Implicit Learning

Methodological Issues and Evidence of Unique Characteristics

Jonathan M. Reed
Peder J. Johnson

This chapter begins with a discussion of what we think is a central issue in implicit learning research. Our intent here is to clarify what is implied by the statement, "learning requires consciousness." In the next section, we define two a priori hypotheses a researcher may adopt in investigating the role of consciousness in learning. We discuss how there has been a bias favoring the hypothesis that learning does require consciousness (referred to as the explicit hypothesis) and go on to critique the basis for this assumption. This is followed by a discussion of how the explicit hypothesis has influenced the interpretation of findings in the implicit learning literature. This sets the stage for the final section of the chapter, which describes a series of recently completed experiments conducted so as to characterize implicit learning, in an attempt to more clearly distinguish it from explicit learning.

WHAT IS AT ISSUE?

What is at issue in the implicit learning literature is whether learning requires consciousness. As perhaps most readers are aware, this issue has
been the subject of a great deal of controversy in the recent literature. It is our contention that most, if not all, of this controversy stems from two problems. One is related to whether participants in this controversy adopt a first- or third-person perspective regarding the role of consciousness, and the other concerns the ambiguity of all three concepts in the statement learning requires consciousness.

First- Versus Third-Person Perspectives

We can view consciousness either from a first-person perspective (how the world appears from the subject's point of view) or from a third-person perspective (how events relating to the subject appear to an external observer, such as the experimenter). In writing this chapter from the perspective of researchers investigating implicit learning, we assumed that we should take a third-person perspective. In doing so, we quite likely stacked the deck toward concluding that consciousness does not play an important role in learning. This becomes quite apparent in the context of the peer commentary to Velman (1991). Velman explicitly adopts a third-person perspective in concluding that consciousness appears to have no causal influences on any cognitive process, from perceptual encoding to problem solving and decision making.

Several of the commentaries that disagree most strongly with Velman's (1991) conclusion often take a first-person perspective. A good example of this is Mackay's (1991) claim that consciousness is king in the sense that it "issues the commands," "sets the goals," and then steps aside to allow the nervous system to implement the details that result in the intended action. Or so it appears from the first-person perspective. It should not surprise us that from the first-person perspective, where we use conscious introspection to reveal the role of consciousness, our consciousness tells us it is omniscient. Given its limited access to cognitive processing, it is difficult to imagine what else we could have expected.

However, from the third-person perspective, it is not at all clear that consciousness is king. Rather, we must ask Mackay (1991) how consciousness sets goals and issues commands and why such functions could not be performed by the brain. From this third-person perspective, the role of consciousness to be greatly diminished as a causal agent in cognitive processing. In fact Baars (1991), in his peer commentary to Velman's (1991) article, states that Velman's conclusion regarding the role of con-
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Sciousness may be more a matter of his pretheoretical assumptions than the empirical findings. In effect, Baars is telling us that the issue regarding the role of consciousness in any cognitive process may become a metaphor, once one takes a third-person perspective.

- The Meaning of Learning Requires Consciousness

Much of the debate surrounding implicit learning has centered around a few methodological issues. Much of this controversy stems from the ambiguity of what is meant by learning, requires, and consciousness in the statement, learning requires consciousness. Unless each of these concepts is clearly defined, it is unlikely that the evidence for or against implicit learning can be considered in a coherent manner. Here we define what we mean by learning, requires, and consciousness in the context of the implicit learning literature.

WHAT IS MEANT BY LEARNING?

Statements in the literature regarding the evidence for implicit learning have ranged from claims that there is no evidence of any implicit learning, thereby implying that all learning is explicit (Dulany, 1991), to claims that a wide range of tasks, including abstract rules, can be learned implicitly (Reber, 1989). Between these extremes, some researchers have claimed that only certain very limited types of simple events may be learned implicitly (Perruchet & Amorim, 1992; Shanks & Johnstone, Chapter 16, this volume), whereas others have allowed that procedural types of knowledge may be acquired implicitly (Mandler, Nakamura, & Van Zandt, 1987, Squire, 1987). Interestingly, we have not found anyone claiming that all learning is implicit and that there is no explicit learning.

For purposes of this chapter, we define learning as acquiring an association that is at least of the complexity of the second-order conditional (SOC) learning we demonstrated in an earlier work (Reed & Johnson, 1994a). Here, using a serial location reaction-time task, we found that subjects were able to learn target locations that were determined by the previous two locations. Later, we discuss the methods and findings of this study in greater detail, but for the moment, we can think of this as a type of configural procedural learning.

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WHAT IS MEANT BY REQUIRED?

There are two obvious interpretations of what is implied by the verb required in the statement, learning requires consciousness. One, which we may consider the strong interpretation, is that consciousness enters into the process of learning and plays a causal role. The other, the weak interpretation, is that consciousness often or always accompanies learning, and in this sense, it could be said to be "empirically necessary." In this role, consciousness functions more as a placeholder, distinguishing those processes that are accompanied by consciousness from those that are not.

It is important to be clear that in the case of the weak interpretation, consciousness does not enter into the process of learning, nor does it play a causal role. Consciousness, from this perspective is epiphenomenal as it relates to learning.

Therefore, there would be no necessity to include consciousness in our models of learning. Perhaps this explains Stanovich's (1991) observation that there does not exist one single model in cognitive psychology where consciousness plays a necessary role. Only the strong interpretation has empirical implications that could potentially lead to a better understanding of learning. Thus, we shall interpret the phrase learning requires consciousness to imply that what is at issue is whether consciousness enters into the process of learning as a causal agent.

WHAT IS MEANT BY CONSCIOUSNESS?

When viewed from various perspectives, ranging from folk psychology to philosophy of mind to cognitive psychology and neuroscience, consciousness appears as a morganel concept taking on a hopeless variety of meanings. However, as studied in the context of implicit learning, consciousness is typically viewed as a state of awareness. It is within this restricted sense of consciousness that we discuss two properties of its meaning that have contributed to the controversy regarding its influence on learning.

Process vs. Product. First, do we view consciousness as a product or process; and second, if viewed as a process, can consciousness be dissociated from other cognitive processes, such as focal attentive processing, that it may cavort with? To the extent that consciousness is viewed as awareness, it suggests that it may be difficult to separate consciousness from the product.
that is the content of awareness. It is difficult to think of awareness in the absence of content. Research findings, such as those reported by Lihert (1985), suggest that consciousness is the consequence or product of the extensive unconscious neural processing that preceded it. This is consistent with the widely held notion of large-scale preattentive processing preceding the occurrence of conscious perception (Neisser, 1967).

Viewed as a product, we are probably less inclined to think of consciousness as exerting a causal influence. However, it remains possible that once an event becomes a conscious product, it is processed differently than if it had not become conscious. For example, Rozin (1976) has speculated that conscious events are broadcast more extensively throughout the information-processing system. In this manner, the product may influence the process and could be said to be part of the causal chain.

We shall take the view that consciousness in the statement learning requires consciousness is only theoretically interesting when it is assumed that consciousness "enters into processing." If viewed exclusively as a product, it is only implied that we may become aware of the consequences of learning. There are probably few who would disagree with such a claim.

