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Explicit feedback maintains implicit knowledge

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ABSTRACT

The role of feedback was investigated with respect to conscious and unconscious knowledge acquired during artificial grammar learning (AGL). After incidental learning of training sequences, participants classified further sequences in terms of grammaticality and reported their decision strategy with or without explicit veridical feedback. Sequences that disobeyed the learning structure conformed to an alternative structure. Feedback led to an increase in the amount of reported conscious knowledge of structure (derived rules and recollections) but did not increase its accuracy. Conversely, feedback maintained the accuracy of unconscious knowledge of structure (intuition or familiarity-based responses) which otherwise degraded. Results support a dual-process account of AGL. They suggest that implicit learning of the to-be-rejected structure at test contaminates familiarity-based classifications whereas feedback allows competing familiarity signals to be contextualised, which is incompatible with theories that consider familiarity context-insensitive.

1. Introduction

People often rely on intuitive feelings when performing everyday tasks requiring high levels of expertise, with the underlying processes difficult to introspect (Cleeremans, 2006). Knowledge is said to be implicit or unconscious (here, the terms are used interchangeably) when one is unaware of its presence or nature despite its ongoing influence on behaviour (e.g. Dienes, 2008a, 2012). Many skills thought to have an implicit component rely on repeated practice or exposure rather than direct instruction. This is thought to minimise explicit learning of the material and the intention to learn is not required (e.g. Allen & Reber, 1980; Berry & Dienes, 1993; Dienes & Berry, 1997a, 1997b; Domangue, Mathews, Sun, Roussel, & Guidry, 2004; Higham, Vokey, & Pritchard, 2000; Mathews, 1997; Reber, 1989; Rebuschat & Williams, 2009; Sallas, Mathews, Lane, & Sun, 2007; Scott & Dienes, 2010a; Ziori & Dienes, 2006, 2008). During the acquisition of implicit knowledge – 'implicit learning' – one may not be aware of learning anything at all. Such learning episodes may also result in feelings of intuition or familiarity or experiences of "rightness" or "wrongness" without knowing directly from where those feelings stem (e.g.: Dienes, 2012; Mangan, 2003; Neil & Higham, 2012; Norman, Price, Duff, & Mentzoni, 2007).

One of the most common experimental paradigms used to investigate implicit learning and the resultant knowledge is artificial grammar learning (AGL; Reber, 1967), where participants are exposed to a series of letter sequences generated by a rule-based system. After several minutes exposure, they are informed of the presence of rules before going on to classify further novel sequences in terms of conformity to or violation of the studied structure. Performance is often around 65% accuracy (with a 50% baseline). However, successful worldly discrimination does not allow inference of the conscious status of knowledge that led to that behaviour. Further, it is perfectly possible for someone to be confident that a sequence is (un)grammatical – which entails awareness that the *judgment* itself constitutes knowledge – but this does not necessitate

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awareness of that sequence's features which make it (un)grammatical, i.e.: the underlying *structural* knowledge which led to the grammaticality judgment (Dienes, 2012).

This structural and judgment knowledge distinction motivated the use of structural knowledge attributions in implicit learning (Chen et al., 2011; Dienes, Baddeley, & Jansari, 2012; Dienes & Scott, 2005; Fu, Dienes, & Fu, 2010; Guo et al., 2011; Jiang et al., 2012; Kemeny & Luckacs, 2013; Kiyokawa, Dienes, Tanaka, Yamada, & Crowe, 2012; Neil & Higham, 2012; Rebuschat & Williams, 2009; Scott & Dienes, 2008, 2010a, 2010b, 2010c, 2010d; Wan, Dienes, & Fu, 2008). Structural knowledge attributions reflect different metacognitive experiences of knowledge (see Fig. 1). Rules and recollection responses index conscious structural knowledge where one can explicitly represent the aspects of a given stimulus which motivate the grammaticality judgment. Intuition and familiarity responses index conscious judgment of unconscious structural knowledge when one has a metacognitive feeling related to grammaticality (or accuracy) but not knowledge of its source. Random selection responses reflect the phenomenology of mere guesses, where both judgment and structural knowledge are unconscious. Structural knowledge can be incidentally learned during a standard AGL training phase where participants are unaware of any structure to learn. See Dienes (2012) for a discussion on the conscious vs. unconscious status of knowledge in relation to the learning of statistical and other regularities.

