

IMPLICIT LEARNING: CONCEPTUAL AND METHODOLOGICAL ISSUES

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The goal of this paper is to discuss the main conceptual and methodological issues raised by implicit learning research. I begin by stating a general definition of this implicit learning, and then discuss under which circumstances can such a definition be operationalized. I claim that (1) a specific relationship between intention to learn and the conscious vs. unconscious nature of the learning results should be assumed, and (2) that one of several possible assumptions regarding the sensitivity of any measure of performance to the contents of awareness should also be stipulated before it is possible to choose among several methodological strategies to demonstrate the existence of implicit learning. In the absence of a complete theory of awareness, it is argued that only the weakest assumption, namely that no measure of performance can be taken as an absolute index of awareness, can safely be accepted. However, despite the weakness of this methodological scenario, some empirical results (Jiménez, Méndez, & Cleeremans, 1996) are described as a way to illustrate that this framework still leaves some room to demonstrate the existence of implicit learning.

Introduction

Up until a few years ago, most empirical work conducted in the area of implicit learning had been concerned with the problem of demonstrating the mere existence of the phenomenon, by starting from a working definition of the term, and by adopting several methodological strategies directed either to confirm its role in a given experimental setting (e.g., Berry & Broadbent, 1984; Mathews, Buss, Stanley, Blanchard-Fields, Cho & Druhan, 1989; Nissen & Bullemer, 1987), or to provide alternative accounts for the observed results (Dulany, Carlson, & Dewey, 1984; Perruchet & Amorim, 1992; Perruchet & Pacteau, 1990; Shanks & St. John, 1994). Today, this strategy is beginning to wane in the face of increasing interest in exploring the mechanisms underlying implicit learning (e.g., Cleeremans, 1993; Dienes, 1992; Dienes & Perner, 1996; Jennings & Keele, 1990; Mathews et al., 1989; Mathews, 1991). However, it is still far from clear whether the implicit nature of implicit learning

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has been demonstrated in the first place. First, there are some issues regarding the definition of the term that need to be clarified before we can proceed to demonstrate its existence. Second, and more importantly, the choice of a methodological strategy with which to accomplish this demonstration does not depend exclusively on the acceptance of a set of assumptions about the definition of this implicit learning, but also on the kind of functional definition that we would be willing to accept about a number of related, phenomenological terms, such as "intention" and "awareness".

In this article, I would like to discuss some of these conceptual and methodological issues. My purpose, then, is first to formulate a general and broadly accepted definition of implicit learning. Then I will show how the choice among several methodological approaches to the demonstration of this form of learning depends on the specific answers we choose to the questions regarding the nature and functions of awareness and, more specifically, on a set of assumptions regarding the sensitivity of some measures of performance to either conscious or unconscious learning contents. I will describe three different methodological scenarios which rely on as many other sets of assumptions concerning this relationship between contents of awareness and measures of performance, and I will show how each of these scenarios does provide an alternative solution to the problem of assessing implicit learning. I will argue that the third scenario, in which no measure of performance is taken as an absolute index of awareness, is the only scenario that can be safely adopted in the absence of a complete theory of awareness. From this standpoint, finally, I will briefly refer to some empirical results (Jiménez, Méndez, & Cleeremans, 1996) that illustrate how the measures provided by this methodological scenario can still be used to demonstrate the existence of implicit learning.

Conceptual Issues

From a phenomenological standpoint, the existence of some processes of learning that take place regardless of our goal-directed, fully conscious activity, may seem obvious, as we are not always consciously monitoring all possible contingencies arising from our environment, but often have the feeling of acting on intuitions attributable to learning about these contingencies. Indeed, "implicitness" may even be considered as the default feature for some elementary forms of learning (Cleeremans, 1993; Reber, 1993), whereas qualifications such as "explicit" or "deliberate" should perhaps be reserved to such learning situations in which learners are told to intentionally try to solve a problem, or in which this intentional stance is prompted by the situation itself (e.g. Anderson & Fincham, 1994; Newell, 1990).

