Differences between implicit and explicit acquisition of a complex motor skill under pressure: an examination of some evidence.

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Masters (1992) argued that an implicitly acquired motor skill is less likely to fail under pressure than an explicitly acquired skill. He demonstrated this by showing that induced anxiety led to differences in the golf putting performance of groups who had acquired the skill implicitly and explicitly. We replicated Masters' basic findings but our results suggest that the difference in performance under pressure is more readily explained in terms of differences between the learning and testing conditions. Our results are consistent with an explicit learning account of the putting task and we found no support for the claim that implicit and explicit learning of motor skills are differentially affected by anxiety.

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Many authors have argued that knowledge can exist in implicit and explicit forms (e.g. Berry & Broadbent, 1984, 1988; Hayes & Broadbent, 1988; Reber, 1989). Implicit knowledge is argued to be unavailable to verbal report, robust in the face of psychological disorder, and acquired without deliberate attempts to learn. Explicit knowledge, by contrast, is available to verbal report, is impaired by some psychological disorders (e.g. anxiety), and is the result of deliberate attempts to learn. This distinction has been referred to in terms of implicit and explicit learning (Reber, 1989), and unselective and selective learning (Berry & Broadbent, 1988).

Evidence for implicit learning has come from a variety of studies including those where participants become sensitive to the underlying structure of an artificial grammar through memorization of sets of strings generated by that grammar whilst being unable to report the rules of the grammar (e.g. Reber, Kassin, Lewis & Cantor, 1980). Other demonstrations of this phenomenon have tended to show improved performance on some task which is not accompanied by improved verbal knowledge about how the task is performed (e.g. Bright & Burton, 1994; McGeorge & Burton, 1990).

It has been argued that these demonstrations are not conclusive evidence of functionally distinct implicit and explicit learning systems. In particular, using measures of conscious awareness of the products of learning are problematical in that (a) it is not clear that the information requested in tests of verbal knowledge reflects the knowledge used to perform the task and (b) that questions asked of participants are sufficiently sensitive to elicit accurate task knowledge (see Shanks & St John, 1994). Consequently a more profitable approach to the study of implicit learning may be to look for differential effects that are not dependent on the availability of verbal knowledge at test. There are several studies that have attempted to do this by demonstrating differences in the susceptibility of implicit and explicit learning to anxiety.

One study compared the explicit memorization phase of the artificial grammar learning paradigm with the implicit classification phase. Rathus, Reber, Manza & Kushner (1994) found that high levels of self-reported anxiety were associated with individuals taking longer to memorize artificial grammar strings (an explicit task), but once memorized there was no difference in classification decisions of grammaticality (argued to be an implicit task). They concluded that 'implicit processes are resistant to the effects of emotional factors that compromise performance of explicit processes'.

The claim that implicit learning is resistant to the effects of emotional factors has immediate practical implications for the acquisition of motor skills. Motor skills have been argued to be susceptible to the effects of anxiety, and this has been a focus of research in the field of sports psychology (e.g. Jones & Hardy, 1990). However, there do not appear to be many studies that have compared implicit and explicit acquisition of these skills. One study that addresses this issue is that of Green & Flowers (1991) who compared the performance on a video game of individuals given prior instructions of how to play the game with a group given no instructions. It was asserted that these represented explicit (given instructions) and implicit (no instructions) learning groups. The inferior performance of the explicit group overall was argued to be due to worry interfering with the explicit instructions. However, they do not report any control of the levels of worry between the groups.

A study that specifically examined a motor task learned implicitly and whether anxiety has a differential effect on explicitly and implicitly learned behaviour was Masters' (1992). Participants were required to learn how to putt golf balls. There were two critical groups: an explicit group that were given explicit advice to read on how to putt based upon well-known coaching manuals. The implicit group were given no explicit instruction, but instead they had to putt golf balls whilst generating random letters (after Baddeley, 1966). It was argued that this task would be so demanding that participants would be unable to introspect

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about their performance and hence be unable to form explicit performance rules.

