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Implicit Learning in a Simple Cued Reaction-Time Task

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Implicit learning tasks usually involve the learning of complex rules. While this does reduce the likelihood of subjects becoming aware of the relationship to be learned, it also raises the possibility of explaining improved performance in terms of explicit processes. The current experiments are an attempt to develop a task which shows evidence of implicit learning, but which involves the learning of a very simple rule and so avoids these alternative explanations. In two experiments, we exposed subjects to learning trials in which a target letter (or shape) was immediately preceded by a cue letter (or shape) in otherwise random nine-letter (or 15-shape) sequences. In a test phase, subjects responded more quickly to cued than uncued targets if the learning phase had involved reliable cue–target pairings, but not following random control pairings. This was true of subjects who were classified as aware and those classified as unaware of the cue–target relationship.

It is fairly commonly accepted, among psychologists and nonpsychologists alike, that people are able to acquire information without being aware that they have and that this may change their behavior in important ways. This phenomenon, at least as it is studied in the laboratory, is referred to as implicit learning (IL). Despite widespread acceptance of the possibility of IL, attempts to develop a paradigm for studying—or even for demonstrating—IL have so far failed to convince the skeptics. To date, there is little evidence that this debate is reaching a resolution, a state of affairs that has led to the recent suggestion that perhaps conceiving of learning as being either conscious or unconscious is itself misleading (Neal & Hesketh, 1997; Whittelsea & Dorken, 1997). Clearly, the extent and vigor of this debate is in part motivated by the fact that an answer to the issue of whether learning

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can occur without awareness is highly significant for a wide range of psychological theories. The current article is an attempt to develop a simple, but flexible, paradigm in which learning without awareness can be clearly demonstrated.

A wide range of tasks have been developed to investigate IL. These range from those in which subjects respond as quickly as possible to a regularly repeating sequence of stimuli (Nissen & Bullemer, 1987), to categorization tasks (both perceptual, Lewicki, 1986, and of artificial grammars, Reber, 1967), and the learning of various kinds of response–outcome relationships (Berry & Broadbent, 1984; Lieberman, Sunnucks, & Kirk, 1998; Lieberman, Connell, & Moos, 1998). A feature common to most of these tasks is that the regularity to be learned is typically quite complex. This is obviously a strategy designed to encourage learning without awareness. If the relationship is simple, then this increases the probability that subjects will consciously notice it. So ubiquitous is the use of complex to-be-learned rules that Seger (1994), in a large review of IL, identified this as one of its defining characteristics. Unfortunately, while rule complexity probably does serve to mask the true relationship from the subject's awareness, it also renders the IL task vulnerable to the criticisms outlined below.

While IL has generated a large number of studies, and continues to be a popular area of investigation, there is, in fact, considerable skepticism about whether the learning which occurs in such tasks is genuinely implicit. Much of this criticism can probably be traced to a series of critical and convincing reviews of the evidence for all kinds of learning without awareness (Brewer, 1974; Dawson & Schell, 1985; Shanks & St. John, 1994; Perruchet, 1994). Although they were not always directed at the same bodies of literature, and although they used different terms to describe the problems with the evidence, these reviews revealed two central criticisms of the test of awareness used by IL researchers. Perhaps the clearest characterization of these problems was that of Shanks and St. John, who suggested that a valid demonstration of IL needed an awareness test that met what they called the *Sensitivity Criterion* and the *Information Criterion.* Because we believe that these criticisms are valid and important, but that the IL task that we have developed is much less likely to suffer from them than tasks used previously, the nature of these requirements is sketched below.

The Sensitivity Criterion refers to the fact that the awareness test needs to measure *all* of the explicit knowledge that the subject possesses and that it does so close enough in time to the learning that the subjects will not have simply forgotten explicit knowledge that they used to perform the task. Of course, there is an unavoidable tension between using a test which is sufficiently sensitive to detect all of the explicit knowledge a subject may have about the regularity to which they have been exposed and using a test which is sufficiently ambiguous that it does not *provide* the subjects with explicit knowledge that they did not possess while doing the task or that is so much like the original task that it could be performed using (or at least be influenced by) *implicit* knowledge. The onus of proof has usually been on those claiming that implicit tasks are not contaminated by explicit knowledge, but of course, if IL does occur, then the opposite, contamination of the awareness task by implicit knowledge, is also a possibility which needs to be guarded against. Ideally, awareness tests should be both exhaustive (as the sensitivity criterion requires) and exclusive—measuring *only* conscious knowledge (Reingold & Merikle, 1988). Meeting such an ideal has proved understandably difficult.