However, the tradition in cognitive psychology has long given priority to

explicit learning, thus considering the processes of hypothesis-testing and problem-solving as the core processes underlying most, if not all, forms of human learning (e.g., Brewer, 1974; Bruner, Goodnow & Austin, 1956; Levine, 1971). It is only recently that a growing number of empirical studies called attention to the role that more elementary and automatic mechanisms may play in the acquisition of complex contingencies (e.g., Cleeremans & McClelland, 1991; Dienes, 1992; in press; Druhan & Mathews, 1989; Jennings & Keele, 1990; Mathews et al., 1989; Servan-Schreiber & Anderson, 1990). These studies suggested that such mechanisms can account for a wide variety of our learning abilities, ranging from the simplest perceptual and motor skills (e.g., Nissen & Bullemer, 1987) to more complex abilities such as those involved in controlling a system (e.g., Berry & Broadbent, 1988), or even those involved in producing and understanding language (e.g., Ellis, 1994; Mathews et al., 1989). These learning situations have in common the facts that (i) people learn by doing, without usually facing the task with the explicit goal of discovering the underlying regularities; and (ii) they often fail to be able of producing a complete account of the knowledge on which their performance is based.

A Definition of Implicit Learning

Consistently with this informal description of the phenomenon, a definition of implicit learning may include some ideas about what people are intending to do when learning, and about the content of the conscious knowledge that they are entertaining at that time. I am not willing to offer an exhaustive account of all the definitions put forward in the literature during the three decades of the history of this topic, but would instead like to focus on the subset of such definitions that varies along the issue of whether they refer to both of the above outlined criteria, or to merely one of them.

Indeed, most of the definitions that I am aware of (see Frensch, in press; for a good sample) include either one or both of these criteria. For instance, Reber (1993) claimed that implicit learning must be defined as the acquisition process that (i) takes place independently of conscious attempts to learn, and (ii) occurs largely in the absence of explicit knowledge of what is being acquired. Other authors, such as Berry (1994), pointed out to the differences between processes and results, and proposed to identify implicit learning exclusively with the processes. Thus, Berry claimed that implicit learning must take place without the use of "conscious analytic strategies", but that it may—and may not—result in the acquisition of some "implicit knowledge". In a similar vein, Stadler and Frensch (1994; see also Frensch, in press) tried to separate these components by relating each of them to either implicit learning or implicit memory.

Therefore, they assumed that the expression "implicit learning" should be applied specifically to those learning processes that run unaffected by intention at the moment of acquisition, regardless of the status characterizing the resulting knowledge, while the expression "implicit memory" should refer to those retrieval processes occurring without conscious intention to recollect, and without awareness of the retrieval episode (see also Schacter, Bower, & Bookers, 1989, for a similar point of view regarding implicit memory). Finally, some other authors opted to refer exclusively to a criterion based on the learning results, thus taking the expression "implicit learning" to mean any learning process by which some unconscious knowledge is acquired, regardless of the learners' intentions during the training phase (e.g., Lewicki, Czyzewska, & Hoffman, 1987; Shanks & St. John, 1994).

Faced with these three types of definition, one can ask which of them is more valid to describe the empirical data, as well as which of them is more able to capture the analytical significance of the expression "implicit learning", as inferred by the meaning of its constituent words. The answers to these questions do not need to be necessarily coincident, though.

For instance, most of the controversies that pervade the field deal, in one way or another, with the question of whether or not the typical implicit learning paradigm can safely be considered as resulting in the acquisition of some unconscious knowledge (e.g., Jiménez et al., 1996; Perruchet & Amorim, 1992; Shanks & St. John, 1994). If this question is tacitly equated with the question of whether or not implicit learning has been satisfactorily demonstrated for these paradigms, then a factual definition of this term would come to identify implicit learning with "learning that produces unconscious results" or, to put it simply, with unconscious learning. However, some authors have recently taken issue with this statement, claiming that if implicit learning should stand for a theoretically relevant, and functionally separable type of learning process, then its definition should be better stated in terms of the specific features that entitle these processes to bear the "implicit" label, rather than just in terms of the conscious vs. unconscious nature of their results (e.g., Frensch, *in press*). Accordingly, Frensch has proposed that implicit learning processes should be defined as processes that occur automatically, that is, that are not intentionally controlled, that occur effortlessly, and that are mandatory, and not always accompanied by awareness. From such a perspective, therefore, implicit learning could be identified with automatic, or incidental learning, and its relationship with awareness would only be collateral.

If each of these approaches to the concept of implicit learning may have been motivated by a different theoretical or empirical interest, and if they sometimes seem to rely on entirely independent criteria, they can nevertheless appear as roughly equivalent when analyzed at a pragmatic level.

On the one hand indeed, those authors who take the concept to refer

specifically to those learning processes that produce some unconscious knowledge often tend to slip in the related assumption that not only the results of, but also the processes underlying implicit learning must be unconscious (e.g., Lewicki et al., 1987). Accordingly, they almost invariably presented their participants with incidental learning conditions, and tacitly assume a close relationship between implicit processes and implicit results.

