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Implicit learning as an ability

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ABSTRACT

The ability to automatically and implicitly detect complex and noisy regularities in the environment is a fundamental aspect of human cognition. Despite considerable interest in implicit processes, few researchers have conceptualized implicit learning as an ability with meaningful individual differences. Instead, various researchers (e.g., Reber, 1993; Stanovich, 2009) have suggested that individual differences in implicit learning are minimal relative to individual differences in explicit learning. In the current study of English 16–17 year old students, we investigated the association of individual differences in implicit learning with a variety of cognitive and personality variables. Consistent with prior research and theorizing, implicit learning, as measured by a probabilistic sequence learning task, was more weakly related to psychometric intelligence than was explicit associative learning, and was unrelated to working memory. Structural equation modeling revealed that implicit learning was independently related to two components of psychometric intelligence: verbal analogical reasoning and processing speed. Implicit learning was also independently related to academic performance on two foreign language exams (French, German). Further, implicit learning was significantly associated with aspects of self-reported personality, including intuition, Openness to Experience, and impulsivity. We discuss the implications of implicit learning as an ability for dual-process theories of cognition, intelligence, personality, skill learning, complex cognition, and language acquisition.

1. Introduction

The ability to automatically and implicitly detect complex and noisy regularities in our environment is a fundamental aspect of human cognition. Much of this learning takes place on a daily basis without our intent or conscious awareness, and plays a significant role in structuring our skills, perceptions, and behavior (Hassin, Uleman, & Bargh, 2005; Kihlstrom, 1987; Lewicki, Czyzewska, & Hoffman, 1987; Lewicki & Hill, 1987; Reber, 1967, 1993; Stadler & Frensch, 1997). This type of learning is often referred to as implicit learning (Reber, 1967, 1993; Stadler & Frensch, 1997) and is typically characterized by a set of automatic, associative, nonconscious, and unintentional learning processes, as distinguished from the conscious, deliberate, and reflective learning processes that are thought to be associated with executive functioning and working memory (e.g., Barrett, Tugade, & Engle, 2004).

Despite considerable interest in implicit processes, few researchers have conceptualized implicit learning as an

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ability. While researchers of the cognitive unconscious have investigated the nature of the unconscious using the experimental approach, they have tended to treat individual differences as "noise" (error or otherwise unexplained variance), or have posited that whatever individual differences in implicit cognition do exist are minimal relative to individual differences in explicit cognition (Reber, 1993; Stanovich, 2009). For example, in distinguishing between the "algorithmic mind" and the "autonomous mind", Stanovich (2009) states that "...continuous individual differences in the autonomous mind are few. The individual differences that do exist largely reflect damage to cognitive modules that result in very discontinuous cognitive dysfunction such as autism or the agnosias and alexias (p.59)." As a consequence of these long-held assumptions, little research has investigated whether there exist meaningful individual differences in implicit learning or the correlates of such individual differences. In the current study we investigated the association of implicit learning ability with a variety of cognitive and personality variables, building on previous research examining the relation of implicit learning to psychometric intelligence, basic cognitive mechanisms, and personality traits. We take up discussion of each association in turn.

In investigating the relation between implicit learning and intelligence, researchers have relied on measures of psychometric intelligence, defined as Spearman's general intelligence, or *g*, the common variance across disparate tests of cognitive ability (Spearman, 1904). What is the link between implicit learning and *g*? According to Reber (1989, 1993) and Reber and Allen (2000), individual differences in implicit learning should be expected to be largely independent of individual differences in psychometric intelligence. The argument is based on the assumption that implicit learning is evolutionarily older than explicit cognition, with the latter developing only with the rise of *Homo sapiens*. The older mechanisms of implicit learning are believed to have been unaffected by the arrival of explicit cognition, which includes hypothesis-guided learning and deduction, and they continue to function independently of one another today. These thoughts converge with arguments advanced by Mackintosh and colleagues (Mackintosh, 1998; McLaren, Green, & Mackintosh, 1994) that the processes underlying performance on implicit learning tasks may be automatically associative rather than cognitive in nature, and are consistent with various other dual-process theories of human cognition (Chaiken & Trope, 1999; Epstein, Pacini, Denes-Raj, & Heier, 1996; Evans & Frankish, 2009; Sloman, 1996; Stanovich & West, 2000).

Thus far, the evidence suggests that performance on implicit learning tasks is independent of differences in IQ, or at most only weakly related. Some paradigms have never shown an association with psychometric intelligence (e.g., artificial grammar learning; Gebauer & Mackintosh, 2007; McGeorge, Crawford, & Kelly, 1997; Reber, Walkenfeld, & Hernstadt, 1991), whereas for other paradigms the majority of studies have not found a significant association (e.g., serial reaction time learning; Feldman, Kerr, & Streissguth, 1995; Unsworth, Heitz, Schrock, & Engle, 2005; but see Salthouse, McGuthry, & Hambrick, 1999). The relation between IQ and one other implicit learning paradigm, which involves incidental exposure to pictures, has been investigated only once but was significant (Fletcher, Maybery, & Bennett, 2000). A possible explanation for the occasional significant association between IQ and implicit learning is that different implicit learning paradigms are only weakly correlated with one other (Gebauer & Mackintosh, 2007, in preparation; Pretz, Totz, & Kaufman, 2010; Salthouse et al., 1999) and may differ in the extent to which they are measuring implicit learning without relying on explicit processes (e.g., Seger, 1994).

Direct comparisons of implicit and explicit versions of specific tasks may further help to explain contradictory results. In some studies, researchers administered the same implicit learning task under two conditions: in one condition, participants were explicitly instructed to detect the underlying covariation, and in the other condition participants did not receive such an instruction, thereby making learning 'incidental' to the task requirements. In these studies, psychometric intelligence was more highly correlated with the task under explicit instructions than under incidental conditions (Unsworth and Engle, 2005a; Gebauer & Mackintosh, 2007). Similarly, in study of 455 adolescents, Feldman et al. (1995) separated an intentional declarative component of an implicit learning task from the procedural component and found that, although the declarative learning component significantly correlated with psychometric intelligence, the procedural component did not. Overall it appears that individual differences in psychometric intelligence, which are clearly associated with variation in explicit cognition, are either weakly or not at all associated with variation in implicit learning (e.g. McGeorge et al., 1997; Reber et al., 1991).

While implicit learning is only weakly related to psychometric intelligence, recent research suggests that individual differences in implicit learning may make an independent contribution to complex cognition. Gebauer and Mackintosh (in preparation) administered a battery of 15 traditional implicit learning tasks and nine traditional psychometric intelligence tests to 195 German school pupils. Factor analyses revealed a low correlation between two second-order principal components, the first corresponding to psychometric intelligence and the second corresponding to implicit learning. In addition, their second-order factor of implicit learning correlated significantly with school grades in Math and English (a foreign language for the German participants in the study). Controlling for psychometric intelligence, the correlation between the implicit learning factor and English grades remained, while the relation to Math was no longer significant. Similarly, Pretz et al. (2010) found a significant relation between a measure of serial reaction time (SRT) probabilistic learning and Math and English achievement scores. These results suggest there may be variance in implicit learning ability that is independent of psychometric intelligence but nevertheless related to some aspects of school learning.

A number of basic cognitive mechanisms, including working memory, explicit associative learning, and processing speed, have been posited as contributors to intelligence (e.g., Kaufman, DeYoung, Gray, Brown, & Mackintosh, 2009). Examining their relations to implicit