Neuropsychologia 51 (2013) 2791–2798

Contents lists available at ScienceDirect

Neuropsychologia

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

Electrophysiological correlates of block-wise strategic adaptations to consciously and unconsciously triggered conflict

Jun Jiang[a,b,c], Simon van Gaal[c,d], Kira Bailey[e], Antao Chen[a,b], Qinglin Zhang[a,b,*]

[a] Faculty of Psychology, Southwest University, Chongqing 400715, China
[b] Key Laboratory of Cognition and Personality, Southwest University, Ministry of Education, Chongqing 400715, China
[c] University of Amsterdam, Department of Psychology, Amsterdam, The Netherlands
[d] Donders Institute for Brain, Cognition and Behavior, Radboud University Nijmegen, Nijmegen, The Netherlands
[e] Department of Psychological Sciences, University of Missouri, Columbia, MO, USA

ARTICLE INFO

Article history:
Received 26 March 2013
Received in revised form
7 August 2013
Accepted 9 September 2013
Available online 17 September 2013

Keywords:
Conscious
Unconscious
Conflict frequency
Block-wise conflict adaptation effect
ERP

ABSTRACT

The role of consciousness in conflict adaptation has been a topic of much debate. The purpose of the current study was to investigate the neural correlates of block-wise conflict adaptations elicited by conscious and unconscious conflicting stimuli in a meta-contrast masked priming task. Event-related potentials (ERPs) were recorded while individuals responded to prime-target pairs in mostly congruent (80% congruent trials, 20% incongruent trials) and mostly incongruent blocks of trials (20% congruent trials, 80% incongruent trials). Mean response times and error rates revealed that the conflict effect (incongruent trials–congruent trials) was reduced in mostly incongruent blocks relative to mostly congruent blocks. Furthermore, conflict related ERP signals (the amplitude difference between congruent and incongruent trials) for three ERP components (early occipito-parietal negativity, the fronto-central N2 and the centro-parietal P3) were attenuated in mostly incongruent blocks compared to mostly congruent blocks, reflecting block-wise adaptation to the frequency of conflict. The conflict-related frontal N2 component differentiated most strongly between visibility conditions. These results further specify the electrophysiological correlates of block-wise strategic adaptations to consciously and unconsciously elicited conflict.

1. Introduction

Cognitive control is an umbrella term that refers to the ability to organize thoughts and actions to accomplish or optimize goal-directed behaviors, including flexibly selecting task-relevant information and initiating, monitoring and adjusting actions (Clayson & Larson, 2011; for reviews see Ridderinkhof, Ullsperger, Crone, & Nieuwenhuis, 2004). There is a long-lasting debate on the necessity and role of consciousness for cognitive control (for reviews see Desender & Van Den Bussche, 2012; Kunde, Reuss, & Kiesel, 2012; van Gaal, De Lange, & Cohen, 2012), although recent studies suggest that at least some forms of cognitive control, such as response inhibition (Hughes, Velmans, & De Fockert, 2009; van Gaal, Lamme, Fahrenfort, & Ridderinkhof, 2011; van Gaal, Ridderinkhof, Fahrenfort, Scholte, & Lamme, 2008; van Gaal, Ridderinkhof, Scholte, & Lamme, 2010) and task-switching (Lau & Passingham, 2007; Reuss, Kiesel, Kunde, & Hommel, 2011) can be influenced unconsciously. In the domain of conflict control, two types of conflict adaptation have been identified: trial-by-trial adaptations to conflict and block-wise conflict adaptations, also referred to as micro- and macro-adjustment respectively (Ridderinkhof, 2002b). Here, we will address a simple question: What are the behavioral and electrophysiological correlates of block-wise adaptations to consciously and unconsciously elicited conflict?