1.1. Unconscious structural knowledge

Laboratory-based empirical studies suggest that unconscious knowledge is weak compared to conscious knowledge in terms of its performance (e.g.: Dienes & Scott, 2005; Scott & Dienes, 2008, 2010a, 2010b, 2010c; contrast Scott & Dienes, 2010d). However, outside of the experimental context, unconscious structural knowledge of one's native language is of better quality than one's conscious structural knowledge (Dienes, 2008a). Mathews (1997) suggests that low confidence in unconscious knowledge (and perhaps its relatively poor performance) obtained during AGL and other implicit learning tasks may be characteristic of the early stages of implicit knowledge acquisition, whereas with sufficient practice implicit knowledge can be used with high levels of confidence and accuracy (Cleeremans, 2006; see also Allen & Reber, 1980). Of course, it is beyond the scope of many laboratory-based single session or small scale studies to train participants to 'expert' levels of unconscious knowledge however one may reasonably define 'expert'. Nevertheless, one feature of natural language acquisition and its use is that speakers are consistently given feedback about the accuracy of their judgment knowledge by virtue of being understood and responded to by others (Demetras, Post, & Snow, 1986). Yet, feedback on judgment knowledge is not given in typical AGL studies after the point that participants are instructed to apply their knowledge, which may detract from ecological validity when drawing conclusions beyond the experimental methodology.

In one of the few published studies to provide feedback in AGL, Mathews et al. (1989) trained one group of participants under typical memorisation instructions. This group proceeded to classify 800 sequences (with feedback) over a number of sessions and after each 10-trial block reported their subjectively derived classification rules. A second untrained group of participants used these rules to classify sequences themselves, thereby assessing their validity. These participants showed above baseline performance, suggesting the first group reported some relevant conscious structural knowledge. Both groups also showed improvement over the course of the experiment. However, the performance of the second group did not reach the level attained by the first, evidence that not all of the first group's knowledge was subsequently reported. However, it is

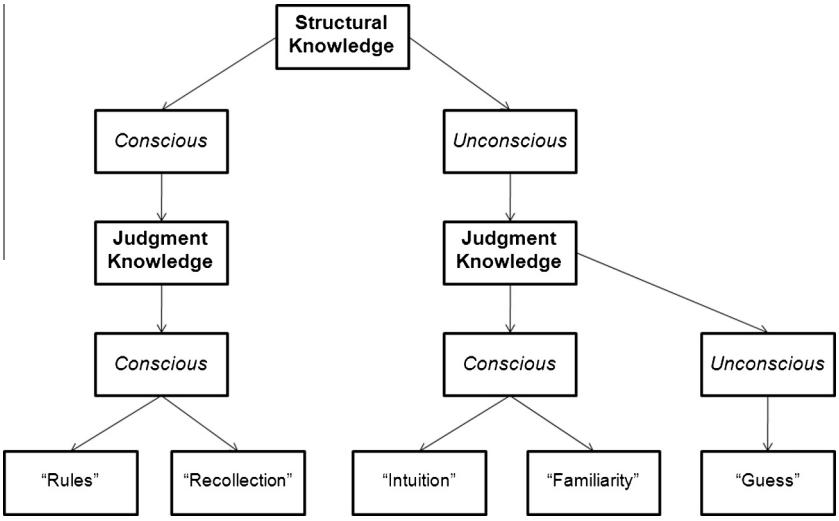

Fig. 1. The relationship between the conscious status of structural and judgment knowledge. The bottom row represents self-reported awareness of knowledge. "Rules" and "recollection" reflect explicit knowledge. "Intuition", "familiarity" and "guess" reflect degrees of awareness of implicit knowledge (Scott and Dienes, 2010a).