The Information Criterion refers to the fact that the awareness test must measure the subject's awareness of the relationship which actually assisted their performance on the task. In many complex tasks conscious hypotheses which merely correlate with the true regularity, or which capture a part of the full pattern, may be sufficient to perform at above-chance levels. Importantly, if the awareness test does not refer to these other ways of performing above chance (and they frequently do not—particularly those from studies before 1994), then subjects will be classified as unaware, when in fact partial or correlated conscious knowledge underlies their performance. Failure to meet the information criterion is a criticism which has mainly been leveled at IL tasks in the ‘‘cognitive’’ tradition (artificial grammar and sequence learning tasks, in particular), and it is this complexity which leaves room for partial knowledge, or alternative hypotheses, to improve performance without the subjects acquiring *any* unconscious knowledge, let alone the complex grammar the experimenter used to generate stimuli, or the true sequence underlying a serial reaction-time task.

Although this criterion has usually been applied to complex IL tasks, it can also apply to simple ones, particularly those involving instrumental conditioning of nonobvious responses. These are, naturally, always the kinds of responses being reinforced in *implicit* versions of such tasks. For example, Lieberman, Sunnucks, and Kirk (1998) conducted an experiment in which subjects were told they were participating in an experiment on ESP and had to guess what card an experimenter was looking at. In reality, they were told they were correct (reinforced) whenever their voice level increased in volume (in one condition) or decreased in volume (in another condition). Upon questioning, subjects were unable to report this contingency, but this may be because reinforcement increased or decreased the subjects' voice level by some indirect means (adopting a particular posture or even thinking about situations in which they talk loudly or softly), of which they were aware, but which was not measured in the awareness test. In fact, these researchers did test extensively for other causes of voice-level changes, but in an instrumental conditioning paradigm, where a nonobvious response is being reinforced, it is difficult to ensure that such tests are exhaustive because the number of ways of indirectly producing the reinforced response is very large. For this reason, although we are sympathetic to using simple conditioninglike paradigms to study IL, we believe that using a task more like Pavlovian conditioning may be a more fruitful avenue of research, since the relationship to be learned can be more precisely controlled and more easily manipulated.

The current study is an attempt to produce a paradigm which avoids many of the criticisms leveled at more complex implicit learning tasks, but which nevertheless shows clear evidence of learning without awareness. The hope is that the simplicity of the to-be-learned relationship will make it much easier to elucidate precisely how behavior may change in the absence of the learner's ability to verbally report any new knowledge. The fact that the task strongly resembles Pavlovian conditioning also raises the possibility of investigating which conditioning phenomena depend on awareness. For example, if basic conditioning does not depend on awareness, does blocking or sensitivity to contingency? This obviously holds important implications for the applications to which conditioning principles are put, as well as for the role of awareness in nonhuman learning, as has recently been pointed out by Clark and Squire (1998).

GENERAL METHOD

The paradigm we have developed to investigate IL is based on a task used by Boakes, Roodenrys, and Barnes (1995) which produced mixed results (it is our belief that the consistency of the current results is primarily a function of the timing used, as is discussed later). In the current experiments, subjects are exposed to a continuous stream of serially presented letters (or shapes) which replace each other every 250 ms in the center of a computer monitor. Subjects are instructed to press the space bar as quickly as possible whenever a particular letter (''R,'' for example; the target) appears on the screen. The order in which the letters appears is random except that the target is *always* preceded by a cue letter (''S'', for example). The subjects are not informed of this relationship. After a number of learning trials (pairings of the cue and target), the subjects move into the test phase, in which half of the presentations of the target are cued and half are not cued.

EXPERIMENT 1

This experiment was designed to examine the potential of the cued reaction-time (RT) task as a means of studying implicit learning. The paradigm had been piloted in a class experiment the results of which suggested that the effect of cueing was robust and that approximately half of the subjects became aware of the relationship between the cue and target. Both aware and unaware subjects responded more quickly to the target when it was cued than when it was uncued. The current experiment formalized and extended these findings by testing subjects in a more controlled environment and by including a control group, in which the cue was not a reliable predictor of the target in the learning phase.

