Feeling the Conflict: The Crucial Role of Conflict Experience in Adaptation

Kobe Desender, Filip Van Opstal and Eva Van den Bussche

Psychological Science published online 6 January 2014
DOI: 10.1177/0956797613511468

Psychological Science OnlineFirst, published on January 6, 2014 as doi:10.1177/0956797613511468

Research Article

ASSOCIATION FOR PSYCHOLOGICAL SCIENCE

Psychological Science
201X, Vol XX(X) 1–9

DOI: 10.1177/0956797613511468
pss.sagepub.com
SAGE

Feeling the Conflict: The Crucial Role of Conflict Experience in Adaptation

Kobe Desender[1], Filip Van Opstal[2], and Eva Van den Bussche[1]
[1]Department of Psychology, Vrije Universiteit Brussel, and [2]Department of Experimental Psychology, Ghent University

Abstract

In the study reported here, we examined the role of conflict experience in cognitive adaptation to conflict. Although the experience of conflict is generally neglected in theoretical models of cognitive control, we demonstrated that it plays a critical role in cognitive adaptation. Using a masked-priming paradigm, we showed that conflict adaptation was present only after trials on which participants experienced response conflict. Furthermore, when subjective experience did not coincide with actual conflict, adaptation effects in the error rates were observed after the experience of conflict, not after response conflict. We conclude that the experience of conflict, and not response conflict per se, is the crucial factor underlying cognitive adaptation effects. The current findings provide a new perspective on the question of why the human cognitive system exerts cognitive control, and they suggest that a crucial role of subjective experience is to allow for top-down control of behavior.

Keywords

Gratton effect, conflict adaptation, conflict experience, consciousness, priming, cognition(s)

Received 9/2/13; Revision accepted 10/11/13

Human cognition is characterized by an extreme flexibility, allowing us to quickly react to rapidly changing circumstances. This capacity for cognitive control allows us to perform a task to the best of our ability. For example, if you need to read a long text before an approaching deadline, you constantly urge yourself to remain focused on the text and extract the relevant information as quickly as possible. If you lose focus and your mind starts to wander, you will regain your focus only when you become aware of the mind wandering. The role of awareness in this example is not trivial. Only when you become aware of your mind wandering can you again devote more effort to the reading process (Schooler, 2002). Remarkably, the notion of awareness remains largely unexplored in research on cognitive control.

Research in the domain of cognitive control deals with such cognitive processes as planning new strategies, evaluating them, controlling their execution, and correcting possible errors. According to the conflict-monitoring theory (Botvinick, Braver, Barch, Carter, & Cohen, 2001), specific parts of the dorsomedial frontal cortex are sensitive to deviations from optimal performance. If a deviation is noticed, the cognitive-control system, presumably located in the dorsolateral prefrontal cortex, will intervene to improve performance. Evidence supporting this theory has been provided by studies focusing on conflict paradigms (Botvinick, Cohen, & Carter, 2004). For example, in the Stroop task, participants view words that appear in different colors. On congruent trials, the meaning of the word is the same as the color (e.g., the word *red* presented in red type), and on incongruent trials, the meaning of the word is different from the color (e.g., the word *red* presented in blue type). Participants need to respond to the color of the type (i.e., the relevant information) but ignore its meaning (i.e., the irrelevant information). Typically, reaction times (RTs) are faster and error rates lower on congruent trials than on incongruent trials (i.e., the *congruence effect*). An incongruent trial not only affects performance on the trial itself but also enhances the control of irrelevant information on the next trial. This reduction of the congruence effect after an

Corresponding Author:
Kobe Desender, Faculty of Psychology and Educational Sciences, Vrije Universiteit Brussel, Pleinlaan 2, 1050 Brussels, Belgium
E-mail: kobe.desender@vub.ac.be

incongruent trial is known as the *Gratton effect* (Gratton, Coles, & Donchin, 1992; for an overview, see Egner, 2007).

In the conflict-monitoring model (Botvinick et al., 2001), conflict is defined as the amount of energy measured over the response level. On incongruent trials, the activation of multiple responses results in a higher amount of energy (i.e., conflict) than occurs on congruent trials. This computed amount of conflict is then directly related to the degree of cognitive control exerted. Whether participants subjectively experience response conflict is not a crucial element in this model. This is noteworthy, because in situations such as mind wandering during text reading, awareness is needed for behavior to be adapted. Researchers have probably overlooked the role of experience in adaptation processes because in standard conflict tasks, it is almost impossible to dissociate conflict and conflict experience. For example, in the Stroop task, word meaning is activated so automatically that participants are typically aware whether each trial was congruent or incongruent. Hence, conflict and conflict experience cannot be dissociated, and researchers take conflict as the source of adaptation.

To investigate the role of conflict experience, we designed a priming experiment that masked the irrelevant information (and hence the conflict), and we measured the experience of conflict on each trial. This allowed us to examine the relations among actual response conflict, conflict experience, and adaptation effects.

Method

Participants

Eighty-six students participated for course credit and provided written informed consent. All participants reported normal or corrected-to-normal vision and were naive with respect to the hypothesis. Four participants were removed because their median RT was more than 2 standard deviations above the mean of median RTs. Four participants were removed because they had error rates of more than 25% in their responses to the target.[1] The final sample comprised 78 participants (18 men, 60 women; mean age = 19.24 years, *SD* = 1.5, range = 17–24).