Dissociation of Consciousness

Proceeding on the assumption that consciousness is a process (or that it at least can enter into a process), we now consider whether this process can be dissociated from the other processes it may covary with. If the concept of consciousness carries with it the meaning of all the concepts that covary with it, it would seem rather pointless to debate the role of consciousness in any cognitive function. This issue whether we are thinking of information-processing concepts such as focal-attentive processing (Velmans, 1991) or neural systems such as levels of activation in the hippocampus (Moscovitch, 1994). Questioning the role of consciousness in learning does not require one to also question the role of focal-attentive processing or the hippocampus.

For this reason, it is necessary that we restrict the definition of consciousness to awareness and show that awareness can be dissociated from other correlated processes that may play a causal role in learning. To illustrate this point, there is abundant evidence that focal-attentive processing can be dissociated from awareness. This perhaps is most clearly demonstrated with so-called preattentive processes such as perceptual encoding.
which is generally agreed to be unconscious but has been demonstrated to require attentional resources (e.g., Johnson, Foresar, Calderwood, & Weigelt, 1983; Paap & Ogden, 1997). Later in this chapter, we present some findings that extend this dissociation to implicit learning. The important implication of these and similar findings is that once focal attentive processing has been dissociated from awareness, it becomes the responsibility of those who believe them to be one and the same to provide evidence to support that view. We conclude this section, proposing that for purposes of evaluating the claim that learning requires consciousness, we restate the definition of consciousness to awareness.

Summary

We can now restate with a greater degree of clarity what we propose is at issue in the implicit learning literature. The claim that learning requires consciousness is interpreted to imply that to learn something as complex as SOC sequences, it is necessary for awareness to enter into the learning process.

CHOOSING AN A PRIORI HYPOTHESIS

Having defined what is at issue regarding the role of consciousness in learning, researchers may proceed by framing the issue in terms of one of two working hypotheses. They may either adopt the implicit default hypothesis that learning does not require consciousness, and this view will be held until there is compelling evidence to the contrary. Alternatively, they may adopt the explicit default hypothesis that learning does require consciousness and maintain this view until there is contradictory evidence. In this section, we argue that there has been a strong tendency for researchers to adopt the explicit default hypothesis and that this choice has largely been based on a posthomicetic first-person perspective that assumes the primacy of conscious over unconscious processing. We shall refer to this view as the consciousness as king (CASK) assumption. We go on, in the next section, to show that opting for the explicit default hypothesis has had a profound influence on how research findings on implicit learning have been interpreted.

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The "Consciousness as King" Assumption

In examining the cognitive literature over the past several decades, there appears a consistent skepticism regarding virtually all evidence of unconscious processing (e.g., Ericksen, 1960; Shanks & St. John, 1994). This skepticism regarding unconscious processing seems to go hand-in-hand with an aversion to the view that consciousness maybe epiphenomenal (see peer commentary to Velmaan, 1991). We introduce the Cask assumption to reflect this perspective. We can only speculate as to the roots of Cask in cognitive psychology. The skepticism regarding unconscious processing may reflect a reaction to psychoanalytic theory, and the rejection of epiphenomenalism may reflect a reaction to behaviorism. More likely, both views reflect the trickle of first-person perspective into what is essentially a third-person approach.

Cask manifests itself in its most subtle form in folk psychology. In its full-blown "person-on-the-street" manifestation, it entails the first-person perspective that we have conscious access and control over all important cognitive processes. We are, indeed, the captains of our ships. This view, as noted earlier, is supported by an insidious trick that consciousness plays when we introspect about what determines our thinking and behavior. Not surprisingly, we find that we are consciously aware of all influential factors.

We assume that most cognitive psychologists are well-aware of the pitfalls of attempting to introspect upon motives and cognitive processes (Nisbett & Wilson, 1977). Moreover, most would be quick to agree that there is more to cognitive processes than meets the conscious eye. However, from an examination of the content of the peer commentary to Velmaan's (1991) article, there is clearly an attitude that a third-person perspective necessarily denies the validity of a first-person perspective. We do not have the space to discuss this issue here but refer you to Velmaan's response to the peer commentary. The upshot of his reply is that taking a third-person perspective toward understanding the role of consciousness in information processing does not require one to reject the importance of the first-person perspective in achieving a more complete understanding of cognition. One can deny the causal role of consciousness from a third-person perspective without endangering an epiphenomenal view of consciousness.
The Case for the Explicit Default Hypothesis

The importance of Cask to implicit learning research is that it promotes a preference for the default hypothesis that learning requires consciousness. This is seen most clearly in the arguments against unconscious processing, which on occasion have been stated so strongly as to suggest that proponents of the view that some processing may occur without consciousness are of dubious scientific credibility (Dulany, 1991). More specifically, as this view pertains to learning, it is claimed that learning requires consciousness and that claims to the contrary are unsubstantiated by empirical evidence (e.g., Dulany, Carlson, & Dewey, 1984; Perruchet, Gallese, & Savoy, 1990; Shanks & St. John, 1994). Proponents of this view are particularly critical of the methods employed in demonstrations of implicit learning. The criticisms primarily focus on whether the tests of awareness were sufficiently sensitive. Clearly, we all support the most rigorous application of available scientific methods. But this is a two-edged sword and must be applied equally to both default hypotheses (Reingold & Merikle, 1990). We discuss this problem in some detail later in the chapter. At this juncture, we only wish to make the point that there has been a far greater concern about conscious processing contaminating implicit learning than about unconscious information contaminating conscious performance.

The Case for the Implicit Default Hypothesis

Here we make the case that the implicit default is the most reasonable of the two a priori hypotheses. To begin with, the preference for the explicit default is largely based on the Cask assumption, which assumes a first-person perspective that is inappropriate in the context of the present controversy, which concerns the empirical (third-person perspective) evidence for implicit learning.

Second, we believe that the plausibility of the explicit hypothesis was largely based on a misunderstanding regarding what is at issue regarding implicit learning. If all that was being claimed is that awareness accompanies learning, it is understandable how first-person knowledge may be marshaled to support this claim. However, if what is at issue is whether awareness is a necessary antecedent for learning to occur, it seems far less self-evident that this is, indeed, the case.

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Third, parsimony alone would dictate that it would be more reasonable to begin with the assumption that animate systems, from flatworms to humans, are all capable of learning without awareness. After all, as noted earlier, there is good evidence that numerous other cognitive processes appear to function without the benefit of consciousness (e.g., preattentive processes, Winner, 1967; implicit memory, Schacter, 1987). Why, other than the subjective experience that learning is usually accompanied by conscious awareness, would it be the case that consciousness is required for learning? It may be reasonable to conclude that certain kinds of learning require consciousness, but only when there are compelling theoretical and empirical reasons for making exceptions to this generalization.

It might be countered that it would be more parsimonious to begin with the assumption that all human learning requires consciousness because we already know that some human learning requires consciousness. Once again, although there is evidence, as in the classical conditioning literature (e.g., Brewer, 1974), that learning only occurs when there is awareness of the conditioned stimulus-unconditioned stimulus contingency, this only involves a correlation; it does not tell us that awareness enters into the processing to play a causal role.

