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ORIGINAL ARTICLE

Differential modulation of prepulse inhibition of the blink reflex in peripersonal versus extrapersonal space

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Peripersonal space;
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Summary
Objective. — Threatening stimuli encountered in peripersonal space (PPS) are processed differently from those encountered in extrapersonal space (EPS). This phenomenon is attributed to tonic top-down modulation. We hypothesized that prepulse inhibition (PPI) of a reflex, which has a protective function, may change according to whether the conditioning stimulus appears in PPS or EPS. We aimed to compare the strength of the PPI according to whether stimulation was delivered in PPS or EPS.
Methods. — The study included 23 healthy subjects with a mean age of 36.8 ± 9.1 years. Recordings of blink reflex (BR) after supraorbital stimulation (so-BR) were performed. Recordings of BR after prepulse stimulation to the median nerve 100 ms prior to the supraorbital stimulation were acquired with the ipsilateral hand 50–60 cm from the face (EPS) and approximately 3–4 cm from the face (PPS). Changes of response magnitudes were compared between PPS and EPS conditions.
Results. — R2 area-under-the curve of so-BR was reduced after prepulse stimulation of median nerve in all subjects while the hand was in EPS. Although the R2 magnitude was also decreased after prepulse stimulation while the hand was in PPS, the percentage of reduction with the hand in PPS was significantly smaller compared to that with the hand in EPS.
Conclusion. — Reduction in R2 magnitude after prepulse stimulation 100 ms prior to test pulse is recognized (PPI). Although PPI was observed under both conditions, PPI of so-BR was attenuated when the stimulus was presented in the PPS. Therefore, our study provides evidence for modulation of PPI of so-BR in PPS and may suggest top-down modulation of the neural circuitry underlying PPI.
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Introduction

Prepulse modulation is a phenomenon in which a reflex response is modulated by a preceding subthreshold peripheral stimulus [6,10,22]. In the literature, this has been generally obtained by applying a somatosensory stimulus prior to the auditory startle response [11]. However, change of the supraorbital blink reflex (so-BR) after a conditioning stimulus in humans has previously been described [1,17,22]. In this case, it may be elicited by application of a somatosensory or auditory stimulus prior to trigeminal stimulation. When the median nerve is stimulated by a subthreshold electrical stimulus within 35 ms prior to supraorbital stimulation, amplitude of R1 is increased, whereas a decrease in R2 magnitude occurs when the subthreshold prepulse stimulus precedes the test stimulus at an appropriate time interval [22]. The reduction of R2 magnitude is called prepulse inhibition (PPI).

The so-BR serves a protective function for the eyes in the presence of a stimulus to the face, whereas PPI protects ongoing information processing interference by the succeeding stimulus according to the 'protective hypothesis' [6]. The general method of obtaining PPI of the so-BR is to apply a conditioning stimulus to the median nerve that is below the perception threshold. A similar modulation of so-BR develops after stimulation of median nerve at the wrist or pure somatosensory stimulation of the second finger [12]. Normally, application of median nerve stimulation is performed while the hands are placed on the knees, far away from the eyes. In other words, the general method of obtaining PPI of so-BR involves use of conditioning stimulation in the extrapersonal space (EPS). Peripersonal space (PPS), on the other hand, is the area immediately surrounding the body [16]. It is the margin between body's ownership and extrapersonal area. The closest region with a sharp onset boundary in the region of 20—40 cm from the face is the defensive PPS; within this space close to the body, there is also a high-risk ultra-near area [2].

The response of organisms to events, social interactions, and the perception of danger may change in several ways when these stimuli are encountered in the PPS [2,3,5,7,8,24]. In their review of the PPS, de Vignemont and Iannetti [3] pointed out that two types of sensory stimuli may enter the PPS: threatening stimuli such as a spider, or graspable objects such as an apple. Each stimulus leads to a specific set of movements. Thus, we hypothesized that magnitude of response obtained after conditioning stimulation may change according to whether it is applied in the PPS of the face compared to the EPS of face. We recorded PPI of the so-BR while the stimulated hand was in the PPS surrounding the face, and compared it with that obtained while the hand was in the EPS of the face. For this reason, we used median nerve stimulation at wrist as a conditioning prepulse stimulation before the supraorbital trigeminal stimulation. We compared the change in magnitude of so-BR after median nerve stimulation at wrist while the stimulated hand was at 50—60 cm from the face (EPS) with the magnitude of so-BR while the stimulated hand was approximately 3—4 cm from the face (PPS).

Methods

Subjects

The study included 23 healthy subjects with a mean age of 36.8 ± 9.1 years (12 women, 52.2%) who volunteered for the study and were working in our electrophysiology laboratory or in the neurology clinics. Subjects using any medications or with any disorder that could potentially confound the electrophysiological studies or that constituted a contraindication were not included in the study. The study was approved by our Institutional Review Board, and all participants provided informed consent.

Recording methods

Electrophysiological recordings were performed using standard techniques with Ag-AgCl surface electromyography recording electrodes (Neuropack Σ-MEB-5504K, Nihon Kohden Corporation, Tokyo, Japan).

Blink reflex

The recordings were done from the orbicularis oculi (O.oc) muscle. The active electrode was placed below the eye, the reference electrode on the lateral orbital margin, and the ground electrode on the forehead. An electrical stimulus of 0.2 ms duration (test stimulus) with intensity three times the perception threshold (8—14 mA, 9.9 ± 3.9 mA) was delivered percutaneously to the supraorbital nerve at the supraorbital margin ipsilateral to the recording site. Five responses were recorded at random intervals of at least 20 s. The analysis time, sensitivity and filter settings were 30 ms/division, 100 μV/division, and 3 kHz and 20 Hz high and low cut-off frequencies, respectively.

Prepulse (conditioning) stimulation

An electrical stimulus of 0.2 ms in duration at the intensity of the perception threshold was delivered to the median nerve at the wrist, 100 ms before the test stimulus was delivered to the supraorbital nerve, using two different stimulators. We stimulated the hand that was ipsilateral to the recording site. The intensity of median nerve stimulation was between 1.6 and 4.4 mA (2.7 ± 0.8 mA). The same test stimulus as in the so-BR recordings was applied 100 ms after the conditioning stimulus. The electrode positioning, filter settings, and sensitivity were the same as for the standard so-BR baseline condition. The analysis time was 30 ms/division. Five trials were performed with at least 10 seconds between two consecutive stimuli.

Experimental design

We used a three-step procedure to assess changes of PPI of the so-BR in PPS. First, the so-BR was recorded while the subject was seated with hands on knees (baseline condition). Then PPI of the so-BR was recorded after stimulating the median nerve at the wrist, with the stimulated hand situated in the EPS and PPS positions. For EPS position, the stimulated hand was still on the knees, at approximately 50—60 cm from the face. For PPS position, the stimulated hand was held at

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