Stimuli and apparatus

All stimuli were presented in white on a black background on 15-in. CRT monitors with a vertical refresh rate of 85 Hz. Primes and targets were arrows (1.33° wide and 0.93° high) that pointed to the left or right. We created two different masks (2.58° wide and 1.22° high) that consisted of randomly selected white, gray, and black pixels. Responses were collected using a standard QWERTY keyboard.

Procedure

We instructed participants to indicate quickly and correctly the direction in which target arrows pointed by pressing the "d" or "k" key for "left" or "right," respectively. They were informed that a nearly invisible prime preceded each target and that they might notice a conflict on some trials, for example, because of slowed RTs, error proneness, or a vague feeling that something was not right. Conflict experience was assessed trial by trial by asking (translated here from Dutch), "Do you think there was a conflict between the two arrows on this trial?" There were four different response options: "1. I think there was a conflict," "2. I don't know! (but I guess there was a conflict)," "3. I don't know! (but I guess there was no conflict)," and "4. I think there was no conflict." We refer to these responses as "conflicting," "guess conflicting," "guess not conflicting," and "not conflicting," respectively.

Each trial started with a central fixation cross presented for 1,000 ms. Next, a prime arrow was presented for 23 ms, followed by two different masks, each of which lasted 23 ms. Next, a blank screen was presented for 23 ms, followed by a target arrow for 160 ms. Responses were recorded for up to 3,000 ms after target onset. On half of the trials, the prime and target pointed in the same direction; on the other half, they pointed in different directions. We asked participants to rate their feeling of conflict immediately after their speeded response to the target. Subsequently, they were to put one index finger on each response button and to press the space bar to initiate the next trial (see Fig. 1).

Participants first completed 8 training trials on which they responded only to the direction of the target arrow. Subsequently, they completed 40 practice trials on which they also answered the conflict question. In both these practice blocks, feedback was provided after incorrect responses to the target. Afterward, we started the main experiment, which consisted of eight blocks of 60 trials each. Feedback (mean RT and mean accuracy) was presented after each block. Finally, prime visibility was assessed by a detection task (100 trials) that was identical to the task in the main experiment, except that (a) participants were instructed to respond to the direction of the prime arrows instead of the target arrows and (b) the conflict question was omitted.

Results

Conflict experience

To assess conflict experience, we examined whether incongruent trials or congruent trials were more frequently rated as conflicting. The responses "guess conflicting" and "guess not conflicting" were too infrequent

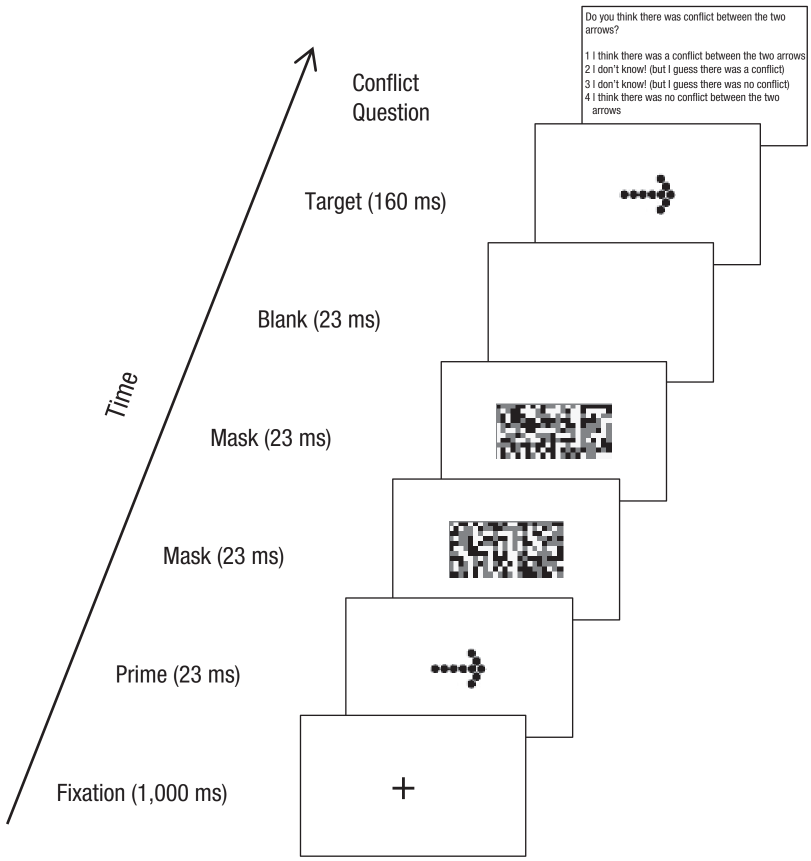

Fig. 1. Example of a congruent trial in the main experiment. Each trial started with a central fixation cross, followed by a prime arrow, and then two different masks. Next, a blank screen was presented, followed by a target arrow. Finally, the conflict question was presented.

