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The effect of subjective awareness measures on performance in artificial grammar learning task

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ABSTRACT

Systematic research into implicit learning requires well-developed awareness-measurement techniques. Recently, trial-by-trial measures have been widely used. However, they can increase complexity of a study because they are an additional experimental variable. We tested the effects of these measures on performance in artificial grammar learning study. Four groups of participants were assigned to different awareness measures conditions: confidence ratings, post-decision wagering, decision strategy attribution or none. Decision-strategy-attribution participants demonstrated better grammar learning and longer response times compared to controls. They also exhibited a conservative bias. Grammaticality by itself was a stronger predictor of strings endorsement in decision-strategy-attribution group compared to other groups. Confidence ratings and post-decision wagering only affected the response times. These results were supported by an additional experiment that used a balanced chunk strength design. We conclude that a decision-strategy-attribution procedure may force participants to adopt an analytical decision-making strategy and rely mostly on conscious knowledge of artificial grammar.

1. Introduction

Implicit learning, which is the ability to learn complex regularities without conscious processing, has been studied in psychology for 50 years since Reber's (1967) seminal paper. In the 1990s, implicit learning was widely discussed in relation to the awareness of knowledge acquired by participants in the experiments involving this kind of learning (Perruchet & Pacteau, 1990; Shanks & St. John, 1994). Verbal reports used as awareness measures were criticized by many researchers (Dulany, Carlson, & Dewey, 1984; Shanks & St. John, 1994). This lead to the broad methodological reflection in the field of implicit learning. As a result, the awareness measures became an independent research problem that was addressed by numerous studies (e.g. Dienes & Berry, 1997; Timmermans & Cleeremans, 2015; Tunney & Shanks, 2003).

Different measures of awareness were compared in several studies (Dienes, Scott, & Seth, 2010; Dienes & Seth, 2010; Overgaard, Timmermans, Sandberg, & Cleeremans, 2010; Seth, 2008; Seth, Dienes, Cleeremans, Overgaard, & Pessoa, 2008; Wierzchoń, Asanowicz, Paulewicz, & Cleeremans, 2012; Gaillard, Cleeremans, & Destrebecqz, 2014). The goal of these studies was to compare these measures with respect to their sensitivity, reliability, easiness for understanding, etc. The present study has a different purpose—to assess the influence of using an awareness measure on performance in an artificial grammar learning task.

Artificial grammar learning (AGL) is one of the standard paradigms used in laboratory studies of implicit learning. It consists of

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the following stages: In the learning phase, participants perform a task (usually memorization) with a set of letter strings. Unknown to the participants, these stimuli obey a complex set of rules governing the order of the letters in the strings. In the test phase, participants are given new strings. Some strings obey the same rules as learning stimuli ("grammatical" stimuli), and some do not ("ungrammatical" stimuli). The difference in responses to grammatical and ungrammatical items is taken as evidence of learning the rules. In classical experiments (Reber, 1967, 1976), participants were asked about their knowledge after the test phase, and they usually failed to report any knowledge relevant to the grammar they had learned.

Shanks and St. John (1994) identified several problems with retrospective verbal reports used by Reber. Insensitivity is one of the main problems; participants fail to report all the relevant knowledge when asked to define the rules of the grammar that they used during the experiment. They can be unsure of the relevance of the particular knowledge they used. Relevant knowledge can also be simply forgotten by the end of the experiment. This issue has been called the sensitivity problem. The second critical point is that participants might acquire knowledge of the form that is different from what was questioned by the experimenter. For example, they might learn some incidental parts of the stimuli (chunks) and use this knowledge in the test phase instead of learning the rules they were asked about. This issue has been called the information problem. The relevance of this problem was demonstrated in several studies, showing that participants' classification performance can be accounted by the acquisition of the different types of knowledge simpler than abstract rules of the grammar (e.g., exemplars memory [Brooks, 1978], microrules formation [Dulaney et al., 1984], chunks memorization [Perruchet & Pacteau, 1990], etc.).

