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International Journal of Psychophysiology 55 (2005) 45–49
INTERNATIONAL JOURNAL OF PSYCHOPHYSIOLOGY
www.elsevier.com/locate/ijpsycho

Postural and eye-blink indices of the defensive startle reflex

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Received 22 December 2003; received in revised form 25 May 2004; accepted 3 June 2004
Available online 27 July 2004

Abstract

Postural and eye-blink reactions to acoustic startle probes were examined in 24 volunteers, who completed two blocked conditions (baseline, startle). A postural reaction during the startle condition demonstrated a reflexive movement in the anterior–posterior direction, which was not observed during the baseline condition. This reflexive response was positively associated with the eye-blink reflex, such that larger blink magnitude related to greater posterior movement. These findings were not observed for postural movements in the medial–lateral direction. The results suggest that a measurable postural reaction may be observed following a startling acoustic stimulus, which may reflect generalized bodily flexion associated with a preparatory behavioral response.

Keywords: Posture; Center of pressure; Approach–withdrawal; Avoidance behavior; Eye-blink reflex; Postural sway

Many contemporary theories of emotion (Davidson et al., 1990; Lang, 2000; see Elliot and Covington, 2001 for review) contend that emotion is organized around basic motivational systems. The defensive system, the focus of the current investigation, is responsible for withdrawal or avoidance behavior that is activated in the context of threat and underlies unpleasant reactions (Bradley et al., 2001).

The acoustic startle reflex is considered a primitive defensive reflex to an abrupt sensory event that serves as a behavioral interrupt of ongoing behavior, and may also protect various organs from injury (e.g., the eye-blink; Lang et al., 1997). The neural circuitry of the basic startle reflex involves a subcortical mechanism in which sensory inputs activate nuclei in the reticular formation with outputs to the descending reticulo-spinal tract to the spinal cord (Davis et al., 1982). In threatening or fearful contexts, this reflex is modulated by other brain regions (e.g., the amygdala) and is thought to reflect withdrawal motivation (Lang et al., 1990).

Some of the earliest studies on the defensive startle reflex in humans employed a revolver shot to elicit a response (“the startle pattern”), captured by high-speed film as generalized bodily flexion (Landis and Hunt, 1939). Since that time, researchers have used

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0167-8760/$ - see front matter © 2004 Elsevier B.V. All rights reserved.
doi:10.1016/j.ijpsycho.2004.06.002

other indices of the human startle reflex including electromyographic (EMG) activity associated with eye closure, neck, shoulder, trunk, and leg flexion, as well as neuroelectric activity. Of these responses, the eye-blink has captured considerable attention due to its sensitivity and slow habituation rate (Stern and Dunham, 1990). Although early research on the startle reflex examined behavioral sequelae, virtually all research since that time has examined electrical activity of the cortical or muscular systems. Given the importance of overt behavior during emotional appraisal in novel environments, this report re-examines behavioral reactions associated with the human defensive startle reflex. Specifically, postural reactions to an acoustic startle probe were investigated. Standing postural reactions, assessed by changes in center of foot pressure (COP), serve as a summary measure of all movements made above the support surface. Postural reactions are dependent upon sensory information (Redfern et al., 2001) and reflect a dynamic coupling of perception and action (Bertenthal et al., 1997). To date, only one study of postural sway has examined overall postural reactions motivated by specific emotional stimuli (Hillman et al., 2004), and no research has assessed postural reactions to abrupt, startling stimuli. Accordingly, we hypothesized that an acoustic startle probe would elicit a defensive whole-body reflexive reaction characterized by bilateral symmetry and rapid anterior movement (indicative of flexion) that would not be observed during a baseline (non-startle) condition. No such reaction was expected in the medial–lateral (ML) direction during either condition (i.e., startle or baseline).

1. Method

1.1. Participants

Twenty-four undergraduate students (12 females, 12 males) from the University of Illinois at Urbana-Champaign participated in this study for extra course credit. Participants ranged from 18 to 24 years (M = 19.7, SD = 1.5) and reported no hearing loss or central nervous system disorders that would affect balance or gait. Informed consent was obtained from all participants.

1.2. Procedure

To measure postural reactions, participants stood in stocking feet on a force platform in their normal, comfortable stance with arms at the side. Sensors were affixed under the left eye to measure the eye-blink response. Headphones were placed on the participants, the lights were dimmed, and they were given a few moments to acclimate to the room. Participants were instructed to stand quietly for the entire length of the trial (40 s). They were told that they would occasionally hear brief noises over the headphones, which should be ignored. One practice startle trial was given. Participants completed two counterbalanced conditions (baseline and startle), each consisting of 11 trials with a brief rest between each trial and a 5-min rest between blocks. During startle trials, participants received one acoustic startle probe. No noise probe was used in baseline trials.

1.3. Stimulus

The startle probe consisted of a 50-ms burst of 95 dB white noise with instantaneous rise time. The startle probe onset, marked on the recordings by a 5-volt signal, was presented between 4 and 8 s following the start of data collection and was counterbalanced within and across participants such that they received an equal number of probes at the 4, 5, 6, 7, and 8 s time points following trial onset. Probes were presented binaurally using calibrated headphones (TDH-49; Telephonics, Huntington, NY).

1.4. Apparatus and response measures

For each 40-s trial, data from the force platform (9281B; Kistler Instruments, Amherst, NY) provided information on the movement of the COP in the anterior–posterior (AP) and medial–lateral (ML) directions. For startle condition trials, COP data were reduced by creating an 11-s epoch of continuous data (from 1-s prior through 10-s after startle probe onset). Data were baseline corrected using mean data from the 1-s period of quiet standing that occurred prior to startle probe onset. For baseline condition trials, an 11-s epoch was created from data during the time period from 5 to 16 s after trial onset. Since the 6-s time point was the average time point in which the