Gambling on the unconscious: A comparison of wagering and confidence ratings as measures of awareness in an artificial grammar task ☆

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ABSTRACT

We explore three methods for measuring the conscious status of knowledge using the artificial grammar learning paradigm. We show wagering is no more sensitive to conscious knowledge than simple verbal confidence reports but is affected by risk aversion. When people wager rather than give verbal confidence they are less ready to indicate high confidence. We introduce a "no-loss gambling" method which is insensitive to risk aversion. We show that when people are just as ready to bet on a genuine random process as their own classification decisions, their classifications are still above baseline, indicating knowledge participants are not aware of having. Our results have methodological implications for any study investigating whether people are aware of knowing.

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How can we tell if a person is aware of being in a mental state? For example, how can we tell if a person is aware of knowing? This is a crucial question for researchers interested in consciousness, and has been a core question in the fields of subliminal perception and implicit learning (Seth, Dienes, Cleeremans, Overgaard, & Pessoa, 2008). For example, Merikle (2007) defined subliminal perception as seeing without being aware of seeing, and Dienes (2008a) argued that implicit learning was a mechanism that produces knowledge one is not aware of. Further, if one accepts the proposal that unconscious mental states are mental states one is not aware of being in (Rosenthal, 2005), then any methodology for determining the conscious status of knowledge should measure as directly as possible whether or not the person is aware of knowing. Even if one does not subscribe to such 'higher-order' theories of consciousness (e.g. Block, 2001), determining when a person is aware of knowing still remains of theoretical and applied importance. Measuring awareness of being in a mental state is therefore a key issue whatever *a priori* assumptions about consciousness one holds (Seth et al., 2008).

On the face of it, the most direct way of measuring awareness of being in a mental state is to ask a person whether they are in that mental state. Just so, verbal confidence ratings ask the person to indicate whether they are guessing or know to some degree. When a person says that they are literally guessing, that they know nothing, then the person is, on the face of it, not aware of knowing. In fact, when people say they are literally guessing, they can still discriminate stimuli at above chance levels in certain perceptual tasks (e.g. Weiskrantz, 1997) and they can still discriminate whether letter and other sequences have a certain structure in implicit learning paradigms (e.g. Dienes & Altmann, 1997; for a review see Dienes, 2008a). These results satisfy the *guessing criterion* of unconscious knowledge (Dienes, Altmann, Kwan, & Goode, 1995): When the person

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claims to be guessing they have above baseline discrimination performance. Similarly, if a person cannot tell what mental state they are in, there should be no relation between confidence and accuracy: This is the *zero correlation criterion* of unconscious knowledge (Dienes et al., 1995), and has been applied to both subliminal perception (Kolb & Braun, 1995; Kunimoto, Miller, & Pashler, 2001) and implicit learning (e.g. Dienes & Longuet-Higgins, 2004; Johansson, 2009; Tunney, 2005; for a review see Dienes, 2008a).

Verbal confidence reports may have face validity for human adults as a measure of awareness of knowing, but they are problematic for at least young children and non-human animals (e.g. Seth, Baars, & Edelman, 2005). Ruffman, Garnham, Import, and Connolly (2001) wished to apply the confidence measures methodology of Dienes et al. (1995) to the question of whether three-year olds might have an unconscious theory of mind before they have a conscious one. However, a three-year old may not properly understand what confidence terms mean. So Ruffman et al. asked children to gamble tokens on different choice alternatives, showing that children's gambling could be sensitive to objective probabilities but not false belief task choices. The amount a child was willing to gamble (children had 10 tokens to distribute among the choices) was taken to be a measure of subjective probability or confidence. Thus, the results indicate a lack of awareness of knowing the correct answer by the zero correlation criterion (lack of positive relation between gambling and correctness of answer). Similarly, Shields, Smith, Guttmannova, and Washburn (2005), Son and Kornell (2005), and Kornell, Son, and Terrace (2007) used gambling to determine whether Rhesus monkeys were aware of knowing. They trained Rhesus monkeys to wager differing amounts of tokens on their perceptual and memory judgments, showing a relation between amount wagered and accuracy: This is conscious knowledge by the zero correlation criterion if we accept wagering as indicating awareness of knowing. With the same assumption, their data also indicated unconscious knowledge by the guessing criterion, in that when Rhesus monkeys wagered the lowest amount, they were still significantly and substantially above chance baseline.