Method

Subjects

Twenty-five undergraduate psychology students from the University of Wollongong participated for nominal course credit. They were tested individually. Results from one of these subjects was not included in the analysis because all but four of their reaction times in the test phase were longer than 1500 ms, suggesting that they were not devoting complete attention to the task.

Procedure

Subjects were told that they were participating in a study examining their ability to learn new visuomotor skills, and the first task they performed was a computerized version of a mirror drawing task. In this task, two concentric star shapes were presented on the computer screen and the subject was required to use the mouse to move a pointer (which drew a line on the screen) around the outside of the inner star without moving outside the space between the stars. The mirror drawing program reversed the left/right movement of the mouse (as a mirror does in mechanical versions of this task). This was presented to the subjects as the major task they had to master in the experiment. Between mirror drawing trials they performed the CRT task, which they were told was designed to prevent them from rehearsing their new visuomotor skills.

The cued reaction-time task (CRT) was the important task from our perspective. This task was divided into three phases, each separated by an attempt at the mirror drawing task. Phase 1 and Phase 2 were identical learning phases, and Phase 3 was the test phase, in which performance on cued versus uncued presentations of the target were compared. This part of the experiment was controlled using Psyscope 1.1.1 (Cohen *et al.*, 1993), running on a Macintosh 6200 PowerPC. In all phases, subjects were simply instructed to respond to the target letter as quickly as possible by pressing the space bar. Responses which occurred before the target, or after the end of the letter sequence for that trial, were not recorded. Reaction times more than 2 standard deviations from the mean for that condition were not included in the analysis

Learning phases. Each learning phase consisted of 56 trials. Each trial was a string of nine 0.5 × 0.5 cm (between about 1 and 0.7° of visual angle at the viewing distance of between 30 and 40 cm) uppercase letters which replaced each other every 250 ms in the center of a standard RGB monitor. The letters were presented in black on a white screen. Seven letters in this string of nine were drawn randomly, without replacement, from a list of the letters chosen to be easily discriminable (B, E, G, H, L, S, T, and X). The letter V followed by R (or R followed by V) filled the other two places in the nine-letter sequence. For half of the subjects V was the target (and R was the cue) and for the other half R was the target (and V was the cue). The cue–target pairing appeared in all possible positions in the sequence. The program cycled randomly through the eight possible V-R (or R-V) positions, before repeating any position. Seven such random orders made up the 56 trials. The trials were smoothly integrated, with the same 250-ms SOA between the last letter of one trial and the first letter of the next.

Test phase. After the second learning phase, subjects participated in their third mirror drawing trial and then moved on to the test phase of the CRT task. This phase consisted of 16 trials, of which in half the cue–target pairing was maintained and in the other half the target appeared without a cue. Again, all 8 possible positions of the cue and target were presented, but in random order, and with the 8 uncued target trials randomly interspersed.

Awareness test. To assess awareness subjects were given a short, written questionnaire immediately after the test phase while still seated in front of the computer. To be classed as unaware they had to respond negatively to a series of questions about whether they noticed any relationships between the letters: (1) Did you notice anything about the order in which the letters appeared? (2) Did you notice any way of predicting when the target would appear? (3) Did you notice a relationship between any of the nontarget letters and when the target appeared? (4) One letter occurred more frequently immediately before the target than the other letters. Please circle whichever you think it was and guess if you do not know. (The cue and six distractor letters—S, G, D, T, H, and L—were printed along the bottom of the questionnaire). The order of the letters was randomized between subjects.

If subjects responded with incorrect answers to the first three questions, but circled the cue, we decided that they had guessed correctly and did not include them in the analysis. Of course, subjects may be using implicit knowledge to circle the correct alternative under such circumstances, but since no subject fell into this category in this experiment, we could not explore this possibility.

Experimental Groups

Two groups of subjects were run in the experiment. Ten were run in a control condition in which, during the learning phases, they were exposed to trials in which the target could be preceded by any of the randomly selected letters in the distractor list (which included the cue, in this condition). In other words, there was no reliable way of predicting the arrival of the target during the learning phases. These subjects participated in a normal test phase, in which the target was signaled by the cue on half of the trials.

This group served as a random control from a classical conditioning perspective (Rescorla, 1967) as well as a control for the possibility that the target and cue somehow primed each other in the test phase.

