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Unconsciously learning task-irrelevant perceptual sequences

Xiuyan Guo [a], Shan Jiang [b], Hongyi Wang [c], Lei Zhu [d], Jinghua Tang [e], Zoltan Dienes [f,*], Zhiliang Yang [c]

[a] School of Psychology and Cognitive Science and Shanghai Key Laboratory of Magnetic Resonance, East China Normal University, Shanghai, China
[b] School of Social Administration, Shanghai University of Political Science and Law, Shanghai, China
[c] School of Psychology and Cognitive Science, East China Normal University, Shanghai, China
[d] Department of Psychology, Fudan University, Shanghai, China
[e] Department of Psychology, Nanjing University of Chinese Medicine, Shanghai, China
[f] School of Psychology and Sackler Centre for Consciousness Science, University of Sussex, Brighton BN1 9QH, UK

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ABSTRACT

We demonstrated unconscious learning of task-irrelevant perceptual regularities in a Serial Reaction Time (SRT) task in both visual and auditory domains. Participants were required to respond to different letters ('F' or 'J', experiment 1) or syllables ('can' or 'you', experiment 2) which occurred in random order. Unbeknownst to participants, the color (red, green, blue or yellow) of the two letters or the tone (1–4) of the syllables varied according to certain rules. Reaction times indicated that people indeed learnt both the color and tonal regularities indicating that task-irrelevant sequence structure can be learned perceptually. In a subsequent prediction test of knowledge of the color or tonal cues using subjective measures, we showed that people could acquire task irrelevant knowledge unconsciously.

1. Introduction

Implicit learning can occur without the intention to learn and without awareness of what has been learned (Reber, 1989). Such learning can lead either to an increase in the number of correct judgments (Reber, 1989) or to faster responding (Nissen & Bullemer, 1987), which may be different cases, judgment-linked and motor-linked implicit learning, respectively, in the terminology of Seger (1998). Although implicit learning goes beyond the limits of intentions to learn and what one is conscious of knowing, implicit learning does have limits. Characterizing what those limits are though is difficult. For example, for motor-linked implicit learning, there has been debate over whether perceptual sequences can be learned as such (rather than motor sequences or perceptual–motor links, e.g., Willingham, Nissen, & Bullemer, 1989), and if they can, whether the perceptual cues have to be task relevant (Jimenez & Mendez, 1999). Here we will explore these suggested limits using the Serial Reaction Time (SRT) task. In a standard SRT experiment, participants are required to respond to sequences of objects, in which at least one of the dimensions of these objects, such as spatial location, color or shape, obeys structural regularities. However, participants are not informed about the sequenced nature of the stimulus dimensions. The fact that people become sensitive to the underlying structure of these sequences has been testified in many experiments, showing that reaction times (RTs) are facilitated by regularities in the sequences (Brown, Aczel, Jiménez, Kaufman, & Grant, 2010; Cleeremans & McClelland, 1991; Cohen, Ivry, & Keele, 1990; Curran & Keele, 1993; Nemeth et al., 2011; Nissen & Bullemer, 1987; Rowland & Shanks, 2006).

* Corresponding author. Fax: +44 1273 678058.
E-mail address: dienes@sussex.ac.uk (Z. Dienes).