There were four training sessions in which participants had to putt 100 golf balls attempting to 'hole' each shot. The number of putts holed (i.e. the number of putts hitting their target) was used as the measure of learning. Both the implicit and the explicit groups demonstrated learning of the putting skill with significant increases in the number of putts holed over trials. The explicit group could name significantly more rules about golf putting compared with the implicit group which was used as evidence that one group had learned the task explicitly and the other group learned implicitly.

At the completion of the fourth training session two stressors were introduced. Firstly, participants were told that during the upcoming test session their participation fee of [pounds]12.00 could be increased to [pounds]15.00 or decreased to [pounds]1.00, depending on their putting performance. Secondly, an individual dressed in a golf sweater was introduced as a golf professional who would be judging their putting during the upcoming session. These interventions led to increases in both physiological and self-report measures of anxiety (heart rate, Spielberger State Anxiety Inventory) comparing pre- and post-intervention levels.

Masters found that 'the implicit group showed no degradation of performance under stress whatsoever', but the increase in anxiety had a significantly different effect on the performance of the explicit and implicit groups. At test, the implicit group appeared to continue to improve their performance whereas there was a small performance decrement in the explicit group. Consequently, this result would appear to provide support for the hypothesis of two distinct learning systems based upon finding an apparent double dissociation. That is, anxiety was shown to have a different effect on implicit learning compared to explicit learning. Masters (1992) concluded that an explicitly learned motor task exhibited degradation due to anxiety whereas the identical task that had been learned implicitly was not affected by the same stressors.

There are, however, difficulties with this interpretation. The critical finding is the differential impact of anxiety on implicit and explicit learning. However, the stress intervention was not the only change in procedure between the learning trials and the test. Participants in the implicit group performed a dual task during the training trials but did not do this during the test trials. Masters acknowledges that this release from the dual task conditions should lead to performance improvement. Consequently, the difficulty is whether the performance improvement observed in the implicit group and the overall differential effect of the stress intervention on the implicit and explicit groups is better attributed to anxiety effects or an artifact of the release from the dual task.

Masters supports his contention that the effects are due to the experimental manipulation of stress by comparing the performance of the implicit group to an implicit control group who completed the dual task during training but were not subject to either the dual task or the stress intervention at test. The similar degree of improvement in both groups is held to be evidence that implicit learning is not subject to the effects of stress. However, this does not rule out the possibility that although the stress intervention led to increased anxiety, this increase was not sufficient to have any effect on performance. Evidence from the explicit group supports this argument. The performance decrement of this group is modest and it is not reported whether this decrement is significant or not. It appears (assuming the decrement is not significant) that explicit learning is relatively robust in the face of modest increases in anxiety as well. Consequently the only evidence that there exists a difference comes from the significant interaction between the implicit and the explicit groups which can be accounted for in terms of improved performance of the implicit group due to the release from the dual task.

The continued performance improvement seen in the implicit group in spite of increasing anxiety may be due to the increased attentional resources made available by removing the requirement to generate random letters (hypothesis 1). Such an explanation does not require positing a functionally distinct implicit learning mechanism with stress resilience characteristics. Rather both groups may have been learning to putt explicitly and any increased cognitive' burden' imposed by the stress intervention could be more than outweighed by the release from the more onerous dual task at test. For the implicit group this would predict a performance improvement, whereas the explicit group, experiencing no-release effect would be expected to show performance deterioration if the stress intervention was powerful enough. If this view is correct we might predict that increases in performance due to release from the dual task will be proportional to the cognitive demands of the dual task. That is release from undemanding dual tasks will yield smaller performance increases than release from demanding dual tasks (hypothesis 2).

Other than the performance dissociation between the implicit and explicit groups, the only evidence that the implicit group really were using less explicit knowledge comes from differences in the levels of reportable rules of

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putting. However, as Shanks & St John (1994) point out, dissociations of performance and verbal knowledge do not necessarily imply implicit knowledge.