On the other hand, even those authors who decide to stick to a "process" definition of implicit learning also need to tone down their restrictions when they come to operational terms, since they finally need to consider the conscious versus unconscious nature of results in order to confirm that the underlying processes can accurately be labelled as "non-intentional".

To illustrate this latter point, let us take the definition proposed by Frensch (in press), and consider how can it be operationalized. Frensch recommended "to define implicit learning in terms of the non-intentional, automatic acquisition of knowledge about structural relations between objects or events". Of course, to make this definition operational one needs to address some issues regarding the meaning of the "non-intentional" property. Thus, one needs to answer questions about (i) what does it mean for a learning process to be non-intentional, and (ii) how can this criterion be empirically used and assessed within a given task.

In response to the first question, it may be assumed, for instance, that non-intentional processes are defined as those processes that run unaffected by intention. As for the second question, it may be said that intentions can be manipulated by providing participants with enough information and instructions to guarantee that their conscious orientation is targeted toward a specific set of goals (e.g., to give a speeded response to current trial), and away from some other set of goals (e.g., detecting a sequence among successive trials). However, such conscious orientation may be modified in the course of the task by the subjects' sudden apprehension of any conscious knowledge relevant to the goal. For instance, incidental learners would be engaged in an intentional search as soon as they become aware of the existence of potentially useful regularities within the task environment, provided that (i) they are being motivated to optimize their performance; and (ii) they believe that an active search for rules would be useful to improve their performance. Given that these conditions hold for most implicit learning paradigms, then even a "process" definition of implicit learning could not avoid to include, as a part of its operationalization, a specific appraisal of whether any conscious knowledge acquired during training may have changed the initial orientation induced by the instruction set.

Toward an Operational Definition of Implicit Learning

Overall, then, we may agree that a "process" definition of implicit learning would be most appropriate to describe the conceptual content of that expression, since the meaning of the expression itself could then easily be derived from the meaning of its constituent words. Thus, implicit learning is defined as "implicit" in the sense that it takes place regardless of subjects' conscious intention to learn about the relevant regularities, and it is defined as "learning" in the sense that it refers to a process of knowledge acquisition, not to a process of knowledge retrieval or to a type of learning outcome. As I have just illustrated, however, adopting such a conceptual definition does not free us from the need to evaluate the conscious versus unconscious nature of the learning results, essentially because intention can not be safely assessed without reference to the conscious knowledge upon which it depends.

Now, how can such a "process" account of implicit learning be operationally defined? Of course, the ideal procedure would be one that could enable the experimenter to simultaneously demonstrate both learning and a complete absence of intention to learn. However, such a procedure can only be arranged in a context in which it would be possible to guarantee both the absolute efficiency of the orienting instructions, and the total absence of any conscious knowledge that might lead the learner to adopt an intentional stance. Unfortunately, such conditions may just be too demanding to be properly fulfilled.

Alternatively, if we can accept an "a priori" assumption about the relationships between intention and awareness, then it would be possible to devise a procedure that could enable researchers to demonstrate the existence of implicit learning. Specifically, if we accept the assumption that intention to learn about some given regularities can not directly produce unconscious knowledge about these regularities, then implicit learning may indirectly be established through the demonstration of the acquisition of some unconscious knowledge. By the expression "unconscious knowledge", I refer to the knowledge from which learners are not aware at the moment of learning, and that produces some effects on performance despite the fact that learners remain unaware of it at the moment of test. By the assumption that intention to learn can not give place to such unconscious knowledge, I mean that even though the use of analytical strategies may foster the development of conscious learning about some regularities, and may trigger a set of attentional responses or some other kind of processes that, in turn, could become the starting point of an implicit learning process, such strategies can not be allowed to produce unconscious knowledge in and of themselves. If such an assumption were accepted, then implicit learning would be automatically demonstrated whenever the acquisition of some unconscious learning was observed, because unconscious

knowledge could only be produced by means of non-intentional, implicit learning mechanisms.

Of course, there may be many cases in which implicit learning may arguably take place, but could not be demonstrated according to this criterion, just because there is nothing in the conceptual definition of the term that rules out the possibility that non-intentional learning processes may give place to conscious results, as well. For instance, in many studies of human conditioning both incidental and intentional learners have been found to become aware of the established contingency by the time at which learning is beginning to influence the measures of performance (e.g., Dawson & Shell, 1987; Shanks & St. John, 1994). This pattern of results does not rule out the possibility that learning was implicitly acquired by participants in the incidental condition, but it makes it more difficult to demonstrate it, simply because the process has given place to conscious knowledge (see Boakes, 1989, for a related argument). As a consequence, even though implicit learning may be taken as a ubiquitous phenomenon, experimental preparations arranged to demonstrate its effects should include fairly complex contingencies, from which participants can hardly become aware.