Fourth, the explicit hypothesis introduces dualist-interactionism issues. If it is being claimed that consciousness does play a causal role in learning, now does consciousness, a mental process, interact with the brain to produce behavioral effects? More likely, it is not being proposed that consciousness plays a direct causal role but rather functions as a placeholder (e.g., consciousness is indicative of hippocampal processing). If this is what is being proposed, then the claim that consciousness is critical only begs the question of what are the mechanisms (ideally in terms of a model) by which consciousness influences the learning process. However, once these mechanisms have been identified, we would no longer refer to the role of consciousness in the same manner.

Fifth, if consciousness is necessary for learning, we should expect to see it playing an explicit role in our theories of learning. This, however, does not appear to be the case, as evidenced by Stanovich's (1991) observation that "there does not exist one single model in cognitive psychology where 'consciousness' plays a necessary theoretical role" (p. 696). Although consciousness is often alluded to, as in Atkinson and Shiffrin's (1968) notion of controlled processing, consciousness-related mechanisms or processes play the critical roles and not consciousness itself.
Finally, and possibly at the crux of the issue, what legitimate inferences regarding the role of consciousness in learning can be made, given the available methods and results from implicit learning studies? Our conclusions regarding the role of consciousness are based on the results of some direct test that informs us regarding conscious access to information learned as a consequence of previous training. If direct test performance is above some baseline control, we conclude that subjects have some awareness of what they learned. Once again, we only have a correlation between learning and awareness. When detected, such a correlation may have resulted due to the fact that awareness was a product or consequence of the learning. The results certainly cannot be taken to necessarily imply that awareness was necessary for the learning to have occurred.

On the other hand, if the results from the direct test fail to show any evidence of awareness, we may be in a stronger position to conclude that awareness is not always necessary for learning to occur. This point will be discussed in greater detail later in the chapter; however, on the basis of what has been presented thus far, it appears that the implicit default hypothesis is more amenable to empirical testing than the explicit default hypothesis.

In conclusion, we find no compelling reason to approach implicit learning research with the assumption that learning requires consciousness. Rather, we find a number of factors suggesting that it would be far more reasonable to approach the area with the assumption that awareness may not be necessary for learning to occur.

**INFLUENCE OF THE EXPLICIT HYPOTHESIS ON IMPLICIT LEARNING RESEARCH**

The preceding discussion of the C&K assumption and its influence on the selection of an appropriate default hypothesis is relevant to the manner in which research on implicit learning has been conducted. This section focuses upon discussion of three methodological issues that have been viewed as often (if not always) underdetermined research that has been interpreted by some as evidence of implicit learning. We discuss these issues as they relate to the C&K assumption and conclude by presenting the general methodological approach we adopted in conducting the research described in the final section of this chapter.

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The Task-Dissociation Method

Cognitive psychologists have usually employed the task-dissociation methodology to investigate implicit learning. This paradigm requires that subjects engage in a task during which they are exposed to potentially learnable information that could be used to enhance performance. Next, learning of the task-embedded information (about which subjects have remained uninformed) is assessed using both indirect and direct tests. Direct tests encourage performance based on consciously available information, and indirect tests avoid encouraging the use of conscious knowledge. Implicit learning is demonstrated when indirect tests indicate that learning has occurred, whereas direct tests do not.

The procedure used by Cohen, Iver, and Keеле (1990) illustrates the task-dissociation method. Subjects pressed keys corresponding to the locations of serially presented visual targets as they appeared in one of several positions on a computer screen. Response latencies of subjects trained on a repeating sequence became faster with practice and then slowed significantly when a series of random target locations were introduced. This negative transfer effect, a type of indirect test, was interpreted as evidence that subjects had learned about the sequence, and subsequent direct tests of conscious awareness indicated that the learning was implicit.

Task dissociations have been presented as evidence of implicit learning of diverse types of information (e.g., sequence structures, Reber & Squire, 1994; the complex rules used to construct "legal" or "grammatical" letter strings, Reber, 1989; and the critical relationships among inputs and outputs in artificial control systems, Berry & Broadbent, 1988). Usually, however, task dissociations have not been considered strong demonstrations of implicit learning. This is because dissociative performance on indirect and direct tests can result for a number of reasons and therefore cannot always be considered compelling evidence for implicit learning. We consider three situations in which one would expect to observe task dissociations that might be interpreted inaccurately as evidence for implicit learning.

CONSTRaining MEASURES OF LEARNING

Researchers are often interested in examining the implicit acquisition of particular types of information. However, in providing subjects with the opportunity to learn, it is usually not possible to present the information...
of interest in isolation. If subjects have been exposed to multiple sources of information, then measures of learning might reflect the acquisition of some or all of the available information. That is, it may not be possible to specify which type of information has been learned.

Consider a study in which subjects trained on a serial reaction time (SRT) task that involved the use of sequences of predictable and unpredictable trials (Lewicki, Hill, & Bazot, 1988). Because response latencies for the predictable subsequences decreased with training and those associated with unpredictable subsequences did not, Lewicki et al. concluded that subjects had learned the rules of predictable subsequence construction. Because subjects could not articulate these rules, it was concluded that they had been acquired implicitly. In a replication study, however, Perruchet et al. (1990) demonstrated that all of the improvement in response latencies occurred for those movements that had a relatively high probability in the predictable subsequences. Because the indirect measure of learning was not sufficiently constrained in the original study, it was not possible to determine which type of information had been learned.

Task dissociations that reflect the sensitivity of indirect and direct tests to different types of information do not provide evidence for implicit learning (Shanks & St. John, 1994). In contrast, if indirect and direct tests are constrained such that they are sensitive to the learning of the same type of information, task dissociations may reflect implicit learning. For example, Reed and Johnson (1994a) gave subjects extensive training on an SRT task that exposed them to a variety of information. Afterward, subjects continued to perform the SRT task for a series of transfer trials in which the probabilistic structure of the original sequence was maintained. It was, therefore, possible to specifically attribute the RT disruption associated with the sequence change to the learning of the manipulated information.

In addition, the direct tests were designed to assess explicit awareness of the same information. Thus, because the dissociation between performance on the two types of learning measures was not attributable to differences in the types of information to which they were sensitive, the results were interpretable as a demonstration of implicit learning.1

It is possible that task dissociations reflect the sensitivity of indirect and direct tests to different types of information whenever ambiguity exists regarding the type of information accessed by the two types of learning measures. It is interesting to note that although researchers have often expressed concern regarding such ambiguity involving the interpretation
of indirect measures of learning (Perruchet, Gallego, & Pacteau, 1992; Shanks & St. John, 1994), this concern has not always been adequately focused on the use of direct measures of learning. For example, Perruchet and Amorim (1992) used a direct test of sequence learning (i.e., the free-generation task) in which subjects made a series of 100 key presses after having been instructed to repeatedly reproduce the sequence of target locations encountered during SRT training trials. It was found that sequence-trained subjects produced certain chunks of the training sequence more reliably than subjects who had received random training trials. It was concluded, therefore, that indirect measures of learning actually reflected explicit rather than implicit learning of these sequence chunks. The manner in which the free-generation task was employed, however, does not necessitate such an interpretation.

