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Mindfulness reduces habitual responding based on implicit knowledge: Evidence from artificial grammar learning

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ABSTRACT

Participants were unknowingly exposed to complex regularities in a working memory task. The existence of implicit knowledge was subsequently inferred from a preference for stimuli with similar grammatical regularities. Several affective traits have been shown to influence AGL performance positively, many of which are related to a tendency for automatic responding. We therefore tested whether the mindfulness trait predicted a reduction of grammatically congruent preferences, and used emotional primes to explore the influence of affect. Mindfulness was shown to correlate negatively with grammatically congruent responses. Negative primes were shown to result in faster and more negative evaluations. We conclude that grammatically congruent preference ratings rely on habitual responses, and that our findings provide empirical evidence for the non-reactive disposition of the mindfulness trait.

1. Introduction

1.1. Implicit learning

Implicit learning is the ability to acquire knowledge of complex regularities without conscious intent or awareness (Seger, 1994). Skill learning, habit learning and procedural learning are related forms of implicit learning. Implicitly acquired knowledge is typically not accessible or represented explicitly (e.g., in a language-based manner) in the form of facts (knowing *that*). Nevertheless, implicit knowledge (knowing *how*), underlies much of our behavioral repertoire – from riding a bike to blind typing – and is important in understanding the world and people around us, from musical appreciation to navigating the complexities of language (Stadler & Frensch, 1998). In the lab, implicit knowledge is often inferred from faster processing of structured stimuli, that are comparable (on some stimulus dimension) to those individuals previously have been exposed to (in e.g. real life or in the lab). In addition, evidence for implicitly acquired knowledge is commonly observed through the development of a preference or 'gut-feeling' for similarly structured stimuli, typically in the absence of verbal access to what is known.

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1.2. Artificial grammar learning

Artificial grammar learning (AGL) is probably the most studied paradigm for investigating implicit learning. The paradigm distinguishes an *acquisition phase* and *test phase* (Cleeremans, Destrebecqz, & Boyer, 1998; Forkstam & Petersson, 2005b). In the acquisition phase, participants are exposed to a set of symbol sequences generated from a formal grammar (i.e., a complex rule system), often in the form of a short term memory task. In the subsequent test phase subjects are often first debriefed about the existence of an underlying complex set of rules and instructed to classify a novel set of sequences according to grammaticality, based on guessing or 'gut feeling'. It is a robust and well-replicated finding that subjects perform significantly above chance on this type of task with little, if any, explicit knowledge about their classification capacity (Cleeremans et al., 1998; Forkstam, Elwér, Ingvar, & Petersson, 2008; Forkstam & Petersson, 2005b). In fact, when subjects are not informed about the existence of a grammar, similar classification performance can be observed using forced-choice preference ratings (like/dislike) (Folia et al., 2008; Forkstam et al., 2008). There is good evidence that the frontal cortex and the basal ganglia (fronto-striatal circuits) are involved in implicit learning in humans. This has been characterized in patient (lesion) studies (Forkstam & Petersson, 2005b; Seger, 1994), functional neuroimaging studies (Forkstam, Hagoort, Fernandez, Ingvar, & Petersson, 2006; Lieberman, Chang, Chiao, Bookheimer, & Knowlton, 2004; Rose, Haider, Weiller, & Buchel, 2002) and brain stimulation studies (de Vries et al., 2010). Furthermore, in healthy volunteers transcranial magnetic stimulation of Broca's area has causal effects on classification after implicit learning of an artificial grammar (Udden et al., 2008). Imaging studies of AGL repeatedly find activations in the basal ganglia, in particular the striatum (Forkstam et al., 2006; Petersson, Folia, & Hagoort, 2010). Taken together these findings suggest a common neural substrate of different forms of implicit learning (for a review see (Forkstam & Petersson, 2005a; Yin & Knowlton, 2006)).

1.3. The role and mechanisms of affect on preference for grammaticality

While implicit knowledge acquisition is a robust and well established phenomenon, a conclusive account of how such knowledge is expressed in implicit preference or explicit endorsement rates does not yet exist. Gordon and Holyoak (1983) proposed a role for the mere-exposure effect (Zajonc, 1968). In the mere-exposure effect, repeated (unreinforced) exposure results in positive affect towards those stimuli (for an overview see Bornstein (1989)). In the *structural* mere-exposure effect grammatical sequences are processed more easily during classification due to the previous grammatical stimuli. Similarly to the traditional mere-exposure effect, this increased fluency is then interpreted as a preference. Interestingly, both Newell and Bright (2001) and Zizak and Reber (2004) showed that when classification sequences are presented with different or degraded surface features, performance based on preference is abolished while explicit ratings of grammaticality remain unimpaired. This suggests that familiarity with lower level features is required before *structural* mere-exposure effects can occur on more complex (grammatical) levels of stimulus processing. Scott and Dienes (2010) showed that while perceptual fluency influences preference judgments, under controlled conditions this provides participants only with a 'dumb' heuristic. In fact, preference judgments were shown to be based on perceptual fluency when participants had only very limited time to process the sequences and more accurate evaluations (based on familiarity) could not be made. Although these studies show that fluency can influence preference ratings, they do not explain in what way preference ratings are related to the implicitly acquired grammar. The question remains whether preference for grammatical sequences is the result of a positive (affective) association with the representation of the grammar, or whether preference instead should be understood as a response outcome of non-affective cognitive processes.

1.4. Feelings vs. affect

It is important at this point to consider 'affect' separately from 'feeling'. Cognitive appraisals and motivational processes are intimately involved in the former, resulting in action tendencies that do not necessarily involve subjective, felt experiences (cf., Frijda (1986), Damasio (2003) and Berridge and Winkielman (2003)). Preference judgments made in AGL classification might therefore not express actual preferences (i.e., conscious feeling states towards (non-)grammatical stimuli) but rather reflect motivational processes that result in automatically endorsing certain stimuli rather than others. In this study, we directly tested whether an affective component is involved in AGL classification by using masked affective primes. Furthermore, we investigated the relationship between individual differences in AGL performance and mindfulness, describing an individual's disposition to disengage from automatic reactions and attend to internal and external stimuli in a non-judgmental and non-reactive way.

1.5. Mindfulness state and meditation

Mindfulness had been formally defined as 'paying attention in a particular way: on purpose, in the present moment, and non-judgmentally' (Kabat-Zinn, 1994), 'the state of being attentive to and aware of what is taking place in the present', Brown and Ryan (2003) or in similar vein Bishop et al. (2004). It prevents one from '...falling prey to automatic judgments or reactivity' (Segal, Williams, & Teasdale, 2002). Often contrasted to the conceptual mode of processing, a mindful mode of processing involves a receptive state of mind wherein attention is kept to bare registering of the facts observed. This permits the individual to 'be present' in reality as it is, rather than to automatically react to or habitually process it through