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On the automaticity of response inhibition in individuals with alcoholism



Xavier Noël^{a,*}, Damien Brevers^{a,b}, Catherine Hanak^a, Charles Kornreich^a, Paul Verbanck^a, Frederick Verbruggen^c

^a Psychological Medicine Laboratory, Université Libre de Bruxelles, Belgium

^b Brain and Creativity Institute, Department of Psychology, University of Southern California, Los Angeles, CA, USA

^c Psychology, University of Exeter, United Kingdom

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ABSTRACT

Background and objectives: Response inhibition is usually considered a hallmark of executive control. However, recent work indicates that stop performance can become associatively mediated ('automatic') over practice. This study investigated automatic response inhibition in sober and recently detoxified individuals with alcoholism..

Methods: We administered to forty recently detoxified alcoholics and forty healthy participants a modified stop-signal task that consisted of a training phase in which a subset of the stimuli was consistently associated with stopping or going, and a test phase in which this mapping was reversed.

Results: In the training phase, stop performance improved for the consistent stop stimuli, compared with control stimuli that were not associated with going or stopping. In the test phase, go performance tended to be impaired for old stop stimuli. Combined, these findings support the automatic inhibition hypothesis. Importantly, performance was similar in both groups, which indicates that automatic inhibitory control develops normally in individuals with alcoholism..

Limitations: This finding is specific to individuals with alcoholism without other psychiatric disorders, which is rather atypical and prevents generalization. Personalized stimuli with a stronger affective content should be used in future studies.

Conclusions: These results advance our understanding of behavioral inhibition in individuals with alcoholism. Furthermore, intact automatic inhibitory control may be an important element of successful cognitive remediation of addictive behaviors..

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1. Introduction

Response inhibition is a key component of executive control (Aron, Robbins, & Poldrack, 2004; Logan, Cowan, & Davis, 1984; Miyake et al., 2000; Nigg, 2000; Verbruggen & Logan, 2008a,b). It supports flexible and goal-directed behavior by allowing people to withhold inappropriate, no-longer relevant, or risky actions. Work in psychiatry and clinical psychology suggests that deficits in 'executive' response inhibition are associated with various clinical disorders, including alcoholism and other substance use disorders

(Dalley, Everitt, & Robbins, 2011; de Wit, 2009; Smith, Mattick, Jamadar, & Iredale, 2014). However, recent work suggests that response inhibition can become 'automatic', triggered by the retrieval of previously acquired associations between stimuli and stopping (Spierer, Chavan, & Manuel, 2013; Verbruggen, Best, Bowditch, Stevens, & McLaren, 2014; Verbruggen & Logan, 2008a). In the present study, we examined whether automatic response inhibition is also impaired in individuals with alcoholism.

Loss of control of no-longer relevant or harmful behavior is central to alcoholism, and is partly due to subjects' inability to deliberately inhibit prepotent responses (Goudriaan, Oosterlaan, de Beurs, & van den Brink, 2005; Lawrence, Luty, Bogdan, Sahakian, & Clark, 2009; Nigg et al., 2006; Noël et al., 2001; Rubio et al., 2008; Smith & Mattick, 2013; Smith et al., 2014; van der Plas, Crone, van den Wildenberg, Tranel, & Bechara, 2009). This 'disinhibition' hypothesis is supported by studies that found impaired performance

* Corresponding author. Psychological Medicine Laboratory, Université Libre de Bruxelles, CHU-Brugmann, CP403/21, place Van Gehuchten, 4, 1020, Brussels, Belgium.

E-mail address: xnoel@ulb.ac.be (X. Noël).

(Noël et al., 2001), abnormal brain electrophysiology (Kamarajan et al., 2006) and abnormal brain metabolism (Li, Luo, Yan, Bergquist, & Sinha, 2009; Schweinsburg et al., 2004) while alcohol-dependent individuals performed various response inhibition tasks. So far, most studies have focused on deliberate and executive acts of inhibitory control in patients with alcoholism. However, response inhibition depends on an interplay between 'bottom-up' and 'top-down' processes (Verbruggen & Logan, 2008a). Several studies suggest that a stimulus can become associated with stopping; when such stimulus-stop associations are retrieved from memory, the stop response or stopping network can be activated via associative retrieval, suppressing ongoing go processes (Spieler et al., 2013; Verbruggen et al., 2014). This may support the development of 'automatic' response inhibition.¹ A series of studies examined the idea that inhibitory control in go/no-go and stop-signal tasks can be triggered automatically via the retrieval of stimulus-stop associations from memory. For example, the experiments of Verbruggen and Logan (2008a) consisted of a training phase, in which a subset of the stimuli was consistently associated with stopping or going, and a test phase in which the stimulus-stop/go mapping was reversed. In this test phase, participants responded slower to stimuli previously associated with stopping compared with stimuli that they had not seen before or stimuli that were inconsistently associated with going and stopping. Furthermore, response inhibition on no-go or stop-signal trials benefited from consistent stimulus-stop associations (Lenartowicz, Verbruggen, Logan, & Poldrack, 2011; Verbruggen et al., 2014). Based on these findings, Verbruggen and Logan (2008a) proposed the 'automatic inhibition hypothesis': inhibitory control in go/no-go and stop-signal tasks can be triggered automatically via the retrieval of stimulus-stop associations from memory.