for reliable analysis (6.9% and 7.4%, respectively; see Fig. 2) and were omitted from further analysis. The remaining responses ("conflicting": 40.5%; "not conflicting": 45.2%) were used to compute d' (Green & Swets, 1966) as an index of conflict experience (henceforth called conflict-*d*). Trials with an incorrect response to the target were omitted. Incongruent trials were treated as signal, and congruent trials were treated as noise. The "conflicting" response was considered a hit on incongruent trials and a false alarm on congruent trials. Hit and false alarm proportions were computed by dividing the total number of hits and false alarms by the number of signals. Proportions of 0 and 1 were adjusted to .05 and .95, respectively (8 participants). Mean conflict-*d* was 0.98, which was significantly better than chance performance, $t(77) = 8.93$, $p < .001$. This result indicates that participants could reliably discriminate between congruent and incongruent trials. On average, 67% of the responses to the conflict question were in agreement with actual congruence.

The experience of conflict influences adaptation

The relation between conflict experience and the Gratton effect was examined by comparing trials that immediately followed a trial associated with correct conflict experience and trials that immediately followed a trial with incorrect conflict experience. Because some participants' data were unequally distributed over the different cells, only 52 participants had a sufficient number of trials per condition ($n = 10$)[2] to be retained in this analysis. Conflict-*d* for this group was 0.71 and differed significantly from chance, $t(51) = 8.23$, $p < .001$.

The first trial of each block (1.2%) and trials that followed an error (5.2%) were removed from further analysis. A 2 (congruence on the previous trial: congruent or incongruent) × 2 (congruence on the current trial: congruent or incongruent) × 2 (accuracy of conflict experience on the previous trial: correct or incorrect) repeated

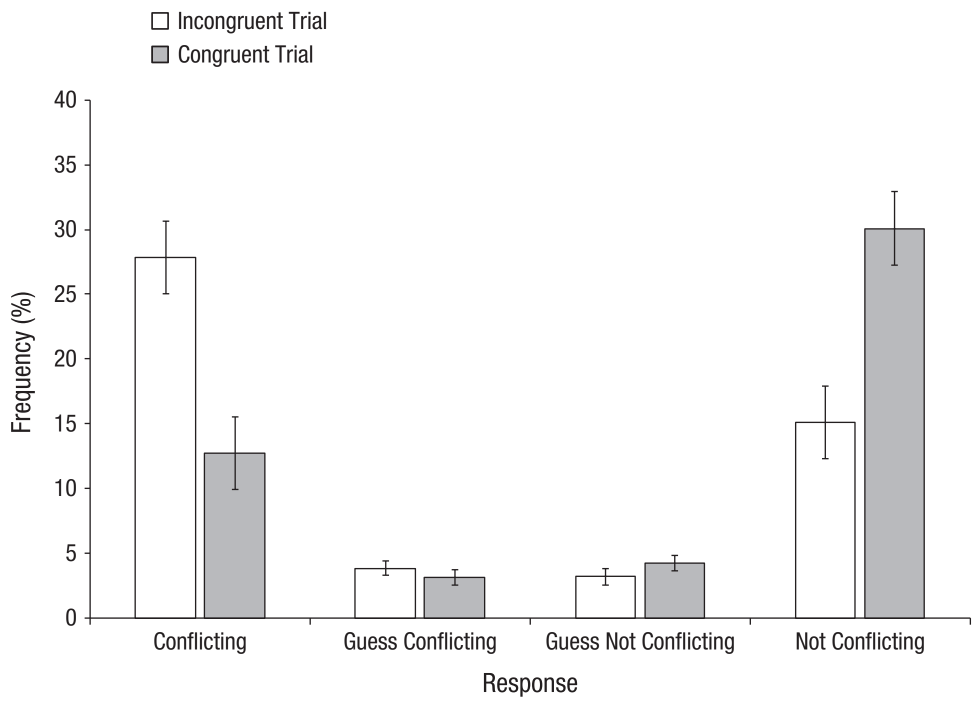

Fig. 2. Mean frequency of each of the four responses to the conflict question on congruent and incongruent trials. Error bars depict 95% within-subjects confidence intervals for the difference between congruent and incongruent trials per response option.

measures analysis of variance was performed on the median RTs of correct trials and on mean error rates.

RTs showed a main effect of congruence, $F(1, 51) = 180.74$, $p < .001$, $\eta_p^2 = .78$. Responses were faster on congruent trials (428 ms) than on incongruent trials (479 ms). There was also a main effect of congruence on the previous trial, $F(1, 51) = 4.22$, $p = .045$, $\eta_p^2 = .08$. Responses were slower when the previous trial was incongruent (455 ms) rather than congruent (452 ms). This main effect was modulated by accuracy of conflict experience on the previous trial, $F(1, 51) = 10.29$, $p = .002$, $\eta_p^2 = .17$; the difference in RTs between postcongruent and postincongruent trials (postincongruent – postcongruent) was positive after a correct conflict experience (14 ms) and negative after an incorrect conflict experience (–7 ms). There was also a significant interaction between congruence on the current trial and congruence on the previous trial, $F(1, 51) = 4.91$, $p = .031$, $\eta_p^2 = .09$, which reflects a Gratton effect.