In general, as Berry (1996) points out, the results of studies looking at the effects of dual tasks on implicit learning have been mixed. Seger (1994) notes a number of studies (e.g. Hayes & Broadbent, 1988; Pew, 1974) in which the effect of dual tasks on implicit learning was examined. A number of different dual tasks were used, such as tone counting, memory load or random number generation. In a number of the reported studies (e.g. Dienes, Broadbent & Berry, 1991; Pew, 1974) dual tasks appeared to have a detrimental effect on implicit learning. Seger (1994), however, noted that different dual tasks may affect different mental processes making comparisons of their effects across studies problematical. Two studies which examined the effect of random number generation on implicit learning are not consistent. Hayes & Broadbent (1988) found no detrimental effect of the dual task on implicit learning, whereas Dienes et al. (1991) found that a dual task appeared to affect implicit learning.

In our first experiment we attempted to replicate Masters' results and in addition we added an extra implicit group who carried out the dual task during training and at test. This was done in an attempt to separate the effect on performance of increasing participants' stress levels from the effect of removing the dual task conditions for the implicit group at test. If the previously observed 'substantial' performance improvement of the implicit group under stress was due to the release from the dual task then maintaining this requirement under stress should yield no such improvements and the implicit and explicit groups will perform similarly under stress. However, any pre/post differences that may be observed in the number of putts holed between the implicit dual-task-at-test group and the explicit group can be attributable to the stress intervention.

In attempting the replication we made some minor alterations to the original procedure for operational reasons. These were mainly concerned with the method of inducing and measuring anxiety. We did not pay participants to participate. Masters made use of the participation fee to help induce anxiety in participants at the prospect of losing their money. Consequently, if this difference is critical it will be measurable in terms of a failure to induce anxiety at test. Secondly, participants were not presented face-to-face with a golf professional, rather they were informed of the professional's presence behind a one-way mirror. In fact nobody was present behind this mirror, but a tape was played (audible to the participants next door) containing occasional coughs and noises of chairs being moved slightly. Again this alteration should only be critical in so much as it may reduce the effectiveness of the anxiety induction procedure. Thirdly, we did not take physiological measures of anxiety, only self-report measures. Again this should only reduce the effectiveness of the anxiety induction procedure by reducing our options for measuring any differences.

The other differences were that the putting task involved hitting a target 200 cm away on a flat surface whereas Masters used a slightly inclined surface with a target 150 cm away. Finally, Masters conducted each putting trial on a different day. We chose to conduct the trials all on the same day with small breaks between trials.

EXPERIMENT 1

Method

Participants

Forty-eight participants consisting of first-year psychology students from the University of New South Wales took part in the study. Their participation was part of the First Year Psychology course and they received course credit for their participation. There were 35 females and 13 males. All participants were 'naive' golfers in that they had not played a round of golf in the previous 12 months. It was thought that by only testing individuals who had not played in the previous 12 months, the number of experienced golfers participating would be reduced.(1)

Apparatus

Standard golf putters were used by all participants. The target was a putting hole of standard dimensions (10.8 cm in diameter) 200 cm away. Standard golf balls were used for the putting task. The putting surface consisted of brown carpet tiles. An electronic metronome was used for the dual task. It was set to click every 1.5 seconds.

The materials used for the test session were: a video-camera which participants were told at test was recording them. A personal stereo, speakers and an audiotape, which were placed in the room behind the one-way mirror. The tape had recordings of a person coughing, noises of chairs banging against a table and paper rustling. That was used to convince participants that there was someone in the room behind the one-way mirror during the test phase. The noises on the tape were piloted to ensure they could be heard from the experimental room.