Preserved automatic (associatively mediated) response inhibition may be crucial in the context of cognitive training of inhibition (for meta-analyses, see Allom, Mullan, & Hagger, 2015; Jones et al., 2016), which has the potential to help reduce excessive or impulsive eating (e.g. Houben & Jansen, 2011; Lawrence, O'Sullivan et al., 2015; Veling, Aarts, & Papies, 2011), hazardous drinking behavior (Bowley et al., 2013; Houben, Havermans, Nederkoorn, & Jansen, 2012; Houben, Nederkoorn, Wiers, & Jansen, 2011; Andrew Jones et al., 2011; Andrew Jones, Christiansen, Nederkoorn, Houben, & Field, 2013), and ultimately, encourage more healthy behaviors. However, some studies have shown associative learning impairments in patients with alcoholism in a variety of learning paradigms (e.g. Pitel et al., 2007). Therefore, the present study investigated whether recently detoxified patients with alcoholism also show impairments in learning stimulus-stop associations, which would prevent the development of automatic response inhibition and reduce the effectiveness of cognitive training consisting of associating response inhibition with alcohol-related stimuli. A recent study provides indirect support for the idea that subjects with alcoholism have spared 'automatic inhibition' (Noël et al., 2013): We found that alcohol-dependent subjects performed worse than healthy participants on three cognitive tasks

assessing the inhibition of irrelevant prepotent responses, whereas group performance was similar in the tasks assessing control of proactive interference in memory (i.e. overcoming interference caused by irrelevant long-term memory representations). Some researchers have proposed that control of proactive interference in memory is more automatic and less intentional than deliberate response inhibition (e.g., Nigg, 2000). However, preserved proactive interference control could also be due to non-inhibitory factors. Therefore, more direct evidence of possible preserved automatic response inhibition is necessary, which is the purpose of the present study.

We used a modified version of a stop-signal paradigm to study automatic inhibition (see Fig. 1, Verbruggen et al., 2014). Recently detoxified individuals with alcoholism and healthy controls made speeded semantic categorizations (alcohol-related or neutral words) on a series of words. We used alcohol-related stimuli because response inhibition deficits in individuals with alcoholism are typically enhanced when alcohol-related words are used in the task (e.g. Noël et al., 2007). Furthermore, applied studies are likely to use alcohol-related stimuli as well. On some trials (stop trials), a visual signal was presented beneath the words, instructing participants to withhold their planned go response. Each word was presented five times within the block; the first four presentations were 'training' trials, the fifth and final presentation was the 'test' trial. There were three stimulus types within each block. 'Stop-then-go' stimuli (25% of all stimuli) always occurred on stop trials during training, but occurred on a go trial in the test phase (stop-stop-stop-go). The 'go-then-stop' (go-go-go-go-stop) stimuli (25% of all stimuli) always occurred on go trials during training, but occurred on a stop trial in the test phase. Finally, control stimuli (50% of all stimuli) occurred with equal probability on stop and go trials during training but the order was otherwise random; half of them occurred on a go trial in the test phase (e.g. go-stop-go-stop-go), whereas the others occurred on a stop trial (e.g. stop-stop-go-go-stop). The overall probability of a stop trial was 0.5. Participants were not informed about the stimulus types or the training/test structure of the blocks. New words were used in each block to prevent re-learning. Automatic inhibition in both groups was assessed by comparing stop performance in the training phase and go performance in the test phase for stop-then-go and control stimuli (Verbruggen et al., 2014). In the control group (i.e. the healthy adults), stop performance should be better in the training phase but go performance should be worse in the test phase for 'stop-then-go' stimuli than for control stimuli due to the retrieval of stimulus-stop associations from memory (Verbruggen & Logan, 2008a; Verbruggen et al. 2014). If automatic inhibition is preserved in the recently detoxified individuals with alcoholism (see above), a similar pattern should be observed in the recently detoxified individuals with alcoholism. By contrast, if associative learning is impaired in the recently detoxified individuals (as suggested by some studies), a reliable interaction between Group and Stimulus Type should be observed.

2. Material and methods

2.1. Participants

Forty recently detoxified individuals with alcoholism and 40 healthy controls participated in the study. All participants were adults (>18 years old) and provided informed consent that was approved by the Ethics Committee of the Brugmann University Hospital.

Alcohol-dependent participants were recruited from the Alcohol Detoxification Program of the Psychiatric Institute, Brugmann Hospital, Université Libre de Bruxelles (ULB), Belgium.

¹ Instance Theory (Logan, 1988) construes automaticity as a memory phenomenon: 'Automaticity is memory retrieval: Performance is automatic when it is based on single-step direct-access retrieval of past solutions from memory. The [Instance Theory] assumes that novices begin with a general algorithm that is sufficient to perform the task. As they gain experience, they learn specific solutions to specific problems, which they retrieve when they encounter the same problems again. Then, they can respond with the solution retrieved from memory or the one computed by the algorithm. At some point, they may gain enough experience to respond with a solution from memory on every trial and abandon the algorithm entirely. At that point, their performance is [completely] automatic.' (Logan, 1988, p.493).

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