In response to these concerns, new awareness measures were suggested, including confidence ratings (Chan, 1992; Dienes & Berry, 1997) and post-decision wagering (Persaud, McLeod, & Cowey, 2007). Using confidence ratings (CR), participants evaluate their confidence in the decisions they make after each trial. The correlation between confidence and classification accuracy is taken as evidence of conscious processing. In post-decision wagering (PDW), participants place a wager on their classification choice. These measures were based on the idea that metacognitive sensitivity depends on access to representations that are impaired in the case of unconscious knowledge. Confidence ratings and post-decision wagering are more sensitive than retrospective verbal reports because they are conducted during the course of an experiment. And these measures also resolve the information problem because they do not require a particular form of knowledge to be reported. They can indicate awareness both when people learn chunks of stimuli and when they learn rules. Thus, trial-by-trial measures allowed for a substantial progress in identifying the level of awareness in AGL.

However, despite all the listed advantages, measures based on metacognitive sensitivity assume that participants can always explain their decisions, which might not be the case. Dienes and Scott (2005) divided the knowledge that people can acquire into two types. In the learning phase, participants acquire some knowledge about the structure of grammar. The authors called it structural knowledge. Facing a new stimulus in the test phase, participants form another type of knowledge that answers the question, "Is this stimulus grammatical or not?". Dienes and Scott called this judgment knowledge because it is related to particular judgments of the new stimuli. Both structural and judgment knowledge can be conscious and unconscious. This means that structural knowledge can be unconscious while judgment knowledge can be conscious. In this situation, participants can confidently and correctly classify new stimuli, but they cannot explain their decisions. Here, measures based on the participants' confidence ratings would indicate conscious learning. Addressing this issue, Dienes and Scott (2005) suggested their own test of awareness. After each trial in a test phase, they asked participants to declare what they based their decisions on, which may be any of the following: A) guessing, B) intuition (confidence that answer is correct but no explanation why), C) knowledge of the grammar rules, or D) memory of particular instances.

After the data have been collected, trials attributed to different decision strategies (A, B, C, or D) can be analyzed separately. When participants perform above-chance in trials attributed to strategy "A", the assumption is that they possess some amount of unconscious structural and judgment knowledge. Above-chance performance in trials that are attributed to the strategy "B" indicates unconscious structural knowledge and conscious judgment knowledge. Above-chance performance in trials that are attributed to strategies "C" and "D" indicates conscious structural and judgment knowledge. Therefore, although this procedure requires self-report about the strategy of decision-making, it can be used to infer the conscious status of participant's structural and judgment knowledge. Awareness according to CR or PDW can be considered a special case of conscious judgment knowledge.

Awareness measures involving participants' responses in every classification trial solve some crucial problems of verbal reports (e.g., forgetting relevant knowledge, reporting irrelevant information, or withholding something the person is not confident about). But these measures raise new concerns. The list of requirements for awareness measures, as identified by Shanks and St. John (1994), was updated by Newell and Shanks (2014) and discussed by Timmermans and Cleeremans (2015). Among others, the authors discuss immediacy criterion that states, "assessments should be made concurrently (so long as they do not influence the behavior) or as soon after the behavior as possible to avoid forgetting and interference" (Newell & Shanks, 2014, p. 4). They do not treat the nonreactivity of the awareness measures (mentioned in brackets) like an additional criterion. However, reactivity when examining knowledge awareness is discussed in some other fields, for example, in problem solving (Ericsson & Simon, 1980; Fox, Ericsson, & Best, 2011; Schooler, 2011).

This problem can be expected to occur with trial-by-trial awareness measures in AGL. First, these measures interrupt the flow of the experiment. Each time participants apply implicit knowledge they are distracted by a secondary task (rate confidence, wager, etc.). Sometimes, it involves a single decision, but sometimes, there is a series of different questions. Additionally, not only these measures interrupt the process of applying the knowledge, they also may prompt participants to actively look for the "rules" of the grammar. This may occur because of the need for observing and categorizing internal mental processes. For example, when people are asked to indicate whether they made guess, relied on intuition, or had some explicit knowledge, they can unwittingly start to search for the explicit criteria behind their decisions.

The purpose of the current study was to estimate how different trial-by-trial awareness measures affect classification behavior in