Congruence effects were smaller after incongruent trials (47 ms) than after congruent trials (56 ms). Crucially, this adaptation effect was modulated by accuracy of conflict experience on the previous trial, $F(1, 51) = 4.69$, $p = .032$, $\eta_p^2 = .09$ (see Fig. 3a). After a correct conflict experience, congruence effects were reduced by 17 ms when the previous trial was incongruent (41 ms) rather than congruent (58 ms), $F(1, 51) = 10.52$, $p = .002$, $\eta_p^2 = .17$. After an incorrect conflict experience, there was no interaction between congruence on the current trial and congruence on the previous trial, $F(1, 51) = 0.001$, $p = .97$, $\eta_p^2 < .001$; congruence effects were virtually identical after congruent (53 ms) and incongruent trials (54 ms).

Error rates showed a main effect of congruence, $F(1, 51) = 51.39$, $p < .001$, $\eta_p^2 = .50$. On average, participants made fewer errors on congruent (1.7%) than on incongruent (9.1%) trials. There was also a significant interaction between congruence on the previous trial and accuracy of conflict experience on the previous trial, $F(1, 51) = 10.36$, $p = .002$, $\eta_p^2 = .17$. The difference in error rates between postcongruent and postincongruent trials was negative after a correct conflict experience (–2.3 percentage points) and positive after an incorrect conflict experience (1.22 percentage points). There was no interaction between congruence on the current trial and congruence on the previous trial, $F < 1$, which indicates the absence of a Gratton effect.

Crucially, there was a significant three-way interaction, $F(1, 51) = 11.31$, $p = .001$, $\eta_p^2 = .18$ (see Fig. 3b). After a correct conflict experience, congruence effects were 3.2 percentage points smaller when the previous trial was incongruent (6.2%) rather than congruent (9.4%), $F(1, 51) = 10.36$, $p = .002$, $\eta_p^2 = .17$. After an incorrect conflict experience, this interaction was also significant,

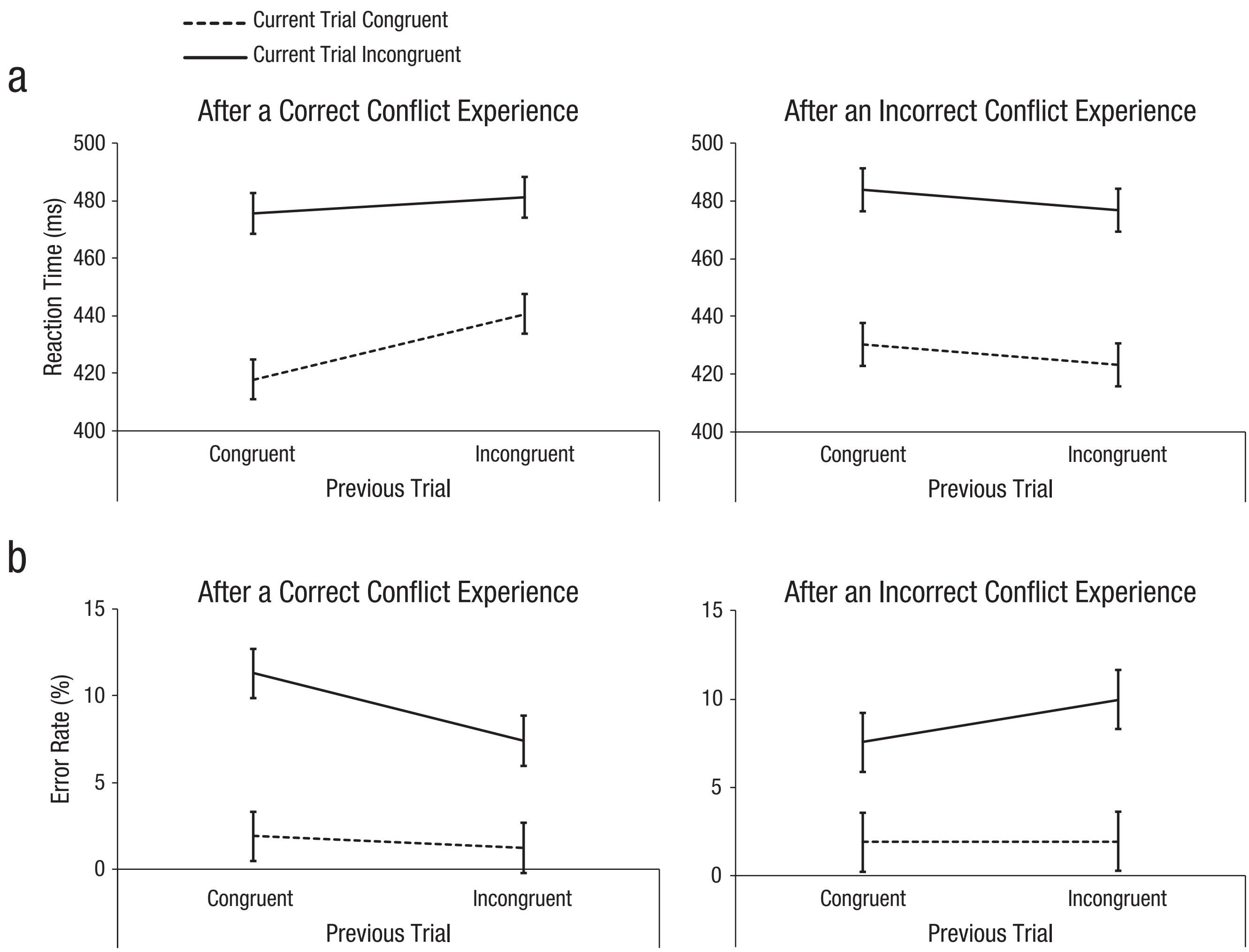

Fig. 3. Reaction time (a) and error rate (b) as a function of previous trial type and current trial type. Results are shown separately for trials that followed correct (left) and incorrect (right) conflict experiences. Error bars depict 95% within-subjects confidence intervals.

