego Instruments, San Diego, CA, USA) was used to examine the eyeblink component of the acoustic startle response. Acoustic stimuli were administered binaurally through headphones (model TDH-39-P, Maico Minneapolis, MN). Electromyographic recordings were taken, while subjects were seated comfortably in an armchair, instructed to relax and stay awake. The eyeblink component of the startle reflex was indexed by recording EMG activity of the orbicularis oculi muscle directly beneath the right eye by positioning 2 miniature silver/silver chloride electrodes filled with Signa Gel electrolyte paste (Parker Laboratories, Inc, New Jersey, USA). The ground electrode was attached behind the right ear on the mastoid. Six acoustic startle-eliciting stimuli were administered, and after exclusion of the startle response to the first stimulus, the average of the remaining five was used to determine initial startle reactivity. Subsequently, subjects received a block of four pulse-alone and four prepulse-pulse stimulus trials in a pseudorandom order to calculate baseline startle and percent PPI of the startle reflex. Pulses consisted of 40ms 115dB white noise bursts and prepulses consisted of 20ms 75dB white noise bursts presented at an 80ms lead interval (onset to onset), over a 70dB background noise. We chose a weak prepulse (75dB–5dB above background) on the basis of its putative ability to discriminate better than an intense prepulse between subjects with different levels of startle inhibition by a prepulse. Percentage PPI (%PPI) was calculated using the formula
\[\text{Amplitude}_{\text{prepulse}} / \text{Amplitude}_{\text{pulse-alone}} \times 100.\]
\[\text{Amplitude}_{\text{prepulse}} / \text{Amplitude}_{\text{pulse-alone}} \times 100.\]

After a median split on their PPI, Smirnov test of normality). In order to decrease skew and score within the group differed from normality (Kolmogorov–Mann–Whitney (K–M–W) test was used). The lack of group effect in simple movement latency and percent PPI of the startle reflex. Pulses consisted of 40ms 115dB white noise bursts and prepulses consisted of 20ms 75dB white noise bursts presented at an 80ms lead interval (onset to onset), over a 70dB background noise. We chose a weak prepulse (75dB–5dB above background) on the basis of its putative ability to discriminate better than an intense prepulse between subjects with different levels of startle inhibition by a prepulse. Percentage PPI (%PPI) was calculated using the formula
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Table 1

<table>
<thead>
<tr>
<th>%PPI</th>
<th>High-PPI group</th>
<th>Low-PPI group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(n = 15)</td>
<td>(n = 15)</td>
</tr>
<tr>
<td>RTI</td>
<td>37.97 ± 15.90</td>
<td>-5.42 ± 28.50</td>
</tr>
<tr>
<td>Simple reaction time (ms)</td>
<td>322.59 ± 28.17</td>
<td>322.52 ± 70.99</td>
</tr>
<tr>
<td>Simple movement time (ms)</td>
<td>320.51 ± 76.63</td>
<td>366.31 ± 67.42</td>
</tr>
<tr>
<td>5-choice reaction time (ms)</td>
<td>349.90 ± 45.86</td>
<td>345.33 ± 62.33</td>
</tr>
<tr>
<td>5-choice movement time (ms)</td>
<td>308.44 ± 58.41</td>
<td>364.73 ± 50.48</td>
</tr>
<tr>
<td>SoC</td>
<td>Mean initial thinking time (ms)</td>
<td>9002.84 ± 4097.74</td>
</tr>
<tr>
<td>Mean subsequent thinking time (ms)</td>
<td>409.93 ± 296.01</td>
<td>1221.12 ± 1774.67</td>
</tr>
</tbody>
</table>

a For this measure, the overall distribution of the score differed from normality and the equivalent non-parametric Mann–Whitney procedure was applied; RTI = Reaction Time; SOC = Stockings of Cambridge.
Performance on this task makes greater demands on visual attention and requires a complex motor response as subjects must release a home button and then touch whichever of five target stimuli has been indicated on the touch screen.

The SoC is a test of planning which is considered a core function of the Supervisory Attentional System. Performance in the SoC depends on the participant’s ability to analyze the problem and plan the sequence of moves before starting (Shallice, 1982). Relative prolongation of STT but not ITT in the “low” compared to the “high” PPI individuals may reflect a tendency in the latter to produce solutions before they are fully planned. Consequently, “low” PPI subjects may need to pause during the task to reconsider and refine their solutions (Owen et al., 1990). This interpretation is consistent with the lack of difference in accuracy between the two groups. As shown by Owen et al. (1990) as well as Newman et al. (2003), complex problem solving depends on the integrity of the frontal lobes. Executive time in the 5-choice RTI may be fully planned. Consequently, (Shallice, 1982). Relative prolongation of STT but not ITT in the problem and plan the sequence of moves before starting in the SoC depends on the participant’s ability to analyze the function of the Supervisory Attentional System. Performance 170

REFERENCES