The second group of subjects were exposed to the contingency described earlier, in which the cue preceded the target on every learning trial. On the assumption that approximately half of the subjects would be classified as aware (as pilot studies had suggested), we decided to run subjects in the cueing condition until 10 were classified as unaware. Rates of awareness were lower in this experiment, however, and this decision resulted in only 5 aware subjects being analyzed. Since these subjects showed a large, reliable effect of cueing, we did not feel it necessary to keep running the experiment until 5 more aware subjects were found.

Results

The experimental procedure, and the elimination of results from one subject, resulted in data from 10 subjects in the unaware group, 9 subjects in the control group, and 5 subjects in the aware group. RTs more than 2 standard deviations from the mean for that condition were excluded from the analysis. Mean RT for both cued and uncued trials in the test phase, for each subject, was entered into a 3 (group) $\times$ 2 (test cueing) mixed-factorial analysis of variance. This revealed a main effect of group [$F(2, 21) = 6.9$, $P = .005$], a main effect of test cueing [$F(1, 21) = 73.21$, $P = .0001$], and a significant interaction between these two factors [$F(2, 21) = 33.32$, $P = .0001$].

As is clear from Fig. 1, both main effects and the interaction are probably affected by the fact that the effect of cueing is very strong in the aware group. Since we are primarily interested in the effect of cueing in the unaware group, we also compared the mean RT in cued vs uncued test trials for the unaware group alone. Although this difference was not very large (approximately 38 ms), it was very consistent (all but one unaware subject was faster on cued than uncued test trials), and it was significant ($t = 2.81$, $P = .02$). Conversely, subjects in the control condition were no faster to respond to cued than to uncued presentations of the target in the test phase ($t = .019$).

Discussion

These results clearly show that exposure to a cue which reliably predicts the arrival of a target leads to faster responding on cued than on uncued trials in both aware and unaware subjects. The effect is much stronger in aware subjects, but it is also plainly present in those subjects who have been rigorously classified as unaware. The effect of cueing in unaware subjects is even more obvious in Experiment 2.

Since the relationship between the cue and target is very straightforward, we believe that the awareness test is sensitive enough to measure it. If the subjects cannot even guess which letter preceded the target immediately after they have finished the test phase of the experiment, then it seems unlikely

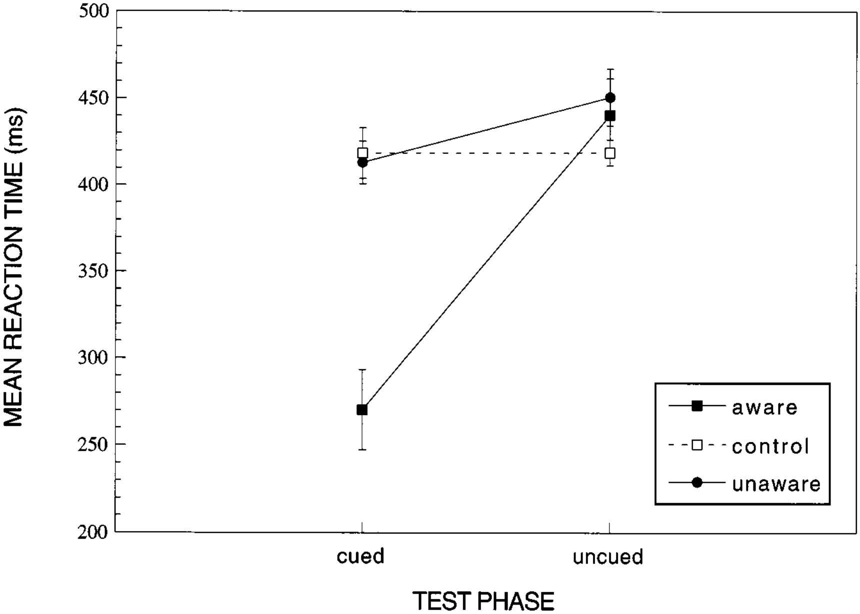

FIG. 1. Mean reaction times of aware, unaware, and control subjects in Experiment 1 as a function of target cueing in the test phase. Error bars represent ±1 standard error.

that they have conscious knowledge of the predictive relationship. While the context of this test is somewhat different from that in which the learning took place, in that the awareness test is not carried out on the computer, we believe that the test provides sufficient cues for the subjects to recall the relationship if they were aware of it. They are seated in the same place and are provided with the cue and distractor stimuli used in the learning task in question 4.