$F(1, 51) = 4.27$, $p = .044$, $\eta_p^2 = .08$, but this result actually reflected reversed adaptation. Congruence effects were on average 2.4 percentage points smaller after congruent trials (5.6%) than after incongruent trials (8.0%). Critically, this finding indicates a regular adaptation effect based on conflict experience. Congruence effects were smaller after the feeling that there was a conflict (although this was not the case) than after the feeling that there was no conflict (although there actually was one).

Prime visibility

To assess prime visibility, we computed d'. The computation of this measure is similar to that for conflict-*d* but in this case was based on the data of the detection task. Left-pointing primes were treated as signal. The response "left" was considered a hit when the prime pointed leftward and a false alarm when the prime pointed rightward. The group of 52 participants had a mean d' value of 0.55, which differed significantly from chance, $t(51) = 7.84$, $p < .001$. As one would expect, d' was positively related to conflict-*d,* $r = .66$, $t(51) = 6.91$, $p < .001$. Crucially, however, there also was a significant intercept, $b = 0.26$, $t(51) = 2.71$, $p = .009$, which indicates that even at zero prime visibility, accuracy in feeling that trials were conflicting or not conflicting was above the level of chance. Regression analysis showed that there was no relation between d' and the adaptation effect after a correct conflict experience, $r = .07$, $t < 1$. Moreover, a median-split analysis showed significant adaptation after a correct conflict experience for both the group with low prime visibility, $d' = 0.14$, $t(25) = 3.14$, $p = .004$, and the group with high prime visibility, $d' = 0.96$, $t(25) = 13.93$, $p < .001$. The reduction in the congruence effect for these two groups was, respectively, 17 ms, $t(25) = 2.01$, $p = .056$, $\eta_p^2 = .14$, and 17 ms, $t(25) = 2.68$, $p = .013$, $\eta_p^2 = .22$.

General Discussion

In the current study, we examined the role of conflict experience in the adaptation to conflict. Our results showed that the Gratton effect was highly dependent on conflict experience during the previous trial. RTs clearly showed an adaptation effect after a correct conflict experience, but not after an erroneous conflict experience. Furthermore, the error rates revealed a reversed adaptation effect after an erroneous conflict experience. In the latter situation, adaptation was driven by the mere feeling that there was a conflict, although in fact the prime and target triggered the same response.

The role of conflict experience in adaptation

The results of the current study indicate that the experience of conflict has an important role in the emergence of adaptation effects. Although the adaptation process itself presumably proceeds mainly outside of awareness (i.e., it seems to be impossible to consciously cause a reduction of the congruence effect; e.g., Wühr & Kunde, 2008), the trigger for this adaptive behavior depends heavily on the experience of conflict. Previous studies have shown that people can become aware of the consequences of completely unconscious stimuli (Rensink, 2004; Wenke, Fleming, & Haggard, 2010). However, no study has yet directly linked these experiences to adaptation effects. On the basis of the current results, we suggest that participants will adapt their behavior only if they have an experience of conflict.

It follows that mere response conflict might not be the underlying cause of adaptation. People's subjective experience that they are underperforming should trigger adaptation. For example, a previous study showed that rewarding participants after incongruent trials was sufficient to reduce adaptation effects (Van Steenbergen, Band, & Hommel, 2009). Presumably, the experience of conflict, which would normally trigger adaptation, was overruled by the reward. This could have given participants the impression that they had performed well on that trial, thereby decreasing the feeling of poor performance. This also implies that any experience of reduced performance should be sufficient to cause adaptation. In a study confirming this prediction, disfluency in processing of number words, induced by presenting them in a hard-to-read typeface, was sufficient to cause adaptation effects (Dreisbach & Fischer, 2011). The difference in performance dependent on the typefaces was sharply reduced when the previous typeface was hard to read. Thus, the experience of difficulty seems to be sufficient for participants to devote more resources to the task.

Although a vast amount of data shows the importance of response conflict as a cue for enhanced control (Botvinick et al., 2004), (response) fluency, rather than conflict, has also received a lot of attention (Alter & Oppenheimer, 2009; Winkielman, Schwarz, Fazendeiro, & Reber, 2003). According to Winkielman et al. (2003), processing fluency might act as a hedonic marker and hence generate positive affect. One possible reason for this is that fluency might act as a signal that provides feedback about ongoing cognitive processes. Fluent responses generate positive affect and thereby motivate participants to relax their control requirements.