To summarize this section, I claim that the use of very complex, and usually arbitrary sets of contingencies does not constitute a conceptual requirement of implicit learning, but that it is commonplace in the empirical study of this topic because of the necessity of preventing participants from becoming aware of a significant part of the established contingencies. Moreover, the requirement that learners should not become aware of all the knowledge manifested through performance is neither a requirement derived from the accepted conceptual definition of the term, but it is an operational criterion that follows from the tacit assumption that only non-intentional processes can directly result in the acquisition of unconscious knowledge. Of course, this kind of operational definition may be limited in scope, and it is only as valid as the assumption upon which it rests. However, as discussed above, it fulfills two important conditions that make it worth pursuing. First, from an analytical standpoint, this definition is coherent with the meaning of each of its constituent words. Second, from a pragmatic point of view, such a definition is valid to describe the empirical interest exhibited by most researchers in the field. Because of these two reasons, it may be interesting to push this claim a bit further, and to discuss which methodological scenarios could enable researchers to demonstrate the acquisition of some unconscious knowledge and, hence, according to the previously stated assumption, to demonstrate the existence of implicit, non-intentional processes of learning.

Methodological Issues

In the previous section, I have conceptually defined implicit learning as designating the processes of learning that take place without participants' intention to learn. I have also claimed that, based on the assumption that intentional processes can not directly result in unconscious knowledge, implicit learning could be demonstrated whenever the acquisition of some unconscious knowledge is observed. One may wish that making such explicit statements about the definition of implicit learning should be enough to avoid the methodological controversy that has continuously plagued this area of research, or at least to redirect the debate toward conceptual issues. However, the reasoning contained in the previous arguments only covers a short path from the concept of intention to that of awareness, and does not reach the level required by an operational definition of implicit learning. To formulate such a definition, therefore, it is still necessary to bridge the gap between the phenomenological level at which both intention and awareness are defined, and the empirical level at which implicit learning should be demonstrated. Put simply, we need to make specific assumptions about the relationship between the phenomenological content of awareness and measures of performance.

Unfortunately, there is not a single theory about the nature and functions of awareness that may help us in making this mapping. Indeed, it is arguable that the elaboration of such a theory should rely on a set of comparisons between pairs of empirical phenomena which, like those of implicit and explicit learning, could be taken to differ specifically on whether they occur with or without awareness (e.g., Baars, 1994). However, if empirical research on unconscious cognition depends on the development of a theory of awareness and if, at the same time, the construction of this theory must be based on the results previously provided by empirical research, then we run the risk of getting trapped into a vicious circle. Hopefully, this circle can be broken by agreeing on some common-sense assumptions about the definition of awareness. This definition could set the stage for a first empirical exploration of these phenomena, and these would in turn provide theorists with results that would foster stronger conceptual developments. In the rest of this paper, I will not try to advance on this incipient theory (see Baars, 1994; 1997), but I will discuss what these minimal assumptions may be, and I will show how these assumptions provide us with the necessary grounds to demonstrate that some knowledge acquired during a typical implicit learning paradigm can safely be taken as unconscious knowledge.

Unconscious Knowledge: Three Scenarios to Demonstrate Implicit Learning

To address the question of whether a typical implicit learning paradigm does result in the acquisition of some unconscious knowledge, we need to solve the methodological problem of assessing participants' conscious knowledge or, to put it differently, we need to assume a specific mapping between the contents of awareness and some measure of performance. Different assumptions at this point may produce radically different interpretations of a similar data base of empirical facts, and hence it is essential to make these assumptions explicit and to thoroughly discuss their plausibility.

Indeed, most studies of implicit learning have taken the form of dissociation paradigms that compare the sensitivity of two different measures, somehow assuming that one of them is either absolutely or predominantly a measure of conscious knowledge, while the other is a measure that reflects exclusively, or at least mainly, implicit learning results. However, to interpret these results it is essential to specify whether these measures can really be considered as pure measures of either conscious or unconscious knowledge or whether, on the contrary, they should just be taken to reflect different blends of conscious and unconscious information. According to the specific answers advanced to these questions, one may envision at least three different methodological scenarios, each providing a specific way of demonstrating the existence of implicit learning (see Figure 1).