The simplicity of the useful relationship in our task also makes it very unlikely that alternative or partial hypotheses underlie faster responding on cued trials. Alternative hypotheses are of no use (since they presumably apply as often to the uncued as the cued target presentations), and it is difficult to imagine what ‘‘part’’ of a two-stimulus relationship it could be. In summary, we believe that our awareness test meets both the sensitivity and the information criteria.

This task is designed to be similar to classical conditioning, involving learning of the simplest kind of stimulus relationship. It is not difficult to see how the cue in our task acts like a CS and the target like a US to elicit a simple response (at least after instruction). Consistent with this way of thinking about the task, the results of this experiment show that if the contingency between the cue and target is zero then subjects respond no faster to the cued than uncued targets in the test phase. Since this task is quite similar to classical conditioning, it raises the question of how we managed to obtain evidence of IL when previous implicit classical conditioning tasks have almost universally failed to (Dawson & Schell, 1985). Recent evidence from Clark and Squire (1998) may help to understand this inconsistency.

Using eye-blink conditioning (in which the CS is a sound and the US is a puff of air to the eye), Clark and Squire (1998) showed that when normal forward conditioning is used, in which the CS comes on before the US, but they terminate simultaneously (so that there is a time when they are both on), aware, unaware, and amnesic subjects all showed evidence of learning—they all produced more eye-blinks to the CS alone as trials progressed. When trace conditioning was used, however, in which the CS terminates before the US starts, only aware subjects showed evidence of learning. This surprising finding is important from our perspective because all of the experiments which failed to show evidence of conditioning without awareness, reviewed extensively by Dawson and Schell (1985) and Shanks and St. John (1994), used either a trace conditioning arrangement or very long CS durations (Lovibond, 1992, for example). A fundamental difference between the task used by Boakes, Roodenrys, and Barnes (1995) and ours is that they had stimuli spaced 1 s apart, and ours are separated by only 250 ms. Formally, our task is a trace conditioning paradigm, since the cue and target do not overlap in time, but the gap between them is very short (no more than one screen refresh), and this may be near enough to overlapping, or the resulting stimulus onset asynchronies may be short enough, for the IL mechanism to correlate the stimuli.

An interesting aspect of these results is the fact that in the unaware group cueing appears to have its effect by rendering subjects slower than they would otherwise be on uncued trials rather than faster than they would otherwise be on cued trials. This result was not expected and is considered further under General Discussion. The aware group shows some evidence of this effect (they are somewhat slower than control subjects on uncued trials), but also show a much stronger positive effect of cueing. This raises the interesting possibility that unconscious learning somehow results in slowed responding on uncued trials (and so is the only effect present in the unaware group), but that conscious learning involves a second, superimposed mechanism which results in faster responding on cued trials (and so the aware group shows both effects). One way of addressing this possibility is to track learning over trials, and this is one of the aims of Experiment 2.

EXPERIMENT 2

This experiment is also primarily designed to assess the utility of the CRT task as a means of investigating IL. It allows us to examine the generality of the effect by using stimuli from a different category (two-dimensional shapes rather than letters) and by including a within-subject control rather than the between-subjects random control from Experiment 1. The within-subject control consisted of requiring subjects to respond as quickly as possible to two different target shapes, only one of which was reliably cued in the learning phase. The inclusion of this sort of control makes it possible to explore the way in which learning progresses in both aware and unaware subjects by plotting RT responding to the cued and uncued targets as a function of trials. This was not possible in Experiment 1, since subjects could not be classified as aware or unaware of the relationship between the cue and the target in the control group (because there was no relationship to be aware of). The within-subject control also allows us to begin the investigation of the nature of the learning which occurs in the CRT task. In the test phase of this experiment, RT was measured to cued presentations of the target which has been cued in the learning phase and to the target which had not been reliably cued in the learning phase. As in the test phase of Experiment 1, RT was also recorded to uncued presentations of both targets. If the learning underlying improved performance in this task is at all specific to the particular cue–target relationship present in the learning phase, then subjects should be faster to respond to this relationship than to any other arrangement in the test phase. If, however, the learning phase merely gives the cue the power to prime the motor response of making the key press, then it should be equally effective when presented before either of the targets in the test phase. Of course, if there are qualitative differences between the kind of learning which occurs in aware and unaware subjects, then these two groups of subjects may show different patterns in the test phase.

Method

Subjects

Twenty new, naive subjects from the University of Wollongong participated for nominal course credit.