In contrast, disfluency in processing generates effort expectancies and hence might have an alerting effect (Song & Schwarz, 2008). From the perspective of the implicit-fluency literature, the subjective ease that participants experience on fluent trials would be crucial for cognitive adaptation effects. Following a fluent experience, high control is deemed to be unnecessary, and as a result, there is much opportunity for irrelevant primes to influence behavior. The results in our RT data are mainly situated on current congruent trials (rather than current incongruent trials), and might therefore reflect response fluency. After responses that are correctly perceived to be fluent, attentional demands are lowered, which results in faster RTs on current congruent trials. In order to determine whether the current results are better explained by experiences of fluency or experiences of conflict, future studies will need to deploy a baseline to disentangle these two explanations. Note, however, that it is not unusual for adaptation effects to be evident on current congruent trials. For example, Ullsperger, Bylsma, and Botvinick (2005) explained this pattern by assuming that response conflict results in both increased attentional focusing and a heightened response threshold.

Subliminal adaptation effects

Although the role of experience in adaptation effects has been largely overlooked in prior research, several studies have already examined the role of awareness in conflict adaptation (for a review on this topic, see Kunde, Reuss, & Kiesel, 2012). Although initial experiments suggested that adaptation was selectively observed when primes were clearly visible (Kunde, 2003; Merikle & Joordens, 1997), several recent studies showed unconscious conflict adaptation (Bodner & Dypvik, 2005; Desender, Van Lierde, & Van den Bussche, 2013; Van Gaal, Lamme, & Ridderinkhof, 2010). These different patterns of results led some researchers to conclude that high-level forms of cognitive control depend crucially on stimulus awareness (Ansorge, Fuchs, Khalid, & Kunde, 2011; Kunde et al., 2012), whereas other researchers provided data in favor of the existence of unconscious control (Desender et al., 2013; see also Hommel, 2013; Van Gaal & Lamme, 2012).

Although at first these two classes of observations seem to be highly contradictory, a closer examination reveals a more conceptual problem. The unconscious adaptation *effect* does not necessarily reflect unconscious adaptation *processes* (e.g., Jáskowski, Skalska, & Verleger, 2003; Kinoshita, Forster, & Mozer, 2008). It is typically assumed that presenting heavily masked primes is sufficient to allow one to examine the role of awareness in conflict adaptation. However, when masking prevents conscious perception of primes, one actually examines whether awareness of the irrelevant information is a prerequisite for conflict adaptation, not whether the experience of conflict is required. Apart from perceptual differences between prime and target, other sources of information might generate experiences of conflict. Response conflict might give participants the general feeling that something is wrong, without their knowing why or what is wrong (Pacherie, 2008; see also Corallo, Sackur, Dehaene, & Sigman, 2008; Marti, Sackur, Sigman, & Dehaene, 2010).

On the basis of our results, we suggest that whether perception of primes is conscious or unconscious is not the critical variable for examining unconscious adaptation effects. More important is whether participants can experience the conflict. This is very easy when irrelevant information is highly salient, such as in the Stroop task, but even when primes are never consciously perceived, the experience of conflict is sufficient to cause a Gratton effect. This conclusion coincides with the observation that posterror slowing is observed only when there is awareness of the error (Nieuwenhuis, Ridderinkhof, Blom, Band, & Kok, 2001; Van Gaal, Ridderinkhof, van den Wildenberg, & Lamme, 2009). As in our study, the mere occurrence of an event (i.e., an error, a conflict) does not seem to be sufficient for the effect to occur (for an exception, see Cohen, van Gaal, Ridderinkhof, & Lamme, 2009). The difference between awareness of a prime and experience of a conflict is of crucial importance, because it seriously affects the conclusions that can be drawn from the data. For example, in a study that was methodologically similar to ours, participants were required to judge whether prime and target were semantically similar after responding to the target (Ansorge et al., 2011). Adaptation effects were observed only after the correct classification of clearly visible primes. Thus, the authors concluded that prime awareness is a critical factor in cognitive adaptation effects. However, because participants were explicitly instructed to access and compare prime and target semantics, this task required conscious perception of the primes. Had the authors questioned their subjects about their subjective feeling of conflict, rather than objective congruency, they might actually have observed that subjective experience, not prime awareness, is a critical factor.

The experience of conflict

In most cases, the experience of conflict seems to be the result of objective response incongruence. However, we observed reversed adaptation in the error rates after incorrect conflict experiences. In this case, experience was not driven by prime-target congruence but nevertheless triggered adaptation. One potential factor responsible for conflict experiences might be expectations. For example, after three "left" responses, a participant might expect that the next correct response would probably be "right." If this expectation does not match the actual required response, a conflict experience can arise independently of prime-target congruence. Thus, conflict experience can potentially be independent of trial type; even prime-absent trials should be able to induce conflict experiences. Note that the reversed adaptation observed in the error rates also excludes the possibility that our results were caused by residual prime visibility. Reversed adaptation after an incorrect conflict experience can be explained only by assuming that adaptation is driven by the experience of conflict.