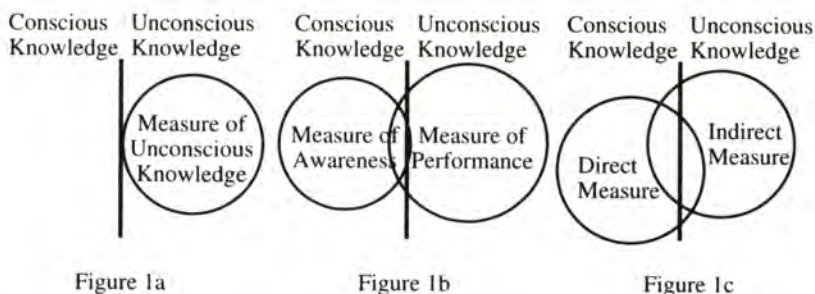


Figure 1. Three methodological scenarios for demonstrating implicit learning (see text).

First Scenario: A Pure Measure of Unconscious Knowledge

In the first place, if it were possible to assume that some behavioral index (e.g., a given measure of performance) can be completely free from conscious influences, then the whole dissociation paradigm would no longer be necessary, since any knowledge expressed through that measure could be taken immediately

as a proof of implicit learning (see Figure 1a). Even though this scenario does not entail the complementary assumption that such a measure would be also exhaustively sensitive to all the unconscious knowledge available to the learner—and thus, could not be used to demonstrate the absence of unconscious influences—it would provide us with the simplest framework within which to investigate implicit learning.

Unfortunately, this assumption is particularly unpalatable. Although there has been a trend in the empirical literature toward identifying some measure of performance as the main index of implicit learning, no author has ever assumed that this index is exclusively sensitive to unconscious influences. For instance, in the typical sequence learning task (e.g., Nissen & Bullemer, 1987), participants see a target stimulus appearing at one of several possible locations on each trial, and they are just required to indicate its current location by making a keypress. Unknown to them, the series of locations follows a deterministic sequence, and this fact is exploited by participants as inferred from their performance, which shows a selective improvement in reaction-time (RT) in response to predictable trials. This measure is considered to be sensitive to implicit knowledge, because it shows an indirect discrimination between predictable and unpredictable trials—i.e., it shows a discrimination between both types of trials, despite the fact that participants are not told to rely on that specific dimension while performing the task. However, this measure is not taken to tap exclusively on unconscious information or, what amounts to the same, it is not assumed to be completely unaffected by conscious knowledge. Curran and Keele (1993) have showed that providing participants with explicit information about the sequence produces greater improvements in RT than those observed in a control condition, so that it seems fair to conclude that this measure is influenced by conscious knowledge, although it may be affected by some unconscious knowledge as well.

If the above conclusion is accepted, that is, that pure measures of unconscious learning do not exist, then there is no other option but to formulate the operational definition of implicit learning in a relative way, that is, by means of a dissociation paradigm. Hence we need to compare the sensitivity of a given measure of performance taken to reflect a blend of conscious and unconscious information with a measure of awareness, that must fulfill a number of specific requirements. Different sets of assumptions at this point would define the following two methodological scenarios.

Second Scenario: A Pure Measure of Awareness

The acquisition of some unconscious knowledge can be assessed by starting from a second scenario that requires the experimenter to assume the existence

of a measure that is exclusively sensitive to conscious knowledge. According to that "exclusiveness" assumption (see Reingold & Merikle, 1988), unconscious knowledge could simply be estimated by subtracting the net conscious effect observed through the measure of awareness from the sum of the conscious plus unconscious influences as registered through the measure of performance.

We can think of two slight variations on this scenario, defined in terms of whether or not the measure of awareness is also taken to exhaust all of the relevant conscious information. On the one hand, if we can find an exclusive measure of awareness that also fulfills the "exhaustiveness" criterion (by being sensitive to all the conscious information available), then we would be in the best conditions to implement such a dissociation paradigm. However, if the measure of awareness does not meet this latter criterion, but it (i) fulfills the "exclusiveness" criterion, and (ii) can be assumed to be the most sensitive measure of awareness, then a dissociation result could still be informative to the question of interest. In this latter case, given that any greater sensitivity produced by the measure of performance can not be attributed to that measure being more sensitive than the measure of awareness to any conscious knowledge—by assumption (ii)—then this pattern of results could only be interpreted as reflecting some unconscious influences affecting the measure of performance (see Figure 1b).

By and large, this latter set of assumptions is the most widely accepted in the literature. However, a strong controversy has centered around the issue of which measure must be taken as the appropriate measure of awareness. While some authors argue that the most sensitive measure available should always be preferred, in that it would be most likely to comply with the constraints of the exhaustiveness criterion, others claim that the most sensitive measures of awareness would also be more likely to be influenced by unconscious knowledge, hence failing the exclusiveness criterion.