Design

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The experiment was conducted in two phases: a training phase and a test phase. The training phase consisted of four sessions of 40 putts. The explicit learning group (EL) acquired the skill after receiving instructions (i.e. explicitly) whereas the implicit learning group (IL) and implicit dual-task-at-test group (IDAT) acquired the skill while completing a dual task (i.e. implicitly).

The second phase of the experiment was the test session. All three groups received the identical stressors; the video, the golf professional and the experimenter telling participants how important it was that they perform well. During the test session the IDAT group had to both putt the golf balls and complete a dual task. IL and EL groups, however, were only required to complete the putting task.

Procedure

Each participant was assigned to one of three conditions: implicit learning, explicit learning, implicit learning with a dual task during the test phase. Each group consisted of 16 participants.

All participants were tested in the same room with the golf professional said to be in an adjacent room behind a one-way mirror. At the start of each experimental session participants were shown the room behind the one-way mirror, so that they knew that it was possible for someone to watch the experiment from inside there. Participants were also made aware that no one would be in that room unless they were told so. The reason for that was so they should not believe that they were being watched from the start of the experiment.

At the start of each training session, participants in the EL group were handed a sheet of 13 instructions on how to putt a golf ball. The rules were taken from Know the Game: Golf (1976) and Esquire's World of Golf (Graffis, 1966). Participants were told to read the instructions. Once completed, the experimenter explained the golf putting task. It was also explained that there was no time limit in which the putts had to be made.

The IL and IDAT groups were given the same general information about the putting task but did not receive the page of instructions. After being told about the putting task, a metronome, that clicked every 1.5 seconds, was switched on. Participants were then informed that, at the same time as they were required to putt, they had to generate a random letter of the alphabet each time the metronome clicked. It was explained that the letters were not to be in alphabetical order, spelling out words or the same letter repeated. Participants were told that if they said three consecutive letters from the alphabet the experiment would shout 'Order' and they must generate a new letter. It was made clear that they had to continue generating the letters the whole time and that if, for some reason, they stopped then their putting must cease as well. Participants in the IL and the IDAT group were also informed that they did not have to putt the ball each time they generated a letter. Consequently, there was no time limit in which the balls had to be putted.

During each of the four training sessions all participants putted 40 golf balls. At the end of each session, participants in the EL group were given the page of instructions to reread and the implicit groups (IL and the IDAT) were given a two-minute break.

At the conclusion of the fourth training session, participants from all three groups were told that what they had been doing was learning a new skill, golf putting. They were told that their proficiency at golf putting was to be tested and that a golf professional was sitting in the room behind the one-way mirror and that he would be watching and rating their performance. They were also informed that the video-camera in the room would film them putting and this was to be sent to a second golf professional for marking, so that the study was not biased by one golf professional's view. It was then stressed how important it was for participants to putt as well as they possibly could during the upcoming test session.

At that point the experimenter left the room to put on the tape-recorder in the room behind the one-way mirror. The tape that had coughing and chair-moving noises recorded intermittently, was left playing until the end of the test session. Participants then completed the test session, the IDAT group were required to complete the dual task as well as the putting. The EL and IL groups, however, only had to complete the putting task. At the conclusion of the test session participants were asked to 'write down what rules they had used in attempting to hole their putts'. Finally participants were debriefed.

The EL and IL groups were run to compare performance at test under stress of implicitly and explicitly acquired putting skills. The IDAT group was run to compare performance with the IL group to see whether performance at test is influenced by the release from the dual task.

The Spielberger State-Trait Anxiety Inventory State Scale (STAI) was used to measure the change in participants' stress levels (Spielberger, Gotsuch, Lushen, Vagg & Jacobs, 1993). These were given to each participant twice: firstly, at the completion of the third training session, before they were made aware of the video and golf professional. Secondly, between the fourth training

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session and test session, after the they were told about the video and golf professional.

Results

Did participants acquire putting skills across the learning trials?