Previous studies have convincingly demonstrated that unconsciously presented conflict-inducing stimuli can delay responses to subsequent target stimuli and lead individuals to make more errors when the prime-target pairs are incongruent than when they are congruent, a phenomenon also referred to as the congruency or conflict effect (Desender, Van Lierde, & Van den Bussche, 2013; Francken, Gaal, & de Lange, 2011; Jaśkowski, Skalska, & Verleger, 2003; Kunde, 2003; for a review see Van den Bussche, Van den Noortgate, & Reynvoet, 2009; van Gaal, Lamme, & Ridderinkhof, 2010; Wolbers et al. 2006). Interestingly, the magnitude of the congruency effect varies depending on the proportion of congruent and incongruent prime-target pairs within an experimental block, in some reported cases even if the conflict-inducing prime stimuli remain undetected (Bodner & Masson, 2001; Bodner & Mulji, 2010; for a review see Desender & Van Den Bussche, 2012; Jaśkowski et al., 2003; Klapp, 2007; Wolbers et al., 2006). That is, the congruency effect is smaller in blocks with a high proportion of incongruent trials than in blocks

* Corresponding author at: Southwest China University, School of Psychology, No.2 TianSheng Street, BeiBei, Chongqing 400715, China. Tel.: +86 023 6825 2660; fax: +86 023 68253304.
E-mail addresses: qlzhang.swu@gmail.com, zhangql@swu.edu.cn (Q. Zhang).

0028-3932/$ - see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.neuropsychologia.2013.09.020

with a low proportion of incongruent trials. For example, Jaśkowski et al. (2003) found that in blocks in which the prime was masked the conflict effect decreased when the proportion of incongruent trials was 80% compared with when it was 20% (see Bodner & Mulji, 2010; Klapp, 2007; Wolbers et al., 2006 for similar results).

A number of studies have been performed on conscious block-wise conflict adaptation effects, using various paradigms, such as Eriksen flanker task (e.g. Gratton, Coles, & Donchin, 1992; Purmann, Badde, Luna-Rodriguez, & Wendt, 2011; Purmann, Badde, & Wendt, 2009), the Stroop task (e.g. Carter et al., 2000; Fernandez-Duque & Knight, 2008; West & Bailey, 2012) and the Simon task (e.g. Stürmer, Leuthold, Soetens, Schroter, & Sommer, 2002). In such conflict studies, several ERP effects have been observed that might reflect conflict processing/monitoring, with different latencies and scalp distributions. Most prominently, the fronto-central N2 is generally larger for conflict (incongruent) trials compared to no-conflict (congruent) trial (Van Veen & Carter, 2002). The N2 is a negative deflection in the ERP peaking approximately 200–400 ms (Folstein & Van Petten, 2008) after conflict processing and previous source reconstruction suggests that it's neural generator is located in the medial frontal cortex, most likely the anterior cingulate cortex (ACC) (for a review see Ridderinkhof et al., 2004). The N2 is typically associated with conflict monitoring/resolution or inhibition of the incorrectly activated response (Botvinick, Braver, Barch, Carter, & Cohen, 2001; Van Veen & Carter, 2002; Yeung & Cohen, 2006). Further, often, a more centro-parietal and spatially broader P3 component, a positive deflection peaking approximately 300–500 ms after the stimulus (Desender & Van Den Bussche, 2012; Purmann et al., 2011), is also observed during the processing of conflict. The specific functional significance of this component is less clear and it has been suggested to reflect processes such as response inhibition, error monitoring, and response evaluation (Clayson & Larson, 2011; Polich, 2007). Finally, relatively early sensory differences have also been observed when comparing conflict and no-conflict trials. These results are interpreted as being related to the increased attentional demands during conflict processing (Abrahamse, Duthoo, Notebaert, & Risko, 2013; Johnstone, Barry, Markovska, Dimoska, & Clarke, 2009; van Gaal et al., 2011).

With respect to block-wise adaptations to the frequency of conflict, Purmann et al. (2011) recently observed that the fronto-central N2 ERP component was larger, and the latency of the more central P3 ERP component later, in incongruent than in congruent trials. More interestingly, both effects were reduced when conflict was frequently experienced compared to when it was infrequently experienced. Wolbers et al. (2006) also explored the underlying brain mechanism of strategic block-wise behavioral adaptations and the relation to conscious awareness of conflict-inducing stimuli using fMRI. They observed that the pre-SMA was more active in high conflict blocks (80% incongruent) than in low conflict blocks (20% incongruent). Further, psychophysiological interaction analyses demonstrated a stronger coupling between the pre-SMA and the putamen, and the Pre-SMA and the lateral occipital complex (LOC), in frequent conflict blocks compared to infrequent conflict blocks. This have led the authors to conclude that the pre-SMA might have an overarching role in controlling the processing of unconscious primes by modulating perceptual analysis (LOC) and response selection (putamen) during block-wise conflict adaptation.