Subjects in the random training condition were likely to have been exposed to different probabilistic information than those who trained with the repeating sequence (Reed & Johnson, 1994a). Because of the unconstrained nature of the free-generation task, performance on this direct test may have reflected the acquisition of such nondeterministic structure rather than explicit learning of sequence chunks.

To test this hypothesis, we engaged two groups of subjects in the SRT task. One group received training with a repeating sequence, and the other trained on a series of nonrepeating trials that shared the same probabilistic structure as the sequence encountered by the first group (i.e., nonrandom training). For both groups, SRT training was followed by the completion of the free-generation task. We found that although sequence-trained subjects did produce certain sequence chunks more often than those who trained with the nonrepeating trials, other chunks were reproduced more reliably by subjects who trained with nonrepeating trials. This pattern of results indicates that when free-generation task performance is not compared between groups of subjects that have been exposed to the same probabilistic information, differences in performance do not necessarily inform one regarding the acquisition of consciously available deterministic sequence structure.

In general, like indirect tests, direct tests can be insufficiently constrained in that they may be free to reflect the learning of more than one type of information. Therefore, in order to appropriately interpret comparisons of performance on indirect and direct tests, both types of learning measures need to be constrained so as to measure the learning of the same
type of information. This principle applies equally to situations in which task dissociations are observed and those in which they are not.

SIMILARITY OF TESTING CONTEXTS

Task dissociations can also be anticipated when direct and indirect tests differ in relation to the extent to which they allow individuals to express what they have learned. Typically, critics of implicit learning research have focused upon the suggestion that studies of implicit learning often involve direct tests that are insufficiently sensitive to explicit knowledge (Holender, 1986; Reingold & Merikle, 1990; Shanks & St. John, 1994). For example, when subjects' verbal reports of explicit knowledge acquired during the performance of a nonverbal task are used as measures of explicit knowledge (Nissen & Bullement, 1987), observed task dissociations may reflect the relative insensitivity of the direct test to the acquired knowledge and not necessarily implicit learning.

In general, direct tests that do not maintain the experimental context encountered during training are likely to be undersensitive to explicit awareness (Schacht & Graf, 1986; Shanks & St. John, 1994). Therefore, researchers have begun using direct measures that provide performance contexts that closely match those of indirect tests (e.g., Cohen et al., 1990; Stadler, 1989). For example, Reed and Johnson (1994a) used a recognition test of sequence structure that involved a retrieval context that closely matched that of the indirect test. On each recognition-test trial, subjects performed the SRT for a small number of trials and then rated the series of target locations as either part of the original sequence (old) or not (new). Thus, the context in which the direct test was performed was similar to that of the indirect test.

If direct and indirect tests provide similar retrieval contexts, task dis- sociations are less likely to reflect the undersensitivity of direct tests to explicit knowledge. On the other hand, when the retrieval context associated with a direct test is highly similar to that of the indirect test, the direct test may be oversensitive to implicit knowledge (Richardson-Klavehn & Bjork, 1988). Using a direct test that is oversensitive to implicit knowledge could result in the failure to observe a task dissociation and lead to the inappropriate conclusion that all learning was explicit.

The selection of an appropriate direct test depends upon ensuring that the associated retrieval context is similar enough to that of the indirect tests

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to allow for full expression of explicit knowledge, while not allowing the measure to reflect the expression of implicit knowledge. In the strictest sense, direct tests used to be exclusively and exhaustively sensitive to consciously available information (Reingold & Merikle, 1990). Unfortunately, it's never possible to be confident that one has employed measures of learning that satisfy these criteria. Therefore, in evaluating the evidence for implicit learning resulting from studies that employ the task dissociation method, one must decide whether a direct test has met these criteria to a reasonable degree.

We expect that, at least in part, how well one believes the use of a particular direct test comes to achieving these ends will depend upon the particular theoretical perspective adopted by the reader. If one is invested in a perspective that assumes that all learning is accompanied by awareness, then task dissociations are likely to be viewed as resulting from the use of a direct test that is insensitive to the relevant consciously available knowledge (i.e., the test failed to meet the exhaustiveness criteria). In contrast, if one adopts the view that learning does not require conscious awareness, the lack of a task dissociation might be interpreted as resulting from the use of a direct test that was oversensitive to the influence of implicit knowledge (i.e., the test failed to meet the exclusivity criterion).

In the studies described later, we attempted to adopt a middle-ground perspective with respect to this issue. Direct tests were designed to maintain performance contexts that were highly similar to those of indirect tests, but subjects were instructed to perform the tasks based upon consciously available knowledge. We rely on the reader to judge the adequacy of this approach, but we hope that caution will be exercised in doing so, such that verdicts are not based solely upon preconceptions regarding the cognitive unconscious.

TEMPORAL APPROPRIATENESS OF DIRECT TESTS

A final methodological issue that we consider involves decisions regarding the appropriate point in time at which direct tests should be administered. Assuming that one is confident that direct and indirect tests have measured learning of the same information, and that the direct test employed was appropriately sensitive, the interpretation of an observed task dissociation remains somewhat ambiguous. This is because one could claim that learning was explicit but that subjects lost conscious awareness of the acquired information prior to the administration of the direct test.

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How might one address such a criticism? One approach would be to administer the direct test after less exposure to the learned information and look for evidence of explicit knowledge at earlier points in time. Assume that this approach was taken and that the direct test was administered at a number of earlier time points. If in every case no evidence of explicit knowledge was obtained, would this demonstration provide unequivocal evidence of implicit learning? It would not, because, if so inclined, one could simply suggest that the particular times at which the direct tests were administered remained inappropriate.

Without supporting empirical evidence, reliance upon arguments of this sort belies the bias inherent in the adoption of the CsK assumption. In addition, the pervasiveness of the CsK assumption appears to have obscured the dual implications of this argument. If one were to assume that awareness is inessential to learning, the same argument could be used to undermine demonstrations of explicit learning. That is, if appropriate direct and indirect tests each provided evidence of learning (i.e., no task dissociation was observed), one could argue that learning occurred implicitly but that subjects acquired awareness of the information at some time prior to the administration of the direct test.

How temporally appropriate one deems the administration of a direct test to be is likely to depend upon which default hypothesis is adopted. If one adopts the CsK assumption, then direct tests are likely to be considered temporally appropriate only when a task dissociation is not observed. Alternatively, if one assumes that awareness is inessential to learning, then direct tests will be seen as temporally appropriate only when task dissociations are observed. In the absence of a clear solution to this problem, we have proceeded with our research by adopting the following perspective:

We assume neither that all learning is implicit nor that all learning is explicit. In addition, we suggest that those who adopt the CsK assumption are faced with the challenge of providing a demonstration of explicit learning that can meet all of the criteria usually reserved for judging the soundness of demonstrations of implicit learning.

Comments on Methodology

As the above discussion suggests, methodological inadequacies can be viewed as prohibiting one from confidently concluding that task dissociations provide evidence for implicit learning. Nevertheless, when these methodological shortcomings are avoided, task dissociations can be
interpreted as reflecting implicit learning with greater certainty. With this assumption in mind, we have conducted numerous studies in an attempt to characterize implicit learning processes. This research, described in the next section, was conducted by adhering to the following guidelines.