A mixed design analysis of variance was conducted comparing experimental group across learning trials (1-4). There was no effect of group (F(2,45) = 2.72, p [greater than] .05), but there was a main effect of trials (F(3,135) = 24.47, p [less than].01). The trial by group interaction was not significant (F(6,135) = 2.05, p [greater than] .05). All groups showed a significant increase in putting ability over the training period (mean number of putts on the first and fourth trials): EL, 3.25 (1st), 9.3 (4th); IL, 3.0 (1st), 5.6 (4th); IDAT, 2.5 (1st), 5.5 (4th). The average improvement in putts holed by each group was: EL, 6.05 putts; IL, 2.6 putts; IDAT, 3.0 putts; and consequently we can assert that the participants were learning the putting skill which replicates Masters' findings. The two implicit learning groups which had identical conditions up to this point were behaving similarly.

Was the stress intervention effective?

An analysis of variance was conducted comparing pre- and post-levels of STAI across the experimental conditions. The mean levels of stress before and after the intervention were: EL, 43.75 (before), 47.00 (after); IL, 34.25 (before), 36.06 (after); IDAT, 41.18 (before), 43.18 (after). There was a main effect of group (F(2,45) = 4.87, p [less than] .05) and stress intervention (F(1,45) = 7.37, p [less than] .01), but there was no interaction (E(2,45) [less than] 1, p [greater than] .05). This indicates that levels of self-reported state anxiety increased after the intervention for all groups. There was no interaction between groups, indicating that this increase was similar for all groups. Consequently, we can assert that our stress intervention procedures were successful in so far as there was a demonstrable increase in anxiety levels.

Did the different conditions result in different degrees of explicit knowledge?

Explicit knowledge was analysed in accordance with the method used by Masters. The verbal protocols were scored by counting the number of explicit rules written down by each participant. Figure 1 shows the mean number of rules written down by each group. The explicit group reported significantly more rules than the implicit groups on a directional hypothesis (t(1,40) = 1.74, p [less than] .05). Consequently, this suggests that the experimental conditions did influence to some degree the levels of reportable knowledge.

Test phase: Performance under stress

Figure 2 illustrates the learning curves for all groups and their subsequent performance under stress. All analyses compared performance on trial 4 (the last before the stress intervention) with performance on trial 5 (after the stress intervention). An analysis of variance was conducted comparing pre- and post-stress intervention performance across groups.

There was no main effect of group (F(2,45) = 1.83,p [less than] .05), but there was a main effect of trials (F(1,45) = 4.11, p [greater than] .05) and there was a significant trial by group interaction (F(2,45) = 6.70, p (.01). This indicates differential performance between trial 4 and test in the three groups. This replicates Masters' findings that these groups differ. Analysis of simple main effects revealed no significant change in performance in the EL group across trial 4 and the test trial (F(1,45) [greater than] 1, p [less than] .05) and, likewise, no change in the IDAT group (F(1,45) [less than] 1, p [greater than] .05). There was a significant performance improvement in the IL group (F(1,45) = 16.48, p [less than] .05). This is supportive of hypothesis 1, that the interaction effect is due to performance differences in the implicit group by reason of their release from dual task demands.

Discussion

The implicit learning group continued to show performance improvements under stress whereas the explicit learning group did not. This is consistent with Masters' results. However, the second implicit learning group, who were not released from dual task conditions at test, behaved similarly to the explicit group in not showing performance improvements. This is consistent with the argument that the presence or absence of the dual task conditions is a more important factor in determining test performance than the introduction of stressors. The stress intervention did not appear to have any impact when the release from dual task is controlled for.