To illustrate these difficulties, consider the debate produced between proponents of free verbal reports (e.g., Reber, 1989) and proponents of the use of more directed, forced-choice discrimination tasks (e.g., Dienes et al., 1991; Dulany et al., 1984; Perruchet & Pacteau, 1990) as measures of awareness in the artificial-grammar learning paradigm. In this paradigm, participants are first presented with a memory task in which they have to learn a number of letter strings. Unknown to them, letters in those strings are generated by following an artificial, finite-state grammar. The results typically show that learners become capable of discriminating between new grammatical versus non-grammatical strings, even though they are not able to articulate the rules underlying their decisions. For some authors (e.g., Reber, 1989), asking participants to freely report on their knowledge of the rule system is the only valid measure of awareness, because any other measures may involve some contextual cueing, and hence are potentially open to the influence of unconscious

determinants. (cf. Reber, Allen, & Regan, 1985). Other authors, however, argue that free verbal reports could largely fail to reflect exhaustively the contents of awareness on which grammatical discrimination may be based, and thus propose that more sensitive and directed tests (e.g., forced-choice discrimination) should be used to assess explicit knowledge (see for instance Dulany et al., 1984; Perruchet & Pacteau, 1990).

This debate has extended over years, and may go on forever unless further constraints are taken into account. Thus, as far as we lack a functional definition of awareness, it is going to be difficult to establish (i) where the line that separates conscious from unconscious knowledge is located in a plane such as that represented in Figure 1b, (ii) which measure is more sensitive to the knowledge located at the "conscious" side of this plane; and (iii) whether there is some measure that relies exclusively on knowledge located at that side of the plane. Indeed, it is perfectly reasonable to assume the alternative view, according to which people tend to base their behavior on all the knowledge available, regardless of whether it is conscious or not. On this assumption, it is rather unlikely that one can identify a pure measure of conscious knowledge, and thus neither verbal reports nor forced-choice discrimination tests could safely be considered as "measures of awareness", contrary to the assumptions required by this framework.

The interpretation of any pattern of results produced under these circumstances is made even more difficult by the fact that the to-be-compared measures may not only differ in the relative proportion with which they are sensitive to conscious or unconscious influences, but also in the specific knowledge to which they are sensitive. To put it differently, the representational space is not as simple as the plane sketched in Figure 1, but it would be better thought of as a multidimensional space in which awareness is merely one dimension, and in which knowledge can vary on many other independent dimensions as well. Thus, for instance, subjects may use some kind of rules (either conscious or not) to perform a classification task in the typical artificial-grammar learning procedure, but they could also be prompted to report on a slightly different type of knowledge when they are asked through a verbal report or when they are presented with any other kind of forced-choice discrimination test. Thus, associations or dissociations between measures can be produced by differences on many other dimensions, and they would only have some bearing on the question of whether they reflect conscious versus unconscious knowledge if they may be assumed to be completely comparable in all other respects.

Shanks and St. John (1994) have referred to these problems by stating that any dissociation procedure must fulfill both "information" and "sensitivity" criteria in order to be informative on the existence of implicit learning. By the information criterion, they meant that the measure of awareness must be sensitive to the same conscious knowledge that may have affected the measure

of performance. By the sensitivity criterion, they referred to the fact that the test of awareness must be sensitive to all of the relevant conscious knowledge. The problem with this second criterion is that it is unclear what the authors meant by the word "relevant" in the above expression. It appears that it can only stand for "the conscious knowledge that may have affected the measure of performance". If that is the case, then one can combine the requirements implied by both criteria, by stating that "the measure of awareness should express all and the same effects that may have been produced by conscious knowledge on the measure of performance".

This requirement seems to be much more stringent than what is usually accepted in the implicit learning literature. In addition, when it is combined with the fact that we do not know which portion of the variance associated to the measure of performance is determined by conscious knowledge, then a specific problem arises because the goal of making both measures equally sensitive to the same conscious knowledge can only be achieved at the cost of making them completely equivalent—a requirement that makes the dissociation paradigm meaningless. This paradox may describe what has happened with the artificial-grammar learning paradigm, where a progressive convergence of the measures used to assess awareness and classification performance has resulted in the unsurprising extinction of dissociation effects (e.g., Dienes et al., 1991).