First, we attempted to use experimental procedures that would satisfy the information criterion (Shanks & St. John, 1994). That is, in every case, the indirect and direct tests were constrained such that we were confident that each test measured the particular information in which we were interested. Second, direct tests were designed so as to recreate the retrieval context associated with the indirect tests and thereby provide sensitive tests of explicit knowledge (Schacter & Graf, 1986). Third, we assumed that the amount of exposure to information that subjects received was insufficient to result in the proceduralization of explicit knowledge and therefore that subjects were not likely to have lost conscious access to explicitly acquired information prior to performing the direct tests. Fourth, the experimental circumstances treated in these studies were intended to maximize the opportunity to observe implicit learning. This was done by making a secondary tone-counting task (Cohen et al., 1990) an integral part of the procedures used in all the experimental conditions, with one exception. By including the secondary task, we hoped to prevent the content of learning from becoming consciously available (Reed & Johnson, 1994a) and thereby to maximize the opportunities for observing implicit learning. Finally, and more generally, we attempted to work from a theoretical perspective that was broad enough to allow for the possibility of implicit learning, while recognizing the importance of the methodological issues discussed above.

**CHARACTERIZING IMPLICIT LEARNING**

Reber (1989, 1992) has described implicit learning as a relatively automatic process whereby perceptual regularities (often highly complex) are abstracted from the environment without conscious awareness. Although the results of numerous studies have been interpreted as being consistent with various aspects of this theoretical characterization (e.g., Reber, 1969), in general, these studies have been criticized in relation to the methodological issues discussed earlier (Shanks & St. John, 1994). We have undertaken the investigation of implicit learning with two primary goals in mind. First, we intended to conduct experiments using procedures that would result in unambiguously interpretable observations. Second, we sought to explore
the nature of implicit learning processes. In particular, we were interested in determining the attentional requirements and complexity-related limits of implicit learning. The remainder of this chapter is devoted to describing these experiments and discussing the implications of their results.

• Attention and Implicit Learning

Secondary tasks have sometimes been employed as a means of manipulating the availability of attentional resources. Some studies indicate that such tasks can interfere with or eliminate implicit learning of complex sequence structures (Coltheart et al., 1990; Nissen & Bullemer, 1987), whereas others have indicated that learning persists during dual-task performance (Kele & Jennings, 1991; Reed & Johnson, 1994a). Alternatively, it has been suggested that dual-task performance specifically interferes with attentionally driven organizational processes required for the learning of certain sequence structures (Stadler, 1993).

In a recent experiment, we manipulated the inclusion of a tone-counting task across conditions to determine whether or not implicit sequence learning is influenced by the availability of processing resources (Reed, Johnson, & Orważay, 1995). Performance on indirect and direct tests of sequence learning was compared across three types of conditions. In some conditions (dual-task), the SRT task was always performed in conjunction with the tone-counting task. In other conditions (single-task), subjects only performed the SRT task. In a third set of conditions (dual-single-task), the tone-counting task was used during most of the SRT trials but not during the last block of training or during transfer trials (i.e., a dual-task learning phase was followed by a single-task testing phase). Each of these types of conditions was associated with either an indirect test (i.e., RT disruptions associated with transfer trials) or a direct test (recognition, Reed & Johnson, 1994a).

The results are summarized in Table 8.1. Disruptions in RTs were significantly greater for the single-task condition compared to the dual-task condition, t(19) = 2.65, p < .05, whereas RT disruptions did not differ reliably between the dual-task and dual-single-task conditions, t(19) = 1.32, p > .05. This outcome indicated that, as assessed by the indirect test, subjects in the dual-task conditions learned less about the sequence structure than those in the single-task condition. In contrast, performance on the direct test indicated that subjects did not acquire explicit awareness of the sequence structure in any of the conditions (i.e., ratings for old and new
### Table 8.1 Summary of Results From Reed, Johnson, and Ottaway (1995)

<table>
<thead>
<tr>
<th>Condition</th>
<th>Mean (SE) RT Disruption</th>
<th>Mean (SE) Ratings for Recognition Items</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Old Trial*</td>
<td>New Trial*</td>
</tr>
<tr>
<td>Single-task, indirect test</td>
<td>130.7 ms (14.06)</td>
<td>NA</td>
</tr>
<tr>
<td>Dual-task, indirect test</td>
<td>76.2 ms (14.22)</td>
<td>NA</td>
</tr>
<tr>
<td>Dual-single-task, indirect test</td>
<td>55.2 ms (5.94)</td>
<td>NA</td>
</tr>
<tr>
<td>Single-task, direct test</td>
<td>NA</td>
<td>2.08 (.06)</td>
</tr>
<tr>
<td>Dual-task, direct test</td>
<td>NA</td>
<td>2.01 (.06)</td>
</tr>
<tr>
<td>Dual-single-task, direct test</td>
<td>2.10 (.10)</td>
<td>2.07 (.10)</td>
</tr>
</tbody>
</table>

**NOTE:** a. Recognition-task ratings represent subjects' judgments of 12 target trade outcomes with the training sequence (1S) and 12 trials not encountered during 1997 training (new) on a 4-point scale (1 = definitely part of original sequence to 4 = definitely not part of original sequence).

recognition-task trials did not differ for any of the conditions, all ps > .05). Thus, although implicit learning occurred in all instances, the inclusion of the secondary task did result in attenuated learning as indirectly measured.

We have also examined the attentional demands of implicit learning using a different type of dual-task paradigm. In particular, we provided subjects with two types of information and determined whether or not the acquisition of one type of information disrupted learning of the other. In the first of these studies, we examined the acquisition of probabilistic structure that accompanied deterministic sequence structure (Reed & Johnson, 1994b). In Reed and Johnson (1994a, Experiment 1) it was demonstrated that probabilistic structure was learned when no deterministic structure was provided. It was, therefore, argued that to accurately assess deterministic structure learning, the probabilistic structure of training and transfer sequences must be equated. This, however, assumed that acquisition of the more useful deterministic structure did not eliminate probabilistic learning.

To test this assumption, we trained subjects with a repeating deterministic sequence structure and then transferred them to a series of non-
repeating trials that provided only probabilistic structure (Reed & Johnson, 1994a). In one condition, the probabilistic structure of the transfer trials was different from that of the training sequence. In the other condition, the probabilistic structure of the transfer sequence was virtually the same as that of the training trials. Learning of the more useful repeating sequence structure during training trials eliminates learning of the less useful probabilistic structure, then one would expect equivalent RT disruptions for both conditions. However, if both types of information are learned concurrently then greater RT disruptions would be expected for the condition in which the probabilistic structure changed. The results were consistent with this latter prediction in that greater mean RT disruptions were observed when the probabilistic structure of the transfer trials was different from those of training trials (97 ms) compared to the condition in which the probabilistic structure was the same during training and transfer (65 ms). Because the training procedures were identical for this experiment and a previous study that demonstrated deterministic learning (Reed & Johnson, 1994a, Experiment 2), we assume that both types of structure were learned concurrently.