One might wonder whether participants in typical masked-priming experiments use these conflict experiences when asked to report prime identity. Given that they typically perform at chance level in detection tasks, this does not seem to be the case. Participants usually do not link their vague conflict experiences with actual prime-target congruence. Presumably, participants always have these experiences during such experiments. However, given that they are usually not alerted that primes are presented, they might not form these context-specific interpretations (Schwarz, 2004).

General Conclusion

In the current study, we showed that the subjective experience of conflict is sufficient to trigger adaptation processes. This was the case even when conflict experiences did not coincide with actual incongruence. Overall, our results suggest that subjective experience plays a crucial role in the exertion of top-down control.

Author Contributions

All authors contributed to the study design. K. Desender performed testing and data collection. K. Desender analyzed and interpreted the data under the supervision of E. Van den Bussche and F. Van Opstal. K. Desender drafted the manuscript, and E. Van den Bussche and F. Van Opstal provided critical revisions. All authors approved the final version of the manuscript for submission

Acknowledgments

We thank Luis Carlo Bulnes for inspiring discussions and Tom Verguts, Bart Aben, Gethin Hughes, Glen Bodner, and two anonymous reviewers for useful comments on an earlier draft of the manuscript.

Declaration of Conflicting Interests

The authors declared that they had no conflicts of interest with respect to their authorship or the publication of this article.

Funding

K. Desender was supported by a Ph.D. grant from the Research Foundation Flanders, Belgium (FWO-Vlaanderen Grant number FWOTM635). F. Van Opstal is a postdoctoral fellow of the Research Foundation–Flanders.

Notes

1. Including those participants in this group who had a sufficient number of trials in each condition (n = 4) did not change the crucial three-way interactions reported in the Results section—RTs: $F(1, 55) = 7.747$, $p = .007$, $\eta_p^2 = .12$; error rates: $F(1, 55) = 9.32$, $p = .003$, $\eta_p^2 = .15$.

2. The results described in this section did not change when other cutoff values were used. The crucial three-way interactions remained significant when we used more strict cutoff values of 15 trials—RTs: $F(1, 38) = 7.21$, $p = .011$, $\eta_p^2 = .16$; error rates: $F(1, 38) = 5.49$, $p = .025$, $\eta_p^2 = .13$—and 20 trials—RTs: $F(1, 34) = 7.08$, $p = .012$, $\eta_p^2 = .17$; error rates: $F(1, 34) = 4.49$, $p = .041$, $\eta_p^2 = .12$. Note that most of the excluded subjects had very high values of conflict-d ($M = 1.69$, $SD = 1.23$) and were thus excluded because of a lack of incorrect conflict responses (i.e., false alarms) rather than because of insensitivity to conflict experience. It is therefore impossible to compute the full three-way interaction for these subjects, but we were able to compute adaptation after a correct conflict experience for all those subjects from the initial sample for which there were a sufficient number of trials in 2 × 2 analyses of variance (n = 67). Confirming our main findings, these analyses revealed interactions between congruence on the current trial and congruence on the previous trial—RTs: $F(1, 65) = 6.77$, $p = .011$, $\eta_p^2 = .09$; error rate: $F(1, 65) = 22.18$, $p < .001$, $\eta_p^2 = .25$. These interactions were not modulated by whether participants were included in the main analysis (both ps > .22).

References

Alter, A. L., & Oppenheimer, D. M. (2009). Uniting the tribes of fluency to form a metacognitive nation. *Personality and Social Psychology Review*, *13*, 219–235. doi:10.1177/1088868309341564

Ansorge, U., Fuchs, I., Khalid, S., & Kunde, W. (2011). No conflict control in the absence of awareness. *Psychological Research*, *75*, 351–365.

Bodner, G. E., & Dypvik, A. T. (2005). Masked priming of number judgments depends on prime validity and task. *Memory & Cognition*, *33*, 29–47.

Botvinick, M. M., Braver, T. S., Barch, D. M., Carter, C. S., & Cohen, J. D. (2001). Conflict monitoring and cognitive control. *Psychological Review*, *108*, 624–652.

Botvinick, M. M., Cohen, J. D., & Carter, C. S. (2004). Conflict monitoring and anterior cingulate cortex: An update. *Trends in Cognitive Sciences*, *8*, 539–546. doi:10.1016/j.tics.2004.10.003

Cohen, M. X., van Gaal, S., Ridderinkhof, K. R., & Lamme, V. A. F. (2009). Unconscious errors enhance prefrontal-occipital oscillatory synchrony. *Frontiers in Human Neuroscience*, *3*, Article 54. Retrieved from http://www.frontiersin.org/human_neuroscience/10.3389/neuro.09.054.2009/full

Corallo, G., Sackur, J., Dehaene, S., & Sigman, M. (2008). Limits on introspection: distorted subjective time during the dual-task bottleneck. *Psychological Science*, *19*, 1110–1117.

Desender, K., Van Lierde, E., & Van den Bussche, E. (2013). Comparing conscious and unconscious conflict adaptation. *PLoS ONE*, *8*(2), Article e55976. Retrieved from http://www.plosone.org/article/info:doi/10.1371/journal.pone.0055976

Dreisbach, G., & Fischer, R. (2011). If it's hard to read . . . try harder! Processing fluency as signal for effort adjustments. *Psychological Research*, *75*, 376–383. doi:10.1007/s00426-010-0319-y

Egner, T. (2007). Congruency sequence effects. *Cognitive, Affective, & Behavioral Neuroscience*, *7*, 380–390.