Procedure

The procedure for this experiment was similar to that for Experiment 1. Again subjects were led to believe that the CRT task was not the main aim of the experiment, but since some of the 2D shapes in this task were similar to stars (the cue, in particular), the distractor tasks were changed to a written anagram task and a written word-stem completion task instead of the mirror drawing task from Experiment 1.

After a word-stem completion task, subjects participated in the learning phase of the experiment. This consisted of 72 trials. A trial was a string of 15 shapes (shown in Fig. 2), which immediately replaced each other in the center of the screen every 250 ms. The shapes were 2 cm^2. This experiment was controlled by RSVP 3.1 [Williams & Tarr (no date)], rather than Psyscope, and this resulted in a brief pause (of approximately 750 ms) between trials as the next trial's pictures were loaded into memory. We increased the

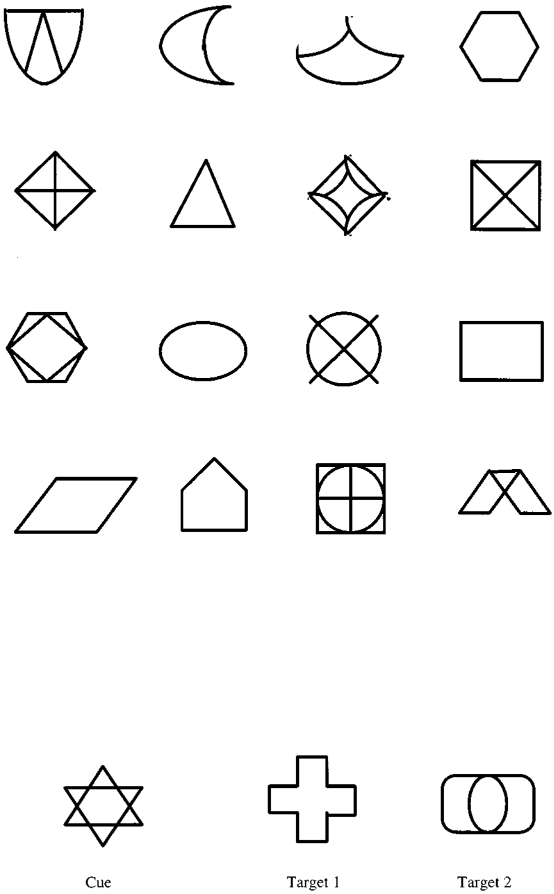

FIG. 2. The stimuli used in Experiment 2. Either target 1 or target 2 was cued in the learning phase of the experiment. The other stimuli served as distractors.

number of stimuli in the trials in order to help to disguise the cue–target relationship despite this pause. There were also no trials in which the cue or the target appeared first or last in the sequence that made up a trial.

Half of the learning trials (36) involved cued presentations of one of the targets (which target this was was counterbalanced across subjects) and half involved uncued presentations of the other target. Targets could appear in any of the positions between stimulus 3 and stimulus 14 of a trial, inclusive. This made 12 different stimulus positions for the appearance of the target, and each such position occurred 3 times for the cued target and 3 times for the uncued target during training, making up the 72 trials. The trials appeared in random order.

Following the learning phase, subjects completed the anagram distractor task and then participated in the test phase of the CRT task. This consisted of five cued and five uncued presentations of the target which had been cued in the learning phase and five cued and five uncued presentations of the target which had not been cued in the learning phase. The test trials also occurred in random order.

Immediately after the test phase, subjects were given the awareness questionnaire and asked to fill it in. It was the same as the questionnaire from Experiment 1 except that the questions referred to shapes and the choices listed under question 4 were pictures of six of the 2D shapes used as distractors and the cue. Again, the order of the shapes was randomized between subjects. Again, subjects who did not demonstrate knowledge of the true relationship between the cue and the target in their answers to questions 1–3, but who circled the cue in question 4, were deemed to have guessed and were not included in the analysis as aware or unaware. Three such subjects fell into this category in this experiment, leaving data for 17.

Results

In this experiment nine subjects became aware of the cue–target relationship and eight remained unaware. RTs more than 2 standard deviations from the mean for that condition were left out of the analysis. The results of this experiment can be seen in Fig. 3. The left half of the figure shows the way in which RT changed as a function of trial block in both aware and unaware subjects. Blocks are simply averages of three trials, designed to reduce the variability of the data plotted. It is clear from these plots that reaction time steadily decreased when the target was cued, but was quite stable when the target was uncued. Reaction time decreased more rapidly in the aware subjects, but by trial block 5 (after 15 pairings of the cue and target), both aware and unaware subjects were responding more quickly to the cued than to the uncued target.