To further examine the neural correlates of block-wise conflict adaptation effects and the role of consciousness therein, we measured ERPs in a typical arrow version of the meta-contrast masking paradigm. In this task, a briefly presented prime arrow was presented, which was followed after a short delay (29 ms) by a meta-contrast target arrow (129 ms) upon which participants had to make a left/right decision (Fig. 1A). When the duration of the prime was sufficiently short, the briefly presented prime arrow was strongly masked by the target arrow. However, when the prime was presented for a longer duration (129 ms) prime visibility was much higher. The proportion of incongruent and congruent trials was manipulated in a block-wise manner. In mostly congruent blocks, 80% of the trials were congruent and 20% incongruent, while in the mostly incongruent blocks the proportions were reversed.

Based on these previous studies, we hypothesized that block-wise conflict manipulations would directly impact the conflict effect in behavior and EEG. Behaviorally, we expected the conflict effect (incongruent trials–congruent trials) to be smaller (for RTs as well as errors) in frequent conflict blocks compared to infrequent conflict blocks (Jaśkowski et al., 2003; Purmann et al., 2011; Wolbers et al., 2006). Further, block-wise conflict manipulations would potentially be reflected in three ERP modulations evolving across time: an early sensory event, a somewhat later fronto-central N2 and finally a centro-parietal P3 modulation (Abrahamse et al., 2013; Bartholow, Riordan, Saults, & Lust, 2009; Jaśkowski et al., 2003; Purmann et al., 2011; van Gaal et al., 2011). More specifically, we predicted that the conflict effect for these components would be smaller under mostly

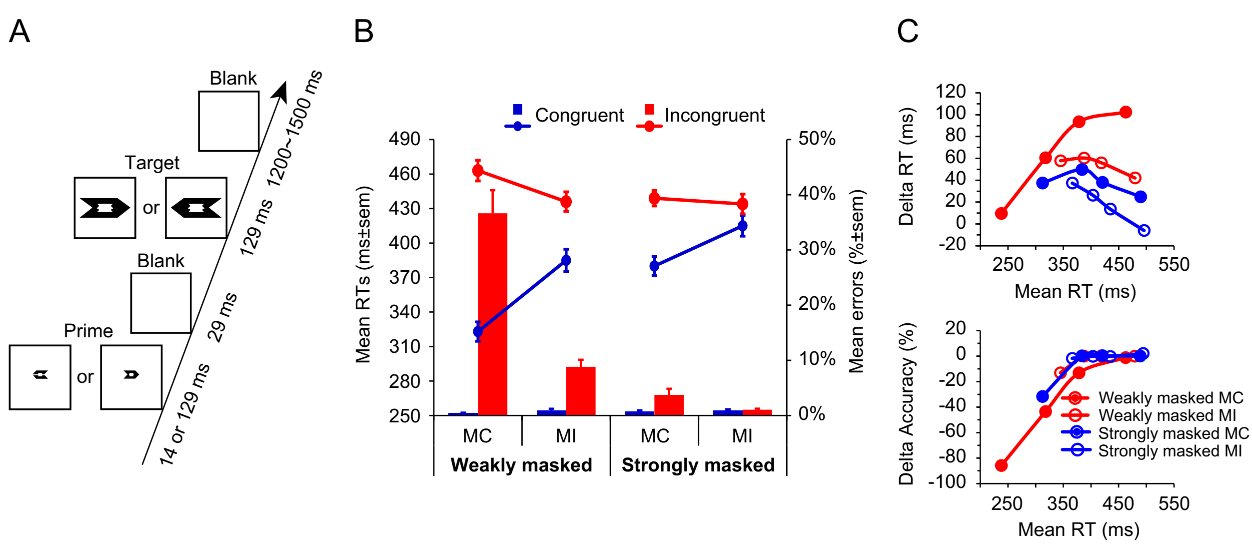

Fig. 1. Experimental design and behavioral results. (A) Schematic representation of the experimental procedure and event timing. (B) Mean response times and error rates for congruent and incongruent trials in mostly congruent (infrequent) blocks and mostly incongruent (frequent) blocks under weakly masked and strongly masked conditions. (C) The delta plots (upper panel) and CAFs plots (lower panel) for the different conflict frequency blocks, separated by masking strength. Bar graphs represent the mean error rates in each experimental condition. MC = mostly congruent blocks; MI = mostly congruent blocks; error bars represent the standard error of the mean (± SEM).