Gratton, G., Coles, M. G, & Donchin, E. (1992). Optimizing the use of information: strategic control of activation of responses. *Journal of Experimental Psychology: General*, *121*, 480–506.

Green, D. M., & Swets, J. A. (1966). *Signal detection theory and psychophysics*. New York, NY: Wiley.

Hommel, B. (2013). Dancing in the dark: No role for consciousness in action control. *Frontiers in Psychology*, *4*, Article 380. Retrieved from http://www.frontiersin.org/Cognition/10.3389/fpsyg.2013.00380/full

Jáskowski, P., Skalska, B., & Verleger, R. (2003). How the self controls its "automatic pilot" when processing subliminal information. *Journal of Cognitive Neuroscience*, *15*, 911–920.

Kinoshita, S., Forster, K. I., & Mozer, M. C. (2008). Unconscious cognition isn't that smart: Modulation of masked repetition effect in the naming task. *Cognition*, *107*, 623–649.

Kunde, W. (2003). Sequential modulations of stimulus-response correspondence effects depend on awareness of response conflict. *Psychonomic Bulletin & Review*, *10*, 198–205.

Kunde, W., Reuss, H., & Kiesel, A. (2012). Consciousness and cognitive control. *Advances in Cognitive Psychology*, *8*, 9–18. doi:10.2478/v10053-008-0097-x

Marti, S., Sackur, J., Sigman, M., & Dehaene, S. (2010). Mapping introspection's blind spot: Reconstruction of dual-task phenomenology using quantified introspection. *Cognition*, *115*, 303–313.

Merikle, P. M., & Joordens, S. (1997). Parallels between perception without attention and perception without awareness. *Consciousness and Cognition*, *6*, 219–236. doi:10.1006/ccog.1997.0310

Nieuwenhuis, S., Ridderinkhof, K. R., Blom, J., Band, G. P., & Kok, A. (2001). Error-related brain potentials are differentially related to awareness of response errors: Evidence from an antisaccade task. *Psychophysiology*, *38*, 752–760.

Pacherie, E. (2008). The phenomenology of action: A conceptual framework. *Cognition*, *107*, 179–217. doi:10.1016/j.cognition.2007.09.003

Rensink, R. A. (2004). Visual sensing without seeing. *Psychological Science*, *15*, 27–32.

Schooler, J. W. (2002). Re-representing consciousness: Dissociations between experience and meta-consciousness. *Trends in Cognitive Sciences*, *6*, 339–344.

Schwarz, N. (2004). Metacognitive experiences in consumer judgment and decision making. *Journal of Consumer Psychology*, *14*, 332–348. doi:10.1207/s15327663jcp1404_2

Song, H., & Schwarz, N. (2008). If it's hard to read, it's hard to do: Processing fluency affects effort prediction and motivation. *Psychological Science*, *19*, 986–988. doi:10.1111/j.1467-9280.2008.02189.x

Ullsperger, M., Bylsma, L. M., & Botvinick, M. M. (2005). The conflict adaptation effect: It's not just priming. *Cognitive, Affective, & Behavioral Neuroscience*, *5*, 467–472.

Van Gaal, S., & Lamme, V. A. F. (2012). Unconscious high-level information processing: Implication for neurobiological theories of consciousness. *Neuroscientist*, *18*, 287–301. doi:10.1177/1073858411404079

Van Gaal, S., Lamme, V. A. F., & Ridderinkhof, K. R. (2010). Unconsciously triggered conflict adaptation. *PLoS ONE*, *5*(7), Article e11508. Retrieved from http://www.plosone.org/article/info:doi/10.1371/journal.pone.0011508

Van Gaal, S., Ridderinkhof, K. R., van den Wildenberg, W. P. M., & Lamme, V. A. F. (2009). Dissociating consciousness from inhibitory control: Evidence for unconsciously triggered response inhibition in the stop-signal task. *Journal of Experimental Psychology: Human Perception and Performance*, *35*, 1129–1139. doi:10.1037/a0013551

Van Steenbergen, H., Band, G. P. H., & Hommel, B. (2009). Reward counteracts conflict adaptation. Evidence for a role of affect in executive control. *Psychological Science*, *20*, 1473–1477. doi:10.1111/j.1467-9280.2009.02470.x

Wenke, D., Fleming, S. M., & Haggard, P. (2010). Subliminal priming of actions influences sense of control over effects of action. *Cognition*, *115*, 26–38. doi:10.1016/j.cognition.2009.10.016

Winkielman, P., Schwarz, N., Fazendeiro, T. A., & Reber, R. (2003). The hedonic marking of processing fluency: Implications for evaluative judgment. In J. Musch & K. C. Klauer (Eds.), *The psychology of evaluation: Affective processes in cognition and emotion* (pp. 189–217). Mahwah, NJ: Erlbaum.

Wühr, P., & Kunde, W. (2008). Precueing spatial S-R correspondence: Is there regulation of expected response conflict? *Journal of Experimental Psychology: Human Perception and Performance*, *34*, 872–883. doi:10.1037/0096-1523.34.4.872