The data for the aware subjects responding to cued targets is more volatile than that for the other arrangements, showing greater changes in RT from block to block. We reasoned that this may partly be a consequence of subjects gaining awareness at different points, but examination of the learning curves for individual subjects did not clearly support this suspicion. The RTs of aware subjects were quite variable, but in none of them was there an obvious drop which could be unequivocally interpreted as a switch from unaware to aware. Of course, with two targets to respond to, subjects may have been adopting and discarding (or modifying) conscious hypotheses as the learning trials progressed, which may mask the point at which awareness occurred.

The right panel in Figure 3 shows the effect of cueing in the test phase. Data from this phase were analyzed separately for aware and unaware subjects, in two 2 (test phase cueing) $\times$ 2 (learning phase cueing) ANOVAs. For aware subjects, there was a significant main effect of test phase cueing [$F(1, 8) = 119.9$, $P = .0001$], and a significant interaction [$F(1, 8) = 6.07$,

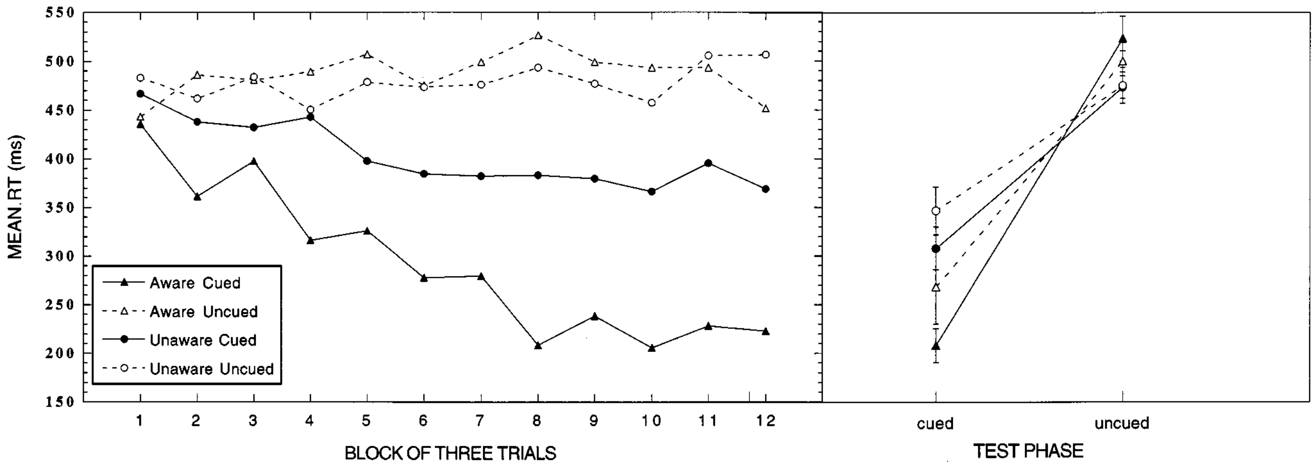

FIG. 3. Mean reaction times for both aware and unaware subjects as a function of target cueing in the learning phase (left panel) and the test phase (right panel) of Experiment 2. Error bars represent ±1 standard error.

$P = 0.039$], but the main effect of learning phase cueing was not significant [$F(1, 8) = 0.55$]. Similarly, the unaware subjects showed a significant main effect of test phase cueing [$F(1, 7) = 47.3$, $P = .0002$], but neither the main effect of learning phase cueing [$F(1, 7) = 1.08$] nor the interaction [$F(1, 7) = 1.39$] was significant.

For both aware and unaware subjects the most obvious effect in the test phase is that of cueing in the test phase. Unaware subjects responded more quickly to cued presentations of a target irrespective of whether the target had been cued in the learning phase. This suggests that the effect of cueing is simply to prime a motor response. Aware subjects showed some sensitivity to the previous relationship between the cue and the target, since the interaction suggests that they were faster to respond to cued presentation of the target that had been cued in the learning phase than to cued presentations of the target that had not been cued, but this tendency is not very strong. These results may be because in aware subjects too, the main effect of the cue is to prime the space-bar response or because they rapidly learn that, in the test phase, the cue also signals the previously uncued target.

