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Measuring strategic control in artificial grammar learning

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ABSTRACT

In response to concerns with existing procedures for measuring strategic control over implicit knowledge in artificial grammar learning (AGL), we introduce a more stringent measurement procedure. After two separate training blocks which each consisted of letter strings derived from a different grammar, participants either judged the grammaticality of novel letter strings with respect to only one of these two grammars (*pure-block* condition), or had the target grammar varying randomly from trial to trial (novel *mixed-block* condition) which required a higher degree of conscious flexible control. Random variation in the colour and font of letters was introduced to disguise the nature of the rule and reduce explicit learning. Strategic control was observed both in the pure-block and mixed-block conditions, and even among participants who did not realise the rule was based on letter identity. This indicated detailed strategic control in the absence of explicit learning.

1. Introduction

During implicit learning, knowledge acquisition occurs largely unintentionally and at least the details of the learned knowledge are not consciously available to the learner. In implicit learning research, it is becoming increasingly common to measure the degree of strategic control that participants have over their acquired knowledge – i.e., to measure the ability to use the knowledge in a flexible, controlled, context dependent manner (Destrebecqz & Cleeremans, 2001, 2003; Fu, Dienes, & Fu, 2010; Norman, Price, & Duff, 2006; Norman, Price, Duff, & Mentzoni, 2007; Wilkinson & Shanks, 2004). In this paper we suggest some limitations in the way that strategic control has been measured in artificial grammar learning (AGL) which is one of the most studied implicit learning paradigms. We then present an experiment which demonstrates how measurement of strategic control can be improved, and which assesses whether strategic control over knowledge is possible without full explicit knowledge of what has been learned.

Following theoretical work on consciousness by Baars (1988, 2002), and the process dissociation procedure of Jacoby and colleagues (Jacoby, 1991, 1994; Jacoby, Toth, & Yonelinas, 1993), strategic control is often taken as a hallmark of conscious or explicit knowledge rather than of unconscious knowledge whose influences are much more automatic. Indeed strategic control has been used methodologically as a broad criterion to decide whether acquired knowledge should be regarded as conscious and explicitly learned, or as unconscious and implicitly learned. For example some studies have argued that the learning of sequences of visual target positions in the serial reaction time task (SRT) – as measured by reaction times of rapid key presses to indicate consecutive target positions – is implicit since participants cannot deliberately withhold the influence of their learned knowledge in a generation task using "exclusion" instructions (Destrebecqz & Cleeremans, 2001, 2003; Goschke, 1998). By contrast other studies have argued that such learning is explicit since they found the influence of learned knowledge *can* be deliberately withheld (Wilkinson & Shanks, 2004).

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Moving beyond a simple dichotomisation between explicit and implicit learning, measurement of strategic control has been included alongside other subjective and objective measures of learning to assess exactly *which* aspects of acquired knowledge participants are conscious of. For example, Dienes, Altmann, Kwan, and Goode (1995) have explored strategic control in artificial grammar learning (AGL). In a typical AGL experiment (Reber, 1967), participants are first presented with a series of letter strings in which the identity and order of letters is governed by a complex rule set referred to as a finite state grammar. Strings that conform to the rule set are "grammatical" and strings that violate it are "ungrammatical". However, participants are not informed of the existence of a grammar during training. The structure of the grammar can be conceived of as a network of nodes between which only some transitions are permitted, with each legal transition corresponding to a letter (see Fig. 1). In a subsequent test phase, participants are informed of the existence of a grammar and asked to classify whether each of a series of novel letter strings follows this grammar or violates it.

The innovation introduced by Dienes et al. (1995) was to passively expose all participants in an AGL experiment to *two* sets of letter strings obeying *two* different finite state grammars (A or B). They then tested participants' ability to classify whether a novel set of letter strings followed specifically one of these grammars. Within any block of trials the target grammar for string classification was either always A or always B. Participants could classify novels strings with above-chance accuracy in all experiments, regardless of whether they were told to classify according to rule set A or rule set B. These experiments therefore showed strategic control over rule knowledge. From the perspective that strategic control should be seen as a hallmark of conscious knowledge, one interpretation is that learning was explicit. This was also supported by an overall significant relationship between classification accuracy and confidence ratings in two out of three experiments. However, strategic control also occurred on the subset of trials where participants rated that they guessed their classification response. It has therefore been argued by Dienes et al. (1995) that participants might be able to strategically control which grammar they are applying even when they are not conscious of the details of the rules of that grammar. Later, Dienes and Scott (2005) distinguished between *judgement knowledge*, which refers to knowledge of whether particular items are grammatical, and *structural knowledge*, which refers to knowledge of the rules of the grammar. The findings by Dienes et al. (1995) could be considered as an example of strategic control in the absence of conscious structural knowledge. A similar finding was reported in a recent study by Wan, Dienes, and Fu (2008) who found strategic control over knowledge of two artificial grammars to which people had been exposed, even on trials where participants rated their grammar classification response to be based on *intuition*, *familiarity*, or even *random choice* rather than *rule awareness.*

However, the procedure used to measure strategic control in these experiments is not without limitations. Participants in the studies of Dienes et al. and Wan et al. successfully attempted, during any given block of test trials, to classify novel letter strings according to only *one* of two learned grammars. However, as suggested by Norman et al. (2006), successful performance on this type of AGL task may reflect an ability to voluntarily control whether or not acquired knowledge of a rule is generally activated and allowed to influence task performance, rather than reflect moment by moment control over acquired knowledge. Switching the target grammar from trial to trial would therefore be a more demanding test of strategic control than instructing participants to activate one mental set rather than another at the start of a block of trials (i.e., instructing to use grammar A vs. use grammar B). If a dissociation between strategic control and metacognitive awareness

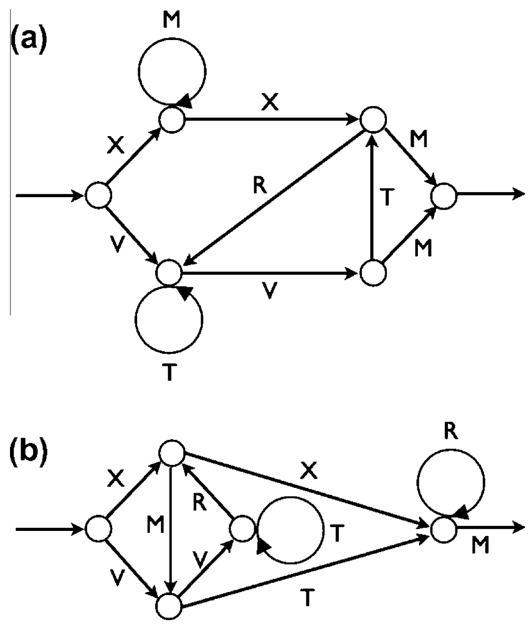

Fig. 1. The two finite-state grammars used, (a) Grammar A, and (b) Grammar B (Dienes et al., 1995; Reber, 1969). The figures are adapted from Dienes et al. (1995).