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ScienceDirect
Consciousness and Cognition 17 (2008) 185–202
Consciousness and Cognition
www.elsevier.com/locate/concog

Implicit sequence learning and conscious awareness

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Received 11 October 2006
Available online 23 March 2007

Abstract

This paper uses the Process Dissociation Procedure to explore whether people can acquire unconscious knowledge in the serial reaction time task [Destrebecqz, A., & Cleeremans, A. (2001). Can sequence learning be implicit? New evidence with the Process Dissociation Procedure. *Psychonomic Bulletin & Review, 8*, 343–350; Wilkinson, L., & Shanks, D. R. (2004). Intentional control and implicit sequence learning. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 30*, 354–369]. Experiment 1 showed that people generated legal sequences above baseline levels under exclusion instructions. Reward moved exclusion performance towards baseline, indicating that the extent of motivation in the test phase influenced the expression of unconscious knowledge. Experiments 2 and 3 revealed that even with reward, adding noise to the sequences or shortening training led to above-baseline exclusion performance, suggesting that task difficulty and the amount of training also affected the expression of unconscious knowledge. The results help resolve some current debates about the role of conscious awareness in sequence learning.

Keywords: Implicit learning; Sequence learning; Subjective measures; Objective measures; The process dissociation procedure; Unconscious knowledge; Reward; Task difficulty; Amount of training

1. Introduction

An issue that continues to divide psychologists, despite decades of research, is whether people can acquire and use unconscious knowledge. The two factions of psychologists can often be separated by whether they use objective or subjective measures of conscious knowledge. Researchers who measure the conscious status of mental states purely by objective measures, i.e. the ability to discriminate features of the *world* (worldly discrimination), tend to be skeptics concerning the existence of unconscious knowledge states (e.g. Dulany, 1997; Perruchet & Viner, 2002; Shanks, 2005). With objective measures, the ability to determine whether an item or part of an item has certain objective properties (for example, whether it occurred previously) is taken to indicate not just knowledge but also conscious knowledge. On the other hand, people who measure the conscious

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1053-8100/$ - see front matter
doi:10.1016/j.concog.2007.01.007

status of mental states by subjective measures, i.e. the ability to report or discriminate *mental states*, tend to accept the existence of unconscious knowledge (e.g. Dienes & Berry, 1997; Willingham & Goedert-Eschmann, 1999). If a participant says they know nothing, or cannot discriminate the cases where they know something from when they are guessing, any knowledge as revealed in worldly discrimination is taken to be unconscious knowledge.

The subjective methodology is based on the assumption that a conscious mental state is a mental state of which one is conscious (Rosenthal, 2002). Merely being able to discriminate features in the world shows only that one has knowledge; it clearly does not show that one is conscious of having knowledge. It is only when there is evidence that a person knows that they know that there is evidence for conscious knowledge. While the rationale of subjective measures is intuitively appealing, there has been resistance to adopting subjective measures because of the problem of bias: How do we know that a subject who *says* they are guessing might not actually *think* they know something (for a discussion of bias, see Dienes, 2004; and for other assumptions of subjective measures, see Dienes & Perner, 2004)?

Jacoby (1991) suggested one could bypass the whole objective–subjective measure issue by the use of control. Conscious knowledge is knowledge one can control the use of. In the Process Dissociation Procedure (PDP), a person is asked to use the same knowledge to do opposite things: For example, in a subliminal perception experiment, to complete a stem or refrain from completing a stem with a word just briefly displayed (e.g. Debner & Jacoby, 1994). If the knowledge is conscious, people should be able to use the knowledge to perform whatever task is requested; if the knowledge is unconscious it will have the same consequence whatever one's intentions (i.e. to complete the stem with the just displayed word even when told to refrain from doing so). Jacoby's insight spawned a vast literature using the PDP (e.g. Buchner, Steffens, Erdfelder, & Rothkegel, 1997; Buchner, Steffens, & Rothkegel, 1998; Dienes, Altmann, Kwan, & Goode, 1995; Goschke, 1998; Kane, Picton, Moscovitch, & Winocur, 2000; McBride & Dosher, 1999; Reingold, 1995).

Recently, Destrebecqz and Cleeremans (2001, 2003) used PDP methodology to look at the conscious status of the knowledge acquired in the serial reaction time (SRT) task. The SRT task was introduced by Nissen and Bullermer (1987) and is now one of the most widely used implicit learning tasks (e.g. Cleeremans, Destrebecqz, & Boyer, 1998; Destrebecqz et al., 2005; Hoffman, Sebald, & Stöcker, 2001; Jiménez, 2003; Wilkinson & Shanks, 2004; Willingham, Wells, & Farrell, 2000). It is a choice reaction time task in which the sequence of buttons to be pressed is structured. The participant is told which button to press by a corresponding location on a screen being indicated. The participant can thus in principle follow instructions without being aware that a structured sequence exists. People come to respond faster when the sequence is maintained rather than switched, indicating structure has been learned. On the one hand, such learning occurs when people deny there is a sequence or cannot freely report it (subjective measures indicate the knowledge is not conscious; e.g. Willingham, Nissen, & Bullemer, 1989; Willingham et al., 2000; Ziessler, 1998); on the other hand, people can generally recognize the sequence or generate it, when such tests have established power (objective measures indicate knowledge is conscious; e.g. Cleeremans & McClelland, 1991; Perruchet & Amorim, 1992; Shanks, Wilkinson, & Channon, 2003).

Subjective and objective measures give opposite answers; can Jacoby's PDP shed any light on the conscious status of the knowledge? Can participants control their use of the knowledge? Destrebecqz and Cleeremans (2001, 2003) used PDP in the SRT task by having an *inclusion* and *exclusion* test after a training phase. In the inclusion test, participants were asked to generate the sequence by remembering it, or else guessing. In the exclusion test, participants were asked to freely generate a sequence that was different from the one they were trained on. Destrebecqz and Cleeremans also manipulated the response stimulus interval (RSI) during training, on the grounds that a long RSI would give conscious knowledge a greater chance both to form and to be applied. Consistently, they found that when RSI was zero, the number of chunks from their trained sequence generated in the inclusion task (I) was not significantly different from the number generated in the exclusion task (E), i.e. they found I = E. Further, E was greater than the number of chunks generated of a control sequence (the baseline, B), i.e. they found E > B. These results indicated that when RSI was zero, participants compulsively generated the sequence even when they were trying to refrain from doing so. They lacked control over the use of the knowledge. On the other hand, when RSI was 250 ms, participants had control over the use of the knowledge: They found that I > E, and also that participants could refrain from producing legal sequences above baseline levels, i.e. E = B. In sum, there was evidence of unconscious knowledge