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A point of debate in the literature has been whether the SRT task demonstrates only motor learning or also perceptual learning. For example, Howard, Mutter, and Howard (1992) found that people who observed someone else learning a sequence (but did not themselves respond) could respond faster to the sequence later, implying learning of a purely perceptual kind (contrast Kelly & Burton, 2001). Remillard (2003, 2009, 2011) and Deroost and Soetens (2006a) showed perceptual learning using a task in which subjects had to respond to the identity of the one underlined item in a row of items. The identity was randomly determined so the sequence of correct responses was random. Thus, there was no motor sequence to be learned. However, the location of the underlined item followed a sequence, and people showed they learnt this location sequence by their reactions times. Gheysen, Gevers, De Schutter, Van Waelvelde, and Fias (2009) argued that while motor learning had been amply demonstrated, previous studies had not actually unambiguously shown the learning of perceptual information because of possible problems including covert responding (e.g. in the Howard et al., study) or the learning of eye movements (in the Remillard studies; also Mayr, 1996). Gheysen et al. addressed these problems by a color matching task, in which three color squares were followed by a colored target square. There were four response keys, to indicate how many of the three initial squares (0–3) matched the target. The sequence of correct responses was random (so once again there was no motor sequence to be learned), but the sequence of colors for the target was determined. As the target was always central, there were no relevant eye movements to be learned. Thus any learning must have been purely perceptual. Implicit learning occurred on this SRT task, even if it occurred more slowly than motor learning on a similarly structured task with a motor sequence (see Kemény & Lukács, 2011, for a non-significant perceptual learning effect).

If learning perceptual features does not define a hard constraint, are there other constraints on implicit learning? In the Gheysen et al., Remillard and Deroost and Soetens studies, the perceptual information was relevant to predicting the right motor response on each trial. Consistently, Van den Bos and Poletiek (2009) argued that people implicitly learnt only aspects of a structure that were useful to the task they performed. Similarly, Jimenez and Mendez (1999) argued that only stimulus details selected for processing in working memory because of task demands could participate in implicit learning. However, Perlman and Tzelgov (2006) and Rowland and Shanks (2006) provided apparent counter-examples to both these claims. Perlman and Tzelgov found that when people had to name the display colors of a sequence of words, they learnt about the sequence of color words themselves. In this case, people learnt about aspects of the task not useful to them, which they had no need to keep in working memory. However, the Stroop effect showed how likely it was that the words were in working memory, primed to be processed (cf Eitam & Higgins, 2010). Rowland and Shanks (2006) showed people could learn an irrelevant sequence of positions occupied by one shape when learning the sequence of locations of another shape. In this case as well, locations were plausibly primed to be processed, because the primary task was to respond to locations. We will investigate whether perceptual information which is not predicted by the correct motor response nor primed by the main task can nonetheless be learned in both visual and auditory domains.

A key issue to establish is whether the learning is implicit. Neither Perlman and Tzelgov (2006) nor Rowland and Shanks (2006) established whether people were aware of the acquired knowledge. But if this is not established, there is no way of knowing whether these studies tell us anything about specifically implicit learning. In order to assess the conscious status of knowledge, we used the subjective measures recommended by Dienes (2008a).

In sum, our aim was to establish whether on the SRT task *perceptual* learning could occur of genuinely task *irrelevant* information and in such a way that the resulting knowledge was *implicit*. If such learning exists, it would show some postulated limits of implicit learning are not hard and fast: Perceptual information need not be useful, nor even needed in working memory for task requirements, yet still be implicitly learnt. In experiment 1, the participant's task was to discriminate which of two letters were presented. The letters were presented in different colors, which was a purely perceptual feature. The color did not predict which letter would be displayed. Further, colors were not primed by task requirements. In a subsequent prediction task, participants gave trial-by-trial confidence ratings to establish if people were unaware of irrelevant knowledge. We determined whether or not RTs could nonetheless be facilitated by regularities in colors.

2. Experiment 1

2.1. Method

2.1.1. participants

A total of twenty participants (16 women, aged from 19 to 33, $M = 20.25$, $SD = 3.09$) from the university community took part in the main experiment. An additional 10 participants (5 women, aged from 23 to 30, $M = 24.10$, $SD = 2.13$) from the university community took part in a control condition who completed only the prediction task and not the reaction time task. All the participants had normal or corrected-to-normal vision.

2.1.2. Design

On the reaction time task, the within-participant variable was regularity (regular versus random); reaction time (RT) was the dependent variable. On the prediction task, the between participant variable was trained versus untrained; the dependent variable was prediction accuracy.