An additional study was designed to determine whether or not two different types of deterministic information would be implicitly acquired concurrently (Riedl, 1995, Experiment 8). During an SRT task, subjects indicated the location of a target (square) that appeared in one location of a display that was divided into equal-size quadrants. Each quadrant contained a centered black figure (i.e., target or distractor—circle, triangle, or diamond) presented on a colored background (red, yellow, green, or blue). Subjects were assigned to one of three different conditions. In the sequence learning condition, the target appeared according to a repeating sequence during training trials but according to a new sequence during transfer trials (as in Reed & Johnson, 1994a). In the perceptual learning condition, the target always appeared diagonal to the quadrant with the blue background during training but vertical to blue during transfer trials. 2 In a third condition ( concurrent learning), subjects were exposed to both the repeating sequence and the perceptual relationship during all training trials. Three different types of transfer trials were used in an order that was completely counterbalanced across subjects. The transfer trials measured sequence learning (i.e., the sequence but not the perceptual rule was different from that used during training), perceptual learning (i.e., the perceptual rule but not the sequence was different from that used during
<table>
<thead>
<tr>
<th>Condition</th>
<th>Mean (SEM) Reaction Time Duration</th>
<th>Mean (SEM) Correct Responses on Concept-Rule Trial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rule 1, indirect test</td>
<td>53.0 ms (5.10)</td>
<td>NA</td>
</tr>
<tr>
<td>Rule 2, indirect test</td>
<td>48.6 ms (7.17)</td>
<td>NA</td>
</tr>
<tr>
<td>Rule 3, indirect test</td>
<td>49.6 ms (7.77)</td>
<td>NA</td>
</tr>
<tr>
<td>Rule 1, direct test</td>
<td>NA</td>
<td>5.8 (4.2)</td>
</tr>
<tr>
<td>Rule 2, direct test</td>
<td>NA</td>
<td>5.9 (3.4)</td>
</tr>
<tr>
<td>Rule 3, direct test</td>
<td>NA</td>
<td>5.9 (2.3)</td>
</tr>
</tbody>
</table>

Note: Correct test results represent the number of rule-violating responses made on 24 trials and were compared to chance performance of six correct responses.

Training, or both (i.e., the sequence and perceptual rule were different from those used during training).

RT disruptions associated with the three conditions are presented in Table 8.2. Reliable disruptions were observed for all types of transfer (all ps < .05). However, RT disruptions associated with the introduction of the new sequence were greater when training trials were not consistent with any perceptual rule, t(18) = 3.26, p < .01. Similarly, RT disruptions associated with the change in the perceptual rule were greater when training trials were not consistent with any repeated sequence, t(18) = 2.27, p < .05. These results indicate that both types of determinate information were learned concurrently but that learning of each type of information was attenuated by the presence of the other.

Based on the outcomes of these studies, we draw three primary conclusions. First, multiple types of information can be implicitly acquired simultaneously, even when one type of information is less useful (i.e., probabilistic) or completely redundant with the other. Second, implicit learning processes are influenced by the availability of cognitive resources and therefore cannot be considered automatic in a strict sense (Posner, 1978). Third, because the secondary task influenced implicit learning but not performance on the direct test (see Table 8.3), conscious awareness and attention appear to be at least partially independent.
Complexity and Implicit Learning

Reed and Johnson (1994a) demonstrated implicit learning of a particular type of sequence structure, referred to as SOC structure. Each target location in these sequences was predicted by the two previous locations but not by the previous location alone. This type of sequence structure can be considered complex compared to first-order conditional structures, in which each location is exactly specified by the previous location. Thus, the complexity of sequence structures has been defined in terms of the number of discrete events that need to be considered to correctly anticipate the location of an upcoming target location (cf., Cohen et al., 1990).

Because methodological constraints made further examination of the relationship between implicit learning and sequence-structure complexity unwieldy, we decided to continue our investigation of the complexity-related limitations of implicit learning by employing the perceptual learning task (Reed, 1995, Experiment 1). In particular, we compared implicit and explicit learning of two different perceptual relationships (Reed, 1995, Experiment 2). In the first (Rule 2), the target appeared diagonally to the blue when an upper quadrant was blue, but otherwise appeared vertically to the blue quadrant. In the second (Rule 3), the location of the target was determined by which particular quadrant was blue: The target appeared in the upper-left quadrant if the upper-left quadrant was blue, the target appeared in the lower-right quadrant if the lower-left quadrant was blue, the target appeared in the lower-left quadrant if the lower-right quadrant was blue, and the target appeared in the upper-right quadrant if the lower-left quadrant was blue.

The previously examined relationship (Rule 1) was considered simpler than either of these relationships because only one general rule was needed in order to exactly specify the location of the target based on the color information. Rule 2 was considered more complex because it required the use of two less general subrules, and Rule 3 the most complex because it required four rather specific relationships.

In the implicit learning experiment, subjects were assigned to one of four conditions defined by the particular rule associated with training trials and the type of learning measure used (indirect vs. direct). For indirect test conditions, the perceptual rules never applied during SRT task-transfer trials and RT disruptions were measured. For direct test conditions,
<table>
<thead>
<tr>
<th>Condition</th>
<th>Proportion of Subjects</th>
<th>Mean (SEM) Trials to Criterion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rule 1</td>
<td>19/20</td>
<td>207.8 (43.74)</td>
</tr>
<tr>
<td>Rule 2</td>
<td>7/20</td>
<td>506.8 (54.88)</td>
</tr>
<tr>
<td>Rule 3</td>
<td>1/20</td>
<td>744.4 (31.51)</td>
</tr>
</tbody>
</table>

The cut-recall task described above was employed instead of transfer trials. The results of the experiment are summarized in Table 8.2. For both of the indirect test conditions, reliable RT disruptions were observed (all ps < .03), but subjects never expressed awareness of the perceptual relationships on the direct tests (all ps > .05). Because each consecutive perceptual relationship can be considered increasingly complex, and even the most complex rule was learned, the data suggested that implicit learning processes are powerful in relation to the complexity of the information that is acquired.

In the explicit learning experiment, we encouraged three groups of subjects to intentionally learn one of the three different perceptual rules (Reed, 1995, Experiment 4). On each experimental trial, subjects were presented with four different colored quadrants, and they indicated where they thought the target belonged. After each trial, feedback was provided (correct tone for incorrect responses, but none for correct), and the target appeared in the correct location. Explicit learning of the rules was considered complete when subjects had made 24 consecutive correct responses. The number of trials completed after 45 minutes of training was used if subjects failed to meet the learning criterion within this time.

The results are presented in Table 8.3. Rule 3 required more training trials than Rule 2, t(19) = 3.65, p < .01, and more trials were required for Rule 2 than Rule 1, t(19) = 4.15, p < .001. Also, more subjects learned Rule 1 than Rule 3, and more subjects learned Rule 2 than Rule 3. Thus, the manipulation of rule complexity had a dramatic effect on explicit learning. Comparison of these results and those of the previous experiments suggests that the same manipulation of complexity had a powerful influence upon explicit learning, but none upon the degree of implicit learning.

