Cognition 129 (2013) 637–651

Contents lists available at ScienceDirect

Cognition

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

To adapt or not to adapt: The question of domain-general cognitive control

Irene P. Kan [a,*], Susan Teubner-Rhodes [b], Anna B. Drummey [a], Lauren Nutile [a], Lauren Krupa [a], Jared M. Novick [b]

[a] Department of Psychology, Villanova University, United States
[b] Center for Advanced Study of Language, Program in Neuroscience and Cognitive Science, University of Maryland, United States

ARTICLE INFO

Article history:
Received 27 December 2012
Revised 25 August 2013
Accepted 10 September 2013
Available online 5 October 2013

Keywords:
Cognitive control
Conflict adaptation
Conflict monitoring

ABSTRACT

What do perceptually bistable figures, sentences vulnerable to misinterpretation and the Stroop task have in common? Although seemingly disparate, they all contain elements of conflict or ambiguity. Consequently, in order to monitor a fluctuating percept, reinterpret sentence meaning, or say "blue" when the word RED is printed in blue ink, individuals must regulate attention and engage cognitive control. According to the Conflict Monitoring Theory (Botvinick, Braver, Barch, Carter, & Cohen, 2001), the detection of conflict automatically triggers cognitive control mechanisms, which can enhance resolution of *subsequent* conflict, namely, "conflict adaptation." If adaptation reflects the recruitment of *domain-general* processes, then conflict detection in one domain should facilitate conflict resolution in an entirely different domain. We report two novel findings: (i) significant conflict adaptation from a syntactic to a non-syntactic domain and (ii) from a perceptual to a verbal domain, providing strong evidence that adaptation is mediated by domain-general cognitive control.

1. Introduction

Consider these scenarios: (1) a British tourist crossing Manhattan's Fifth Avenue; and (2) a reader encountering the following sentence in a novel, "*At the bank, John got out his fishing pole and cast his line*." Ostensibly, these circumstances are drastically different. One entails a physical act; the other involves word and sentence comprehension. Despite obvious dissimilarities, however, both scenarios share the need for the individuals to overcome routinized responses and adjust their thoughts and actions accordingly. In the first case, the tourist must suppress her well-learned habit of looking rightward before crossing the street, in favor of looking first to the left. In the second case, the reader must abandon the initial, more frequent interpretation of "bank" (financial institution) and recover the less common but context-appropriate meaning (river's edge) instead. In both situations, individuals must dynamically adapt their information-processing strategies to countermand the "knee-jerk" response and select a competing alternative. This ability is known as "cognitive control," a term that describes a constellation of mental functions that guide goal-directed behavior consistent with situation-specific requirements; as such, it is particularly important for performing non-routine tasks. Although researchers generally agree that cognitive control is fundamental to complex cognition, its underlying mechanisms remain controversial. In the present research, we test whether cognitive control mechanisms are domain-general in the context of a behavioral phenomenon known as "conflict adaptation."

According to one prominent theory of cognitive control (the Conflict Monitoring Theory, Botvinick et al., 2001),

* Corresponding author. Address: Department of Psychology, Villanova University, 800 Lancaster Avenue, Villanova, PA 19085, United States. Tel.: +1 610 519 4720.

E-mail address: irene.kan@villanova.edu (I.P. Kan).

0010-0277/$ - see front matter © 2013 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.cognition.2013.09.001

the detection of conflict—regardless of its source—automatically initiates cognitive control mechanisms (see also Desimone & Duncan, 1995; Miller & Cohen, 2001; Norman & Shallice, 1986; but see Schlaghecken & Martini, 2011). Conflict arises when an individual receives mismatched or ambiguous information about how best to characterize some input (i.e., representational conflict) or how best to respond to that input (i.e., response conflict). Consider the classic Stroop task (Stroop, 1935), where subjects must name the ink color in which color words are printed. Conflict occurs when the ink color and color name are incongruent (e.g., the word RED printed in blue ink). The conflict generated by the stimulus automatically triggers cognitive control, which mediates conflict resolution by overriding dominant but goal-irrelevant information (word meaning) and/or promoting goal-relevant processing (color naming, Botvinick, Cohen, & Carter, 2004; Egner & Hirsch, 2005; van Veen & Carter, 2006). Furthermore, sustained cognitive control engagement can yield enhanced resolution of *subsequent* conflict, reflected by better performance on an incongruent trial when preceded by another incongruent trial, versus when it is preceded by a congruent trial. This behavioral savings, called "conflict adaptation" or the "Gratton effect" (Gratton, Coles, & Donchin, 1992; Mayr, Awh, & Laurey, 2003; Ullsperger, Bylsma, & Botvinick, 2005), has been observed within various tasks that elicit representational and/or response conflict (e.g., within Stroop, Flanker, Simon tasks; Botvinick, Nystrom, Fissell, Carter, & Cohen, 1999; Hommel, Proctor, & Vu, 2004; Kerns et al., 2005; Runger, Schwager, & Frensch, 2010).