Third Scenario: An Explicit Assumption Instead of a Pure Measure

To avoid the comparison between measures of performance and measures of awareness to become a meaningless test-retest reliability assessment, it is thus necessary to move to a third scenario (see Figure 1c), in which the idea that one can identify pure measures of awareness should be abandoned in favor of the search for some minimal operational definition of this term. Such an operational definition can enable researchers to identify a single dimension of variability that may be taken a priori as relevant to the conscious versus unconscious distinction. Comparisons between measures that differ exclusively in that dimension can then be informative about the existence of unconscious knowledge, even though none of them is taken to rely exclusively on conscious knowledge.

What could this operational definition be? Some authors have claimed that a good starting point may be the common-sense notion that the best way to assess awareness consists of asking people to describe what they are aware of. From this perspective, awareness is related to intentional, controlled responding (e.g., Jacoby, 1991; Reingold & Merikle, 1988), so that contrasting experimental situations that differ only in whether participants are intentionally oriented or not to respond based on some target information may be the best

way to learn about the existence of unconscious knowledge.

For instance, Reingold and Merikle (1988) have shown that the existence of unconscious effects can be demonstrated whenever an indirect measure shows greater absolute sensitivity to some relevant knowledge than a comparable direct measure does, provided that one is willing to assume that conscious information should not be better expressed through the indirect measure rather than through a comparable direct measure. The term "indirect measure" refers to any measure of a given discrimination that is obtained in conditions in which participants are not asked to respond based on the target information, whereas a direct measure would be a measure of the same discrimination in which participants are specifically instructed to respond based on such target information. According to the notion of awareness put forward in the previous paragraph, it follows immediately that conscious knowledge can not be better expressed when people are not asked to rely on it rather than when they are instructed to base their responses on precisely that knowledge, so that any greater sensitivity manifested through the indirect measure must be caused by some unconscious influence. This logic has recently been successfully applied in several domains, including unconscious perception (Greenwald, Klinger, & Schuh, 1995; Reingold & Merikle, 1988), implicit memory (Merikle & Reingold, 1991) and also implicit learning (Jiménez et al., 1996).

From a similar perspective, Jacoby and his coworkers (e.g., Jacoby, 1991; Jacoby, Lindsay, & Toth, 1992; Toth, Reingold, & Jacoby, 1994), have proposed a "process dissociation procedure" to contrast what they called intentional and automatic uses of memory. This procedure, however, is somewhat more stringent than the one proposed by Reingold and Merikle (1988), in that it requires the experimenter to assume that only conscious knowledge can be used upon instruction, and that unconscious knowledge exerts the same influence regardless of participants' intentions. If one accepts these assumptions, then a contrast between two situations in which participants are instructed either (i) to take advantage of the information acquired through some previous training to respond to a subsequent task (inclusion conditions), or (ii) to actively suppress any response that is judged as based on such previously acquired information (exclusion conditions), could enable the experimenter not only to demonstrate the existence of automatic effects, but also to estimate their contribution in a given task. Further assumptions are needed to estimate this contribution, such as for instance the assumptions that only the use but not the availability of conscious information does change between conditions, or that intentional and automatic effects are stochastically independent. However, even though these assumptions may be open to questioning (see Buchner, Erdfeiler, & Vaterrodt-Plünnecke, 1995; Cowan & Stadler, 1996; Curran & Hintzman, 1995; Graf & Komatsu, 1994; but also Toth, Reingold, & Jacoby, 1995), obtaining a learning effect in the exclusion

condition could probably be enough to demonstrate the existence of some unconscious knowledge, and would come as close as possible to the goal of using a measure exclusively sensitive to unconscious information.

An Empirical Example and a Conclusion

The kind of experiment that may be envisioned to fulfill the requirements of the process dissociation procedure has not been conducted yet in the context of implicit learning, but there is an experiment conducted in the context of a sequence learning paradigm (Jiménez et al., 1996) that has been specifically arranged to fulfill the requirements of the approach advocated by Reingold and Merikle (1988). To end this article, I would like to briefly refer to this study, as a way to illustrate how a typical implicit learning paradigm could deal with these constraints.

In that study, participants were presented with a typical serial reaction-time task, in which the target stimulus could appear on each trial at one of six different locations arranged through the horizontal axis of a computer display. The task was simply to respond as fast and as accurately as possible to the current location of the target, by pressing the corresponding key. Unknown to participants, the sequence of locations followed a probabilistic structure, that was generated by following a finite-state grammar, and by interspersing a proportion of random trials with the structured material. The use of this complex sequential structure was decided so as to minimize the efficiency of any hypotheses-driven type of learning, and to enable the use of both long periods of training and highly sensitive measures of performance. Each participant completed 20 sessions of training, and measures of performance were obtained separately for each sequential regularity, and averaged through a great number of trials.