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Although this conclusion is consistent with the outcome of the two experiments, we doubted this interpretation because each rule appeared to have been implicitly learned equally well (i.e., the RT disruptions did not differ across the three conditions). Whereas we had been prepared to accept the possibility that the most complex rule could be learned implicitly, we did not anticipate a complete lack of an effect of rule complexity upon the indirect measure of learning. That is, because we considered Rule 3 to be sufficiently more complex than Rule 1, we anticipated that if subjects became sensitive to the perceptual consistencies described by Rule 3, learning would not be as great as observed for the other rules.

An alternative explanation of these results requires one to suppose that subjects in the implicit learning conditions had overtrained on the SRT task. If subjects had overlearned the more complex rules, then possible differences in learning across conditions could have been obscured. Therefore, the conditions from the original experiments (Reed, 1993, Experiments 1 and 2) were used in a replication study, but subjects received only half as many training trials (Reed, 1995, Experiment 3). The resulting RT disruptions were reduced (by about 32 ms), but no reliable differences among disruptions were observed, F(2, 57) = .97, p > .05. We, therefore, concluded that the similarity among the magnitudes of the RT disruptions observed in the original experiments was not the result of overlearning but that indeed each perceptual relationship had been learned equally well in the implicit learning conditions.

Such an observation is consistent with Reber's (1989, 1992) contention that implicit learning processes are capable of abstracting highly complex information from the environment. This interpretation, however, appears to require one to assume that unlimited attentional resources are available to implicit learning processes. That is, the four abstract contingencies of Rule 3 were implicitly acquired as easily as the single contingency of Rule 1 because the acquisition of the multiple relationships did not compete for attentional resources. Although this account may be accurate, it is inconsistent with the findings from the previously described experiments, which indicated that manipulations of attentional resources influence the degree to which implicit learning occurs. As an alternative, we offer an interpretation that does not rely upon such an assumption.

We begin by concluding that the pattern of data does support the notion that implicit and explicit learning processes involve different cognitive processes. In addition, however, we suggest that these distinct processes
result in the acquisition of different types of cognitive representations of the learned information. In particular, the data are consistent with the notion that implicit learning processes yield less abstract knowledge representations than do explicit processes. This is suggested by the lack of complexity effect for the implicit learning conditions. If the implicitly acquired perceptual relationships were represented in a relatively less abstract manner, then the three perceptual relationships can be viewed as equally complex.

For example, all three perceptual relationships may be represented as four less abstract rules, each of which relates the specific location of the target to the particular location of the blue quadrant (see Table 8.4). Alternatively, each relationship may be represented as the entire set of 24 exemplars used to illustrate the more general rules during SRT training. In either case, the three relationships, which differ in complexity at the more abstract level of analysis, can be considered equally complex at a less abstract level.

Therefore, if implicit learning is assumed to result in less abstract representations than explicit learning, the differential effects of the complexity manipulations are easily interpreted. By this account, complexity is in the

<table>
<thead>
<tr>
<th>Rule</th>
<th>Type of Representation</th>
<th>Exemplar</th>
</tr>
</thead>
<tbody>
<tr>
<td>1  T diagonal to blue Q</td>
<td>Q 1 blue, T diagonal</td>
<td>24 examples</td>
</tr>
<tr>
<td></td>
<td>Q 2 blue, T diagonal</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Q 3 blue, T diagonal</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Q 4 blue, T diagonal</td>
<td></td>
</tr>
<tr>
<td>2  Upper Q blue, T diagonal</td>
<td>Q 1 blue, T diagonal</td>
<td>24 examples</td>
</tr>
<tr>
<td></td>
<td>Q 2 blue, T diagonal</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Q 3 blue, T vertical</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Q 4 blue, T vertical</td>
<td></td>
</tr>
<tr>
<td>3  Q 1 blue, T in blue</td>
<td>Q 1 blue, T in blue</td>
<td>24 examples</td>
</tr>
<tr>
<td></td>
<td>Q 2 blue, T vertical</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Q 3 blue, T horizontal</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Q 4 blue, T diagonal</td>
<td></td>
</tr>
</tbody>
</table>
eye of the beholder, and the complexity discerned by the conscious explicit eye does not necessarily generalize to that ascertained by the unconscious implicit eye.

Unfortunately, the designs of our experiments do not allow us to specify more precisely the manner in which the implicitly acquired perceptual rules were represented. In addition, observations made by other researchers also do not allow one to draw firm conclusions in this regard. Reber (1969) has found that learning in the artificial grammar paradigm allows subjects to accurately judge the grammaticality of letter strings that are formed by the same underlying set of rules used to form training strings, but that differ completely in relation to the specific letter constituents of test items. These results imply that implicitly acquired representations may not be so specific as to be isomorphic to the particular set of stimuli encountered during training. In contrast, reports that all learning observed in artificial grammar studies can be accounted for in terms of explicit learning of letter-string fragments are consistent with the notion of exemplar representations (Gomer & Schvaneveldt, 1994; Perruchet, 1994). Regardless of the exact nature of the implicitly acquired representations, we suggest that the data presented above can only be accounted for by assuming that implicit learning results in less abstract representations of information than explicit learning and that definitions of complexity are inextricably tied to the manner in which information is represented by the cognitive system.

Finding that implicitly acquired information is less abstract than explicitly learned information may have some potentially important implications regarding our theoretical conceptualization of implicit learning. As we discussed earlier, meeting the information criterion requires knowing precisely what subjects have learned. If one assumes that abstract information is learned, then it is critical to demonstrations of implicit learning that subjects be unaware of this abstract structure. In contrast, this assumption does not require that subjects be unaware of the stimuli presented during the learning situation. However, if it is the case that only concrete exemplars are learned, then direct tests need to assess memory for specific stimulus instances rather than knowledge of abstract structure. In the extreme case, subjects' awareness of stimuli encountered during learning situations would be sufficient to undermine a demonstration of implicit learning. Moreover, this would have the effect of blurring the distinction between implicit learning and implicit memory. Implicit memory is generally defined as a situation in which a previously consciously experienced event subsequently influences behavior at a point in time when one fails to recall the event.
Therefore, it becomes critical to demonstrate that what is learned implicitly is more abstract than the specific exemplars that were experienced. This would seem to be the case with sequence learning because of subjects' apparent inability to distinguish SOC structural elements encountered during SRT training from the new structural elements used in the recognition task. We also have evidence that subjects learned more than specific exemplars in the perceptual learning paradigm. In a single-condition experiment, subjects were exposed to half of the original set of training exemplars used in the original study of Rule 1 learning (Reed, 1995, Experiment 3). Learning was indirectly assessed by discontinuing the presentation of these exemplars and introducing the Rule 1 exemplars that had not been previously encountered. Observed RTS for these trials did not differ from those associated with the final block of training trials involving the previously trained set of exemplars, $t(30) = -.74$, $p = .46$, suggesting that learning was somewhat more abstract than the acquisition of the specific set of training exemplars.

