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Positive emotion speeds up conflict processing: ERP responses in an auditory Simon task

Philipp Kanske [a,b,*], Sonja A. Kotz [a]

[a] Max Planck Institute for Human Cognitive and Brain Sciences, Independent Research Group: Neurocognition of Rhythm in Communication, Leipzig, Germany
[b] Department of Cognitive and Clinical Neuroscience, Central Institute of Mental Health, Mannheim, Germany

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ABSTRACT

Emotions signal the particular relevance of situations, threatening or rewarding, and influence perception and behaviour accordingly. Research to date has predominantly investigated the impact of negative emotional stimuli. However, rapid reactions to positive emotional stimuli are similarly adaptive. Here, we tested the influence of positive emotional stimuli on attentional control, which enables reacting to conflicting stimulation. We therefore presented positive emotional and neutral words in an auditory Simon task. Reaction times revealed faster resolution of conflict when target stimuli were positive compared to neutral words. Also, emotion modulated the first conflict-sensitive event-related brain potential, a negativity at 420 ms, indicating an influence on early stages of conflict processing. These results complement recent data on negative stimuli and suggest that positive stimuli are equally salient. The rapid impact on attentional control is evolutionary highly adaptive as it reduces the time that conflict yields an organism incapable of responding to reward-signalling stimuli.

1. Introduction

Emotions have been described as "relevance detectors" that influence stimulus processing and behaviour to secure survival in particularly salient situations (Scherer, 1994). Consequently, it has also been suggested that stimuli signalling danger may trigger attentional control which resolves conflict among incompatible response tendencies (Norman and Shallice, 1986; Posner et al., 2007). Using two different paradigms, we recently showed that negative emotional stimuli speed up conflict resolution (Kanske and Kotz, 2010b, 2011, in press). Responses to incongruent stimuli which elicit conflicting response tendencies, are faster when these stimuli are emotionally negative compared to neutral. This effect is consistent across different types of conflict tasks (Flanker and Simon task; Eriksen and Eriksen, 1974; Simon and Rudell, 1967) and across different sensory modalities (visual and auditory) demonstrating its independence from specific experimental settings. This mechanism reduces the time that an organism is incapable of responding to potentially dangerous stimuli. In contrast, the impact of positive emotional stimuli on behaviour is little explored (LeDoux, 2007; Ohman, 2005) even though fast detection of, and reaction to positive, reward-predicting signals in the environment is also highly adaptive to ensure survival. There is some evidence showing the influence of positive emotion on early attentional processing. Brosch et al. (2008) used a dot probe task to show that positive and negative stimuli have analogous effects on attentional orienting. Similarly, negative and positive stimuli both modulate performance in affective versions of the attentional blink paradigm. This task involves participants in recognizing targets interspersed in a stream of rapidly presented stimuli. Identification of a second target presented 200–500 ms after a first target is impaired due to the attentional blink. However, processing of emotional items presented in this period is spared (see e.g. Anderson, 2005; Keil and Ihssen, 2004; Trippe et al., 2007). Interestingly, the relevance of positive emotional stimuli can also be experimentally enhanced. For example, fasting individuals exhibit an enhanced attentional bias towards food-related words (Leland and Pineda, 2006). However, it is unclear whether positive emotional stimuli also modulate the way an individual responds to situations of conflicting stimulation. Therefore, we asked if attentional control and the resolution of conflict are enhanced in reactions to positive emotional stimuli.

To test this question, we adapted our previous experimental design and presented positive emotional words in an auditory Simon task (Simon and Small, 1969). This task creates conflict through incompatible stimulus-response mappings and has been widely used to study the processing of conflict in healthy and patient populations (Carriero et al., 2007; di Pellegrino et al., 2007; Egner et al., 2007; Fielding et al., 2005; Leuthold and Schröter,

* Corresponding author at: Department of Cognitive and Clinical Neuroscience, Central Institute of Mental Health, Square J5, 68159 Mannheim, Germany. Tel.: +49 621 1703 6307; fax: +49 621 1703 6305.
E-mail addresses: philipp.kanske@zi-mannheim.de, philipp@kanske.de (P. Kanske).

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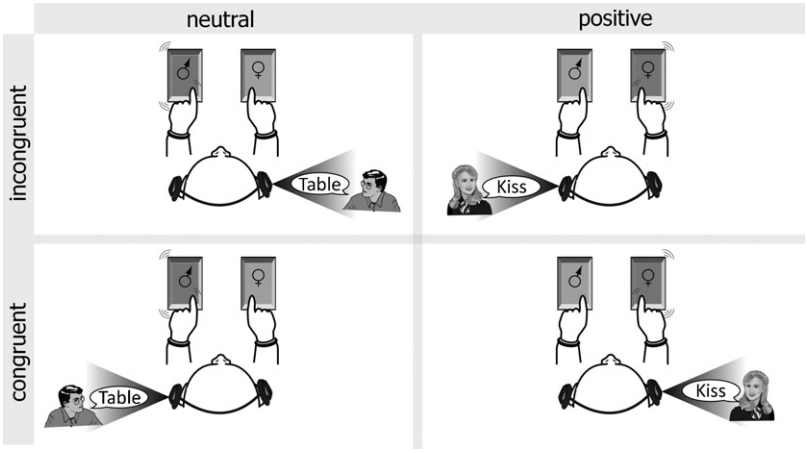

Fig. 1. Schematic of the modified Simon task. Participants identified the gender of a voice that was presented to the right or left ear. Responses were given with the right or left hand, yielding congruent and incongruent presentation and response sides. Positive and neutral words were presented in the corresponding emotional prosody. Source: Adapted from Kanske and Kotz (in press), by permission of Oxford University Press.

