Neuroscience Letters 617 (2016) 134–138

Contents lists available at ScienceDirect

Neuroscience Letters

journal homepage: www.elsevier.com/locate/neulet

Research paper

Effects of simulated interpersonal touch and trait intrinsic motivation on the error-related negativity

Mandy Tjew-A-Sin [a,*], Mattie Tops [a], Dirk J. Heslenfeld [b], Sander L. Koole [a]

[a] *Department of Clinical Psychology, VU University Amsterdam, Van der Boechorststraat 1, 1081 BT Amsterdam, The Netherlands*
[b] *Department of Cognitive Psychology, VU University Amsterdam, Van der Boechorststraat 1, 1081 BT, Amsterdam, The Netherlands*

HIGHLIGHTS

- Simulated interpersonal touch was manipulated during a Go/No-Go task.
- Holding a teddy bear versus a cardboard box led to greater ERN amplitudes.
- This effect was especially pronounced for people high in trait intrinsic motivation.
- Simulated interpersonal touch may be a useful way to prevent loss of task engagement.

ARTICLE INFO

Article history:
Received 20 June 2015
Received in revised form 7 September 2015
Accepted 25 January 2016
Available online 10 February 2016

Keywords:
Task engagement
Touch
Intrinsic motivation
Error-related negativity
Action versus state orientation
Persistence

ABSTRACT

The error-related negativity (ERN or Ne) is a negative event-related brain potential that peaks about 20–100 ms after people perform an incorrect response in choice reaction time tasks. Prior research has shown that the ERN may be enhanced by situational and dispositional factors that promote intrinsic motivation. Building on and extending this work the authors hypothesized that simulated interpersonal touch may increase task engagement and thereby increase ERN amplitude. To test this notion, 20 participants performed a Go/No-Go task while holding a teddy bear or a same-sized cardboard box. As expected, the ERN was significantly larger when participants held a teddy bear rather than a cardboard box. This effect was most pronounced for people high (rather than low) in trait intrinsic motivation, who may depend more on intrinsically motivating task cues to maintain task engagement. These findings highlight the potential benefits of simulated interpersonal touch in stimulating attention to errors, especially among people who are intrinsically motivated.

People inevitably make errors, no matter how skilled they are at a task. However, there is considerable variation in how much people care about errors. When people care little about a task, they are prone to ignore errors, but when people are motivated to perform well, they are likely to heed errors and to respond to them by increasing their efforts [1,2]. To understand how people respond to errors, it is therefore critical to examine the factors that influence people's motivation to do well at a task. In the present study, we consider how error processing is influenced by the interplay between a contextual factor that influences intrinsic task motivation, i.e., simulated interpersonal touch, and individual differences in intrinsic motivation.

An important neural correlate of error monitoring is the error-related negativity (ERN), a negative event-related potential that is elicited when people produce an incorrect response in choice reaction time tasks, peaking about 20–100 ms after the erroneous response with a fronto-central scalp distribution [4,5]. One often-used paradigm to elicit the ERN is the Go/No-Go task [6,7]. This task requires people to perform an action given certain stimuli, often pressing a button (e.g., the 'Go' response), and inhibit that action given different, less frequent, stimuli (e.g., 'No go'). The greater frequency of Go stimuli creates a tendency for people to respond on every trial, which leads them to commit errors when the less frequent No-Go stimulus appears. Such errors typically elicit the ERN.

Functional brain imaging studies have shown that the ERN reflects activity in a neural conflict monitoring system in the anterior cingulate cortex [8–10]. The size of the ERN depends on the person's motivation or task engagement. When people are striving for accurate performance, ERN amplitudes increase, while ERN amplitudes decrease when people respond with greater speed at the expense of accuracy [11,12]. Moreover, the ERN varies as a func-

* Corresponding author.
E-mail address: m.m.tjew-a-sin@vu.nl (M. Tjew-A-Sin).

http://dx.doi.org/10.1016/j.neulet.2016.01.044

tion motivational states and traits [12,13]. For instance, the effects of motivational context on the ERN are moderated by aspects of trait persistence, such as intrinsic motivation, which reflects whether people are motivated by interesting or novel tasks [13].

So far, research on error processing has mainly studied the role of motivation in a direct, explicit manner, by instructing participants to be concerned about errors or by providing rewards based on task performance [14,15]. However, how much people care about errors may also be influenced by subtle contextual factors. One such factor may be brief, non-threatening experiences of actual or simulated interpersonal touch, which can have a motivating or encouraging effect. For instance, students who were touched twice on the arm during an interview after a first examination improved their performance on later examinations compared to students who were not touched [16]; see also Refs. [17–19], and elderly people who were stroked by an anthropomorphic robot performed more working actions and spent more time working on the task [20]. In view of these findings, we hypothesized that simulated interpersonal touch may increase people's task motivation, and hence increase error processing.

To test this hypothesis, we conducted an experiment in which we manipulated simulated interpersonal touch, by asking participants to hold either a teddy bear [see Refs. [21,22]] or a cardboard box during a Go/No-Go task. We predicted that simulated interpersonal touch (i.e., holding a teddy bear) would lead our participants to care more about errors, leading to larger ERN amplitudes (relative to holding a cardboard box). In line with prior research [e.g., Refs. [23,24]], we also expected that simulated interpersonal touch would be more effective among people high in trait intrinsic motivation, because they are more motivated by interesting tasks than people low in trait intrinsic motivation.

1. Method

1.1. Participants and design

Twenty-three right-handed students from VU University, Amsterdam, participated voluntarily in a 2-hour session for course credit or €15. None of the participants had a history of neurological or psychiatric disease. The study was conducted in accordance with the Code of Ethics of the World Medical Association. All participants gave written informed consent. Three participants were excluded: one participant showed excessive noise in EEG recording; a second participant committed more than 35% errors on Go trials; and a third participant committed too few errors in the No-Go trials (less than 10%). Thus, the final dataset consisted of 20 participants (16 women, 4 men; average age: 20). The study had a within-subjects factorial design in which participants completed two sessions of a Go/No-Go task, one while holding a teddy bear and one while holding a same-sized cardboard box (order was counterbalanced). The main outcome measures were performance and ERNs during the Go/No-Go task. We also measured individual differences such as trait intrinsic motivation.

1.2. Procedure and materials

We ran the experiment in a soundproof chamber that was equipped with a computer. Participants were told that the study investigated the effects of distracting objects on task performance. Participants first completed questionnaires including the Action Control Scales [25] with the Persistence subscale (Cronbach's alpha = .63) that we used to measure trait intrinsic motivation. The Persistence subscale has been linked consistently to intrinsic motivation and task engagement in work settings [23,26] and in laboratory tasks [24,27]. It measures the degree to which a person becomes caught up in interesting tasks. An illustrative item is "When I am trying to learn something new that I want to learn: (A) 'I will keep at it for a long time', B. "I often feel like I need to take a break and go do something else for a while". In this example, option A reflects a high and option B reflects a low intrinsic motivation response. We summed participants' number of action-oriented responses to provide an index of trait intrinsic motivation.

We continuously measured EEG while participants completed a Go/No-Go task. Participants started with practice trials, after which they completed two sessions in counterbalanced order, one while holding an 80 cm teddy bear and one while holding a cardboard box. Finally, participants were asked for some biographical information and debriefed.

1.3. Dependent variables

1.3.1. Go/No-Go task

Participants completed a version of the Go/No-Go task that was specifically designed to elicit frequent errors [see Ref. [28]]. Participants were told that they would see a fixation cross on the screen, followed by either the letter M or the letter W. They were instructed to press the space bar if they saw the letter M (the Go stimulus), and to refrain from pressing when they saw the letter W (the No-Go stimulus). Participants were told to do the task quickly but accurately. The fixation cross was presented between 300–700 ms, and the stimulus letter was shown for 100 ms. Participants were given 500 ms to respond to the stimulus letter before moving to the next trial. Participants started with 20 slower practice trials with feedback to familiarize them with the task. For the actual task, participants completed two sessions without feedback (one per object to hold), each consisting of six experimental blocks of 100 trials. The first six participants were erroneously presented with only 5 experimental blocks per session. Of every 100 trials, 80 Go and 20 No-Go trials were presented randomly. We measured average reaction time on correct and incorrect trials, and the number of omission (not pressing during a Go trial) and commission (pressing during a No-Go trial) errors.

1.4. Neurophysiological recordings

Recording sites on the face and mastoids were lightly abraded and cleaned with alcohol. Bipolar leads were placed to record horizontal electrooculogram (HEOG) from the left and right temple, and vertical electrooculogram (VEOG) from above and below the left eye. Continuous EEG during the Go/No-Go task was recorded using a stretch ECI cap embedded with 62 sintered Ag/AgCl electrodes. Recordings were digitized at 500 Hz using Neuroscan acquisition software (Compumedics Neuroscan, Hamburg, Germany) with average-ear reference and ground on the left cheek. EEG was corrected for vertical electrooculogram artifacts [29].

We used Brain Vision Analyzer software (Brain Products, Gliching, Germany) to digitally filter the EEG offline between 0.1 and 30 Hz (FFT implemented, 12 dB zero phase-shift Butterworth filter). The 200 ms period before button press was used for baseline correction. An epoch was defined as 200 ms before and 400 ms after the response. Epochs containing EEG artifacts exceeding 80 μV were excluded. Data for these epochs were averaged within participants independently for correct trials (correct related negativity; CRN) and incorrect trials (ERN), and then grand-averaged within the respective conditions. The ERN was defined as the most negative peak on error trials in the 100 ms following the response at the central midline electrode Cz, where visual inspection showed that this component was maximal. For statistical analyses, we used the average amplitude of the ERN in a time window starting 25 ms before the peak until 25 ms after the peak. For correct trials, on which no negative peak was present in the 100 ms following the