Although data from within-task conflict adaptation has been instrumental to our understanding of cognitive control, the extent of the behavioral effects of sustained cognitive control—via generalized performance to another task—remains unclear. In other words, is cognitive control "one size fits all," operating across seemingly disparate situations, or is it idiosyncratic to tasks or domains? Some researchers (Miller & Cohen, 2001; Rajah, Ames, & D'Esposito, 2008) argue that cognitive control mechanisms mediating conflict detection and its resolution are domain-general, meaning they operate systematically (and similarly) across conflict types that arise in different domains (e.g., verbal, non-verbal, syntactic, semantic). Others argue for domain-specificity, wherein multiple independent conflict-control systems support conflict processing only within a particular domain (Akcay & Hazeltine, 2011; Egner, Delano, & Hirsch, 2007).[1] Since evidence from within-task adaptation does not address the issue of domain-generality, some researchers have adopted *cross-task* adaptation designs to test how broadly cognitive control operates on a trial-by-trial basis (e.g., across Stroop and Flanker tasks).[2] If conflict adaptation reflects sustained engagement of a domain-general system, then conflict adaptation should be observable across tasks and domains, provided that conflict arising in one domain sufficiently activates cognitive control. Conversely, if adaptation is mediated by domain-specific cognitive control, then cross-task (or cross-domain) behavioral adjustments should not occur.

Evidence for cross-task adaptation has been mixed, however: whereas some studies demonstrate adaptation from one task to another (Freitas, Bahar, Yang, & Banai, 2007; Notebaert & Verguts, 2008), others do not (Akcay & Hazeltine, 2011; Funes, Lupianez, & Humphrey, 2010). These mixed results question the notion that conflict adaptation reflects sustained engagement of domain-general cognitive control. However, such lack of adaptation may be explained by an experimental-design artifact rather than domain-specificity. Most studies failing to find cross-task adaptation have used a paradigm in which subjects encounter a single stimulus that merges two different conflict sources (Akcay & Hazeltine, 2011; Egner et al., 2007; Funes et al., 2010). One example is the lateralized presentation of a Stroop stimulus: whereas stimulus *features* might induce conflict between color and word representations, stimulus *location* might simultaneously elicit Simon-like conflict (stimulus location conflicts with response-button location). Because conflict could occur in either task alone or in both tasks concurrently, some incongruent trials may produce less conflict than others. Consider a case where stimulus location conflicts with response-button location (incongruent Simon) but stimulus color and word meaning converge (congruent Stroop). It is possible that the Simon-conflict is opposed by the Stroop-congruency, thus eliciting a relatively weaker conflict signal that may be insufficient to engage sustained cognitive control across trials (Stroop-conflict may also be opposed by Simon-congruency in a similar manner). In other words, some conflict trials in this design may generate weaker conflict signals than those in within-task designs, thereby masking cross-task adaptation effects.

Consequently, we revisit the question of domain-general cognitive control using a cross-task adaptation design that circumvents the aforementioned methodological issue (but see Egner, 2008). Moreover, our study addresses limitations in prior studies that *have* observed cross-task adaptation. For instance, most studies have tested adaptation effects across Stroop, Flanker, and Simon tasks, which share the need to overcome stimulus–response conflict. Given this similarity, it remains unclear how far conflict adaptation extends. Here we ask, can behavioral adjustments be observed across syntactic and lexical domains and across perceptual and verbal domains, where task demands and stimulus characteristics are wildly different?

We hypothesize that two tasks sharing conflict-control demands, regardless of apparent dissimilarities, should yield conflict adaptation—the engagement of online adjustments that generalize from one task to another. Demonstrating that conflict detection in one task facilitates conflict resolution in a different task would provide strong evidence for domain-general cognitive control, since cross-task adaptation should occur only as a result of the activation of cognitive control resources that operate across both task-domains. We selected well-established tasks known to elicit conflict: in Experiment 1, reading syntactically ambiguous sentences that generate temporary misinter-

[1] Some define "domain" differently. For example, Egner (2008) argued that in conflict adaptation contexts, one might classify domains by response versus representational conflict. We return to this issue in Section 6.

[2] Cross-task designs also have the advantage of eliminating stimulus- and response-repetitions, a concern raised by some regarding the locus of within-task adaptation (e.g., Mayr et al., 2003).