2006; Liu et al., 2004; Peterson et al., 2002). It is a superb tool to probe attentional control as it elicits opposing action tendencies and necessitates detection and resolution of the resulting conflict. Neuroimaging studies showed that the processing of Simon-type conflict shares neural circuits with other conflict tasks such as the Flanker or Stroop paradigm (for a study comparing these three tasks see Fan et al., 2003). The Simon task applied in the present study (see Fig. 1) had participants evaluate the gender of vocally expressed stimuli presented to either the right or the left ear. They responded via a left or a right button press, resulting in congruent and incongruent presentation and response sides. Comparing responses to incongruent vs. congruent stimuli yields a measure of conflict processing efficiency (Posner and DiGirolamo, 1998). To examine whether conflict processing is modulated by emotion, the presented stimuli were positive and neutral words. If target stimulus emotionality has an influence on conflict processing than the incongruent–congruent comparison should differ for neutral and positive stimuli.

The second question of the present study concerns the timing of a possible modulation of conflict processing by positive emotion. Our previous data show that negative emotion influences the amplitude of a first conflict-sensitive event-related brain potential (ERP; Kanske and Kotz, 2010b, in press). This conflict negativity varies in time as a function of the specific conflict task (200–550 ms post-stimulus onset; Folstein and Petten, 2008; van Veen and Carter, 2002), and is enlarged for negative emotional stimuli. We hypothesized to find a similar early effect of positive words on conflict processing, as ERP data from visual and auditory word perception also indicate very early detection of positive emotion, for example, in the P2 potential (Kanske and Kotz, 2007; Paulmann and Kotz, 2008).

To conclude, the present study aims at probing the influence of positive emotion on conflict processing and at elucidating which conflict processing stages are modulated by emotion with event-related potentials.

2. Materials and methods

2.1. Rating and stimuli

From the Leipzig Affective Norms for German (LANG; Kanske and Kotz, 2010a), 40 positive and 40 neutral words were selected. An ANOVA and Scheffé's multiple comparisons test showed that the word groups differed significantly in valence and arousal (all $p < .01$), but were not different in concreteness, word frequency according to the Wortschatz Lexikon of the University of Leipzig (http://wortschatz.uni-leipzig.de/), and word length in number of letters and syllables (all $p > .30$; see Tables 1 and 2). Words were spoken by two professional actors (male and female) and the emotional expression corresponded to the emotional valence of the words. A group of 30 participants (16 female, mean age 24.2, SD 3.1) rated the valence and arousal of emotional prosody for four recordings of each word. Of these, 40 positive and 40 neutral stimuli recorded from each speaker were selected. These words differed significantly in valence and arousal (all $p < .01$). The conditions also differed in mean pitch and duration (all $p < .05$). According to reviews across different paradigms studying vocal affective communication, these acoustic parameters constitute positive emotional prosody and were therefore expected to also differ in the present stimuli (Scherer, 2003). To control for loudness, all stimuli were normalized to an intensity of 75 dB SPL.

2.2. Participants

Twenty-six (14 female) participants completed the experiment. Mean age was 24.5 years (SD 2.8). All participants were native speakers of German, right-handed according to the Edinburgh Handedness Inventory (Oldfield, 1971), with a mean laterality quotient of 96.7 (SD 6.6), and reported normal hearing. The study was approved by the Ethics Committee of the University of Leipzig. All participants gave written informed consent prior to participation.

2.3. Task and procedure

Participants performed a gender voice decision task (see Fig. 1). Words spoken by a male or a female voice were presented either to the left or right ear. Participants responded with a left- or right-hand button press. Mapping of responses to left and right response keys was counterbalanced across participants. Half of the trials were congruent (same stimulus presentation and response hand side) and the other half incongruent. Each stimulus (each word spoken by both the male and the female speaker) was presented in the congruent and in the incongruent condition yielding a total of 320 trials, 80 per condition. Each trial lasted 6000 ms. The stimulus onset in a trial was jittered (0–2000 ms) to avoid temporal orienting. Stimulus presentation duration was 700 ms on average. Maximum response time after stimulus

Table 1
Descriptives for word stimuli.

	Positive	Neutral
Example word	Kuss [kiss]	Tisch [table]
Rated visual valence	7.5 (0.3)	5.0 (0.1)
Rated visual arousal	6.6 (0.6)	2.3 (0.3)
Rated auditory valence	7.3 (0.2)	5.0 (0.1)
Rated auditory arousal	6.8 (0.4)	2.4 (0.2)
Rated concreteness	6.2 (1.7)	6.0 (1.3)
Word frequency	10.7 (2.0)	11.3 (1.9)
Number of letters	5.8 (1.3)	5.9 (1.1)
Number of syllables	1.7 (0.5)	1.8 (0.4)
Duration	0.8 (0.2)	0.6 (0.1)
Mean pitch	262.1 (52.2)	159.7 (22.7)

Valence, arousal, and concreteness ratings for the selected word groups taken from the Leipzig Affective Norms for German (LANG; Kanske and Kotz, 2010a). The ratings were done on 9-point scales ranging from negative to positive, low to high arousing, concrete to abstract, respectively. The material was also controlled for word frequency, and number of letters and syllables.