**Summary of Findings**

Historically, the cognitive investigation of learning has concentrated upon the examination of explicit forms of such processes (e.g., hypothesis testing and category learning). The large body of research regarding explicit learning has resulted in a particular characterization of these processes. Probably the most obvious is that they are typically accompanied by conscious awareness of the information that is acquired. Additionally, they can be characterized as directive and highly influenced by the availability of attentional resources. Furthermore, they appear to be sensitive to the complexity of available information in that less complex information is acquired with relative ease compared to highly complex material. Finally, they are generally considered to result in the acquisition of abstract representations of learned information.

The experiments we have described were designed to examine the characteristics of implicit learning. In contrast with explicit learning, the defining feature of implicit learning processes is the apparent lack of concomitant conscious awareness of acquired information. The results of our studies are consistent with this characterization but also provide information regarding other ways in which implicit learning can be contrasted to explicit learning processes.
As regards the relationship between implicit learning and attention, we reported three primary observations. First, implicit learning was influenced by a manipulation of available attentional resources and, therefore, like explicit learning processes, appeared to be nonautomatic. Second, implicit learning resulted in the assimilation of multiple sources of simultaneously presented information and accordingly was characterized as a nonselective process. This characteristic can be viewed as contrasting with the directive and selective nature of explicit learning processes. Finally, conscious awareness was at least partially dissociated from attention in that the inclusion of a secondary task influenced the degree of implicit learning observed without affecting measures of explicit awareness. In this manner, implicit learning processes are divergent from explicit learning in that conscious awareness and the allocation of attentional resources appear to covary in the latter form of learning.

Regarding the complexity-related limitations of implicit learning, we observed that sequence structure and strictly perceptual relationships that can be considered complex were acquired implicitly. It was suggested, however, that the appropriate characterization of information in terms of its complexity is dependent upon the manner in which the cognitive system represents the knowledge that it acquires. In particular, it was proposed that when information is encoded in a relatively nonabstract manner, the acquired knowledge might best be considered less complex. In this regard, issues of information complexity and representational abstraction appear to be highly related. In accord with this view, we have suggested that implicit learning results, at least in certain circumstances, in the acquisition of relatively specific and simple information. This stands in contrast with explicit learning processes, which are capable of representing highly complex information in abstract forms.

In general, the results of our research suggest that implicit learning processes can be characterized as unique in a number of ways as compared with explicit forms of learning. This conclusion is based upon research that we consider to be rigorous in relation to the methodological concerns that have frequently appeared to undermine the interpretation of task-dissociation studies. It is acknowledged that by necessity, the methods employed cannot be deemed as allowing for entirely unambiguous interpretation of the results presented. However, we suggest that they can be viewed as informative if the biases inherent in the adoption of the Cask assumption are avoided.
SUMMARY

The way we frame a question, and the underlying (often implicit) assumptions that guide our thinking, will always shape the manner in which we conduct research. This inevitable fact makes it particularly important for researchers to make explicit the nature of the issues they hope to investigate and to recognize and address the validity of the assumptions that guide their pursuits. In the first sections of our chapter, we described our perspective on implicit learning research. These considerations struck us as necessary given the controversial status of demonstrations of implicit learning.

At the start, we considered questions regarding the relationship between consciousness and learning to be of particular interest when they examine the role of consciousness as a force that exerts an influence upon learning processes. Given this, we considered two alternative default research hypotheses from which one can approach the investigation of implicit learning. The intent was not to champion a particular choice of default hypothesis, but rather to illustrate that arguments can be made favoring either one. The implications of adopting either of these choices were presented, and it was suggested that those who choose to adopt the default hypothesis that learning requires consciousness until proven otherwise are faced with serious theoretical challenges. By our assessment, the CaK assumption is adopted by the many critics of implicit learning research, and we suggest that they have not provided adequate justification for this position.

If universally agreed-upon methods were available for potentially demonstrating implicit learning in an unambiguous manner, we probably would not have felt the need to include the preceding discussion. Because this is not the case, however, we felt the need to review the methodological issues of particular relevance. In doing so, we highlighted the kinds of decisions concerning experimental design that one needs to make and how one's choice of default hypothesis can influence these. In addition, we attempted to make an explicit justification for the methods we adopted and the criteria we used in establishing evidence for implicit learning in the research described in the final section of the chapter.

The studies we described focused on two particular issues: (a) the attunational requirements of implicit learning, and (b) the complexity-related limits of implicit learning. The data we reported regarding implicit learning
have been interpreted as suggesting that (a) consciousness can be dissociated, at least in part, from attention, (b) manipulations of attention can influence implicit learning processes, and (c) complex information regarding sequence structure and perceptual relationships can be acquired implicitly. The difficulty in establishing a metric of complexity independent of considerations of mental representations was also discussed.

NOTES

1. These results stand in contrast to those reported by Shanks and Johnstone (Chapter 16, this volume). In particular, the results of their direct test suggested that many SOC elements were learned explicitly. To explore this discrepancy, we reanalyzed our data by examining all 10 responses observed on each of the 24 cued-generation task trials, thus approximating the use of the free-generation task used by Shanks and Johnstone. This analysis revealed two particularly interesting findings. First, subjects generated reversals (e.g., 121, 212, etc.) on only 13% of their responses. In fact, even the reversal encountered during training (i.e., 121) was rarely generated. We interpret this finding as indicating that subjects acquired sensitivity to the global statistical constraints of the training sequence. This interpretation is consistent with previous evidence of learning of such statistical constraints within this paradigm (Reed & Johnson, 1984a; Readly, 1989). Given that subjects are sensitive to such constraints, an adjustment must be made in what is considered “chaotic” correct responding (i.e., when a subject has encountered two previous locations, the probability of guessing the next location is closer to .50 than the .33 used by Shanks and Johnstone).

Second, our analysis of all 10 responses generated in the cued-generation task revealed some evidence in support of Shanks and Johnstone’s (Chapter 16, this volume) contention that subjects may explicitly learn some SOC elements. Specifically, there was evidence for explicit knowledge of 2 of the 12 SOC elements. However, the observation that subjects had acquired conscious knowledge of a subset of the SOC elements does not imply that all learning was explicit. Instead, the fact that significant RT disruptions were associated with changes in all 12 SOC elements indicates that learning was primarily implicit.

2. Previously referred to as simple frequency information.

3. Previous research indicated that this perceptual relationship (referred to as Rule 1) was implicitly learned (Reed, 1995; Experiment 1). For an indirect test condition, a 53 ms RT disruption was associated with the change of the perceptual relationship, t(19) = 10.39, p < .01. In a direct test condition, subjects performed a cued recall task in which they responded to displays of colored quadrants (without...
figures) by indicating where they thought the target belonged. On average, subjects produced 3.8 training-consistent responses for the 24 trials. This level of performance did not differ reliably from that expected by chance responding (6 correct), i(38) = 47, p > .05, indicating that subjects did not have consciously available knowledge of the perceptual relationship.

4. In the indirect test conditions, all irrelevant perceptual consistencies provided during training and transfer were held constant. This was accomplished by contrasting the location of the target figure such that (a) appeared in each possible location with equal frequency; (b) appeared in, vertical to, and horizontal to all colors, except blue, with equal frequency; and (c) appeared vertical to, horizontal to, and diagonal to each of the distractor figures with equal frequency.

REFERENCES


Evidence of Unique Characteristics


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