With this experimental setting, the authors compared the sensitivity of two similar measures of the discrimination attained by participants at the end of the training between predictable and unpredictable trials. These two measures were selected so as to comply with the constraint that they would be as similar as possible to each other in all their relevant aspects, with the exception that one of them was an indirect measure of that discrimination, while the other was a direct measure of the same knowledge. Specifically, the indirect measures assessed participants' discrimination by comparing reaction times to each of the sequentially predictable or unpredictable locations during the choice reaction-time task, in terms of the specific context provided by the locations at which the stimulus had appeared during a number of previous trials. The direct measure evaluated the same discrimination in the course of a subsequent generation task, by directly asking participants to predict next location, and

comparing the relative proportion of generation trials on which each of these sequentially predictable or unpredictable locations were generated, in terms of the context provided by the previous locations at which the stimulus had appeared. The procedural details of these two measures were kept as similar as possible, in order to fulfil the essential requirements of the approach. The results showed that, although both types of measures provided results that were moderately correlated, and revealed participants' sensitivity to the same order of sequential information—i.e., they both showed that participants were able to anticipate successors of contexts composed by up to two previous trials—significant partial correlations were also observed between the structure of the sequence and the results obtained through the indirect measures, that could not be explained through the knowledge manifested through the direct measure. In other words, the results of these analyses showed that there was a significant part of the learned structure that was exclusively expressed through the indirect measure.

These results have been thoroughly discussed by Jiménez et al. (1996), and have been taken to indicate that at least some part of the knowledge manifested under these circumstances must be considered as unconscious knowledge. The final question, though, is whether this demonstration of unconscious knowledge can safely be taken as a demonstration of implicit learning in the sense that has been maintained throughout the first section of this paper. Indeed, I can think of three reasons to endorse such a conclusion. First, the use of very difficult, probabilistic contingencies constitutes in itself a guarantee that learning was incidental, because even if participants became aware of a reduced portion of them, this conscious knowledge would have been invalidated by many random trials, hence discouraging participants from maintaining a permanent, intentional orientation to learn. This reasoning is confirmed by a second source of evidence reported in the same study, which showed that participants that had been given intentional instructions did not perform any better than incidental learners. Even though such a pattern of results can tentatively be accounted for by assuming that participants in the incidental condition had become aware of a significant part of these contingencies, and then started behaving as intentional learners, the very nature of the sequential structure strongly favors the alternative accounts that either (i) participants in the intentional condition obtained no advantage from their breaking-code strategy despite obeying the searching instructions; or (ii) participants realized that their searching efforts were doomed to failure, and hence started to act as incidental learners. In any of these two cases, the observed equivalence between intentional and incidental conditions may be taken to indicate that either learning was incidental in both groups, or it was independent from participants' orientation to learn.

Finally, a third and fundamental reason to endorse the claim that learning was implicit in this paradigm comes from the very fact that some of its results

have been demonstrated to be unconscious. Even though I have taken care in avoiding a conceptual identification between implicit learning and learning of unconscious knowledge, I have also pointed out that demonstrating the acquisition of some unconscious knowledge may be a good way to accomplish an empirical demonstration of implicit learning, if we just assume that intentional learning processes can not directly give place to unconscious knowledge.

Of course, there may be some alternative ways of accomplishing such a demonstration, depending on the assumptions that one is willing to accept. For instance, if one accepts that non-intentional learning must be effortless, then a simple alternative may consider this learning to be any form of learning that is not subject to interference in dual-task manipulations (e.g., Frensch, in press). A definition like that has been sustained on pragmatic grounds, as a way to circumvent the thorny issues concerning the measure of awareness. However, it is easy to show that such an operational definition is in fact not as simple as it may appear. Indeed, a definition like that would be satisfied whenever a measure of learning produces results that are equivalent regardless of whether participants are trained under single-task or under dual-task conditions. But measures of learning are not necessarily process-pure, and thus they could reflect a blend of the results of both implicit and explicit processes. Under these circumstances, and given that explicit learning effects do indeed depend on the availability of attentional resources, an empirical difference between the levels of performance observed under these two conditions may simply arise because the effects of implicit learning are mixed with those produced by explicit strategies. Again, therefore, to demonstrate implicit learning according to this framework one needs a preparation that uses complex contingencies to prevent participants from becoming aware of a significant part of them, and that assesses whether the acquisition of such conscious knowledge may have oriented participants toward the use of some conscious analytical strategies. And hence awareness enters the picture again...

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