Shields et al. (2005) used the same wagering method with adult humans as they had used with Rhesus macaques to show analogous cross-species effects. But is there any advantage in using wagering over verbal confidence in showing awareness of knowing in adult humans with well developed linguistic abilities? Like Shields et al., Persaud et al. asked adult humans to wager either a small or large amount (e.g. one versus two tokens) on the correctness of a decision. If the decision was correct the participant won the amount they wagered; if the decision was incorrect, the participant lost the amount wagered. Unlike Shields et al., Persaud, McLeod, and Cowey (2007) argued that wagering constitutes a gold standard for measuring awareness (cf. also Koch & Preuschoff, 2007, and contrast Seth, 2008). We will address in this paper the question of whether such wagering constitutes the most sensitive measure we have of the conscious status of knowledge, that is, of whether people are aware of knowing.

Is there a reason to expect wagering rather than verbal confidence as being more direct, intuitive or sensitive as a measure of the conscious status of knowledge, as Persaud et al. claim? Verbal confidence can be susceptible to bias: People may *think* they know to some degree but *say* they know nothing at all. Of course, people can also *think* they know to some degree, and only wager low. Conversely one can wager high as a guess. Yet, if a conviction in a belief is to be shown in any way, it may plausibly be shown by the amount one is willing to stake on it. And when an amount of money is thrown down on the table, surely it lays public one's convictions not only to others but also to oneself. So gambling may often go hand-in-hand with awareness of one's own convictions; and hence, if those convictions are reliably caused, of one's states of knowing. Still, some forms of gambling may be better in this role than others (cf. Mellor, 1971, 1991).

On what grounds can it be argued that specifically wagering measures awareness of knowing? The expected pay off from a wager is the subjective probability of being correct multiplied by the amount of the wager. Consequently, if a person is aware of knowing to any degree, they should always go for the highest wager. Thus, the use of a low wager implies the person thinks they know nothing. This seems a somewhat sophisticated train of reasoning and it is not clear people directly or intuitively grasp it. For example, Shields et al. (2005) asked people to wager one, two or three tokens, where one won or lost the amount wagered. In terms of expected pay off, if one had any confidence at all, one should always go for the highest wager. If one had no confidence at all, then from the person's point of view, the amount wagered does not matter. However people were more accurate for medium than low wagers, indicating people were not wagering optimally (in terms of expected pay off of tokens) given their confidence.

One explanation for suboptimal wagering performance is that wagering likely involves trial by trial considerations of risk (or loss) aversion. For example, the prospect of losing $10 is often considered more salient than the prospect of winning the same amount (Kahneman & Tversky, 1979). These considerations are extra to whether or not one is aware of knowing; one could for example wager low even though one had some confidence in order to minimise loss. On this argument, verbal confidence rather than wagering may be the more direct and intuitive measure of awareness of knowing. In the following experiments we use a simple measure of risk aversion to determine empirically whether or not confidence or wagering are sensitive to risk aversion.

Persaud et al. used artificial grammar learning (Reber, 1967, 1989) as a task to produce knowledge that could be conscious or unconscious: Participants memorised strings of letters, which unbeknownst to participants were generated by a set of rules. Participants were then informed of the existence of rules, though not what they were, and were asked to classify new strings as obeying the rules or not. We already know that people perform at above baseline levels when they believe they are guessing (by their verbal report), indicating some unconscious knowledge by the guessing criterion, and typically (though not always) people also show a relation between confidence and accuracy, showing some conscious knowledge by the zero correlation criterion (e.g. Dienes et al., 1995). Persaud et al. showed the same conclusions follow with wagering: People perform at above chance levels when they use the low wager, indicating unconscious knowledge by the guessing cri-