GENERAL DISCUSSION

In both of the experiments reported, there appears to be clear evidence of subjects learning to respond faster to cued than to uncued targets, whether or not they are aware of the relationship between the cue and target. In both experiments, the effect is larger in aware than unaware subjects, but it is clearly present in both groups. Unlike in Experiment 1, there is no hint in Experiment 2 that the learning renders unaware subjects slower to respond to uncued presentations of the target than they would otherwise be. For both aware and unaware subjects, responding was faster to cued test-phase presentations of either target than it was to presentations of the uncued target in the learning phase. Cueing appeared to speed up responses for all subjects, in other words. This difference between the results of the experiments could be a consequence of differences between the kind of stimuli used (letters vs 2D shapes) or of use of the between subject control in Experiment 1. The latter possibility seems more likely. Perhaps unaware subjects have slower baseline reaction times than aware subjects, with control subjects (as likely to be aware as unaware had they been allocated to the cueing group) falling somewhere in between. Such a systematic difference between aware and unaware subjects would not be particularly surprising (*some* difference between them must account for differences in awareness) and could explain the pattern found in Experiment 1. Unfortunately, comparing the RTs of aware and unaware subjects in Experiment 2 does not help us to resolve this issue. The RTs to uncued targets are similar in the two groups in Experiment 2, but in the aware subjects responding may be slower than baseline to the uncued target because they are ‘‘surprised’’ by its appearance. In any case, the results of Experiment 2 strongly suggest that the effect of cueing is in the same direction for aware and unaware subjects.

Perruchet, Gallego, and Savy (1990) provided a convincing demonstration that a serial reaction-time task used by Lewicki, Hill, and Bizot (1988) violated the information criterion in a way which could be seen to hold implications for our task. The details of Perruchet *et al.*'s critique are not directly relevant to our task, since the problem is, in large part, a function of the complexity of the to-be-learned rules in Lewicki *et al.*'s study, but part of the critique is based on the claim that transitions between stimulus locations (apparent movement cues) may be what is encoded by subjects, and this could also be true in our task. Since the stimuli in the current experiments replace each other very rapidly, there is the possibility that subjects learn to respond on the basis of an apparent movement cue (or a stimulus blend of some kind) which is specific to the cue–target relationship. This is the only pairing that is consistent and so the only transition which could be learned in this way. The awareness test does not ask subjects about any such perceived transitions (at least not directly), and so it is possible that subjects are classified as unaware because they are not tested for the knowledge that actually assisted their performance. Fortunately for the utility of our task, such an explanation cannot explain how a cue can prime responses to a previously uncued target, as occurs in the test phase of Experiment 2. This result effectively rules out any such explanation of the effect reported in these experiments.

Our primary objective in this article has been to develop a technique for studying IL which is sufficiently simple that it avoids the important criticism that have been leveled at other demonstrations of IL. It is our belief that we have done this, at least for the kind of learning which underlies improved performance in the CRT task. It is possible that qualitatively different learning mechanisms underline improvements on other kinds of implicit learning tasks, and so our results do not bear directly on the likelihood of them occurring implicitly.

The simplicity of our task also makes it easier to try to understand the kind of learning underlying improved performance. It seems clear from Experiment 2 that subjects responded more quickly to cued presentations of a target primarily because their motor response was somehow primed by the appearance of the cue. The most straightforward explanation for such an effect is that our procedure resulted in classical conditioning. The cue was a reliable predictor of the arrival of the target and this relationship gave the cue the power to elicit a conditioned space-bar response (at least in the context of responding as quickly as possible to target letters or shapes). It will be interesting in future studies to examine whether this response would in fact occur without the arrival of the target—to presentations of the cue alone, in other words. The fact that this task does resemble Pavlovian conditioning also invites an examination of the more complex conditioning phenomena which have been the driving force of such research for the last 30 years. Perhaps the basic relationship can be learned implicitly, but more complex phenomena (like blocking, for example) cannot be.

It is the possibility of qualitative differences like those suggested above that offers the greatest hope of differentiating implicit from explicit learning, and it is only through such differences that we will be able to discover a functional role for awareness in learning. It seems to us that the most fruitful kinds of qualitative differences will be those found using simple tasks for which there is already a rich array of competing explanations. Tasks which resemble classical conditioning, like the CRT task, fall into this category.

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