One possibility is that our slightly different stress intervention is responsible for our results. However, we believe there are two reasons to reject this possibility. Firstly, a comparison of Fig. 2 showing the mean performance of the groups over trials with a similar figure in Masters (p. 353) shows a remarkable degree of similarity in the pattern of performance of the implicit and explicit groups across the studies. This further encourages us to argue that the original interpretation of Masters'

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results was incorrect. Secondly, it is possible that our stress intervention was not sufficiently stressful. However, we did find significantly increased levels of anxiety in our participants, suggesting that our stress intervention was effective in so much as it raised levels of self-reported anxiety. As in the original study we found a small decrement in the performance of the explicit group at test; however, this was not significant. Consequently (and, as suggested, might have been the case in the original study), the significant increase in the levels of self-reported anxiety at test did not have any impact upon the explicit learning group. This would suggest that the intervention was not sufficiently stressful as it is the explicit group (at least) who would be expected to show performance decrements under stress. Again we draw attention to the similarity of the pattern of our results to those originally reported and suggest that the modest (non-significant?) performance decrement of the original explicit group does not lead one to expect that the stress intervention will adversely affect any of the other experimental groups. If the stress intervention does not affect the group hypothesized to be most at risk (the explicit group), then why does a lack of any impact upon the implicit group imply some unique resilience to stress?

The alternative, and we believe more parsimonious, explanation is that the observed differences between the implicit and explicit groups observed in both studies are due to the increased attentional resources at test for those groups released from the dual task. This would explain the improved performance of the 'implicit' group and does not require positing a separate learning mechanism. Masters allows for the likelihood of such release effects existing, which is why he controls for this effect by reference to an implicit control group who are not stressed at test. The lack of difference between the implicit group and the implicit control is meant to indicate that the implicit group who are stressed maintain performance levels. As we have shown, this may merely reflect the dominance of the dual task in determining performance, even if stress levels are shown to rise significantly it does not necessarily imply the rise will be sufficient to cause performance decrements on this task. There is also a logical difficulty with this line of argument.

The imposition of the dual task during learning is supposed to remove the likelihood of explicit learning of the putting skill. Consequently, any increase in skill levels reflects the acquisition of implicit knowledge. It is further supposed that this type of learning is not affected by stress compared to explicit learning due to the implicit basis of the acquired skill. However, Masters argues that the removal of the dual task may result in improved performance of the implicit group. It is not clear, given the hypothesized lack of an effect of stress, why generating random letters (an explicit task) should affect a task based on implicit knowledge (putting). The random letter generation task is assumed to occupy the resources of working memory, yet implicit learning theorists have argued that implicit learning does not require working memory (e.g. Berry & Broadbent, 1988; Hayes & Broadbent, 1988). The observed suppressed performance under dual task conditions suggests that this task involves a significant explicit component. Then there is no difficulty with the prediction if you assume that both groups learn to putt explicitly and (presumably) given a sufficiently high degree of stress both groups will show similar performance decrements.

We argue that it is the nature of the dual task conditions that influences performance improvements when the dual task requirement is removed. If, as we argue, there is a significant explicit component to the putting task and that this is attenuated under dual task learning conditions, the degree of attenuation will be determined by the nature of the dual task. That is, demanding dual tasks will attenuate performance more than undemanding tasks. Furthermore the degree of performance improvement when the dual task requirement is removed will be greater for release from demanding dual tasks than undemanding tasks. We address this question in our second study.

EXPERIMENT 2

Method

Participants

The study was conducted with 22 first-year psychology students from the University of New South Wales. There were 11 males and 11 females. Again it was ensured that all participants were naive golfers in that they had not played a round of golf in the last year or taken part in Expt 1.

Materials

The apparatus was same as that used for Expt 1.

Design

The experiment consisted of two stages: a training stage and a test stage. The experiment had two groups: a hard dual task group and an easy dual task group. Both groups learned the putting task under dual task (implicit) conditions but were not required to complete the dual task during the test phase.

During the training phase the easy dual task group were

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required to generate a random letter every three seconds whereas the hard dual task group were required to generate a letter every second. The dual task manipulation required two levels of difficulty. These levels were constrained by the need to ensure that the secondary task was frequent enough to prevent the tasks being executed alternately (i.e. too easy) and not so frequent so as to prevent any primary task execution (i.e. too hard). Informal pilots revealed an easy level to be three-second intervals and a difficulty level to be one-second intervals. A couple of volunteers who tried both dual tasks reported that the tasks differed in the demands placed upon the individual; however, neither task appeared to allow the putting task to be carried out in alternation with the random generation task.

Procedure

The participants were randomly assigned to one of the two groups, hard dual task group (HDT) and easy dual task group (EDT). Both groups consisted of 11 participants. The basic procedure for the putting task and the dual task was the same as in Expt 1. Both groups learned the putting under dual task conditions but did not complete the dual task during the test session. The EDT group were required to say out loud a random letter of the alphabet every three seconds and the HDT group had to generate a letter every second. The stressors were the same as those used in Expt 1. Participants again completed the STAI (State Scale) twice, once before the stress intervention and once afterwards.

Results

One participant in the EDT group had to be removed from the data analysis. The reason for the removal was that he did not learn the skill during the training stages and then showed a large improvement in putting between the fourth training session and the test stage. The improvement was over three standard deviations above the mean improvement shown by the rest of the group. His explanation was that 'once I realized I was hitting it too hard (during the test stage) then I got better'. The results of that participant during the test stage were therefore not due to the 'dual task release effect' or robustness against stress, but rather learning of the task.

An analysis of variance was conducted comparing putting performance across trials (1-4) and groups to test for learning. There was no main effect of group (F(1,19) [less than] 1, p [greater than] .05), but there was a main effect of trials (F(3,57) = 9.25, p [less than] .05). The interaction of group and trials was not significant (F(3,57) [less than] 1, p [greater than] .05). Learning was apparent across trials in both groups and there was not a significant difference between the two groups in their improvement in putting over the four training sessions. The mean number of putts holed on the first and fourth trials were: EDT, 2.40 (1st), 7.7 (4th); HDT, 3.36 (1st), 6.63 (4th). The EDT group improved on average by 5.30 putts holed, and the HDT group improved on average by 3.27 putts holed.

An analysis of variance was conducted comparing stress levels across trials (4, test) and groups to test the effectiveness of the stress intervention. The stress intervention was found to increase levels of stress (F(1,19) = 2.99, p [less than] .05) on a directional comparison, but we feel this is reasonable given the preceding results. The mean stress levels (STAI) of the groups measured before and after the stress intervention were: EDT group, 41.2 (before), 43.1 (after); HDT group, 37.4 (before), 39.9 (after). There was no interaction with groups, indicating this effect was consistent across groups (F(1,19) [less than] 1, p [greater than] .05).

The performance curves of the two groups (shown in [ILLUSTRATION FOR FIGURE 3 OMITTED]) show that both groups continued to improve during the test session. The EDT group, after the stressors were introduced and the dual task removed, improved, on average by 2.5 putts, from an average of 7.7 to 10.2 putts holed. The HDT group increased from an average of 6.6 putts holed during the fourth trial to an average of 12.3 putts holed during the test session. Putting performance comparing performance on trial 4 and the test trial across the experimental groups was also analysed using an ANOVA. There was no main effect of group (F(1,19) [less than] 1, p [greater than] .05). The main effect for trials was found to be significant (F(1,19) = 30.98, p [less than] .05), meaning that significantly more putts were holed during the test session than the fourth training session. The interaction was also found to be significant (F(1,19) = 4.43, p [less than] .05). Analysis of simple main effects revealed a significant difference in performance of the EDT group (F(1,19) = 14.43, p [less than] .05) and a significant effect for the HDT group (F(1,19) = 30.02, p [less than] .05). From Fig. 3, it can be seen that the increase in holed putts shown by the HDT group was greater than that shown by the EDT group, which explains the interaction. This is confirmed by an analysis of simple main effects. There was no significant difference in performance on the 4th trial between groups (F [less than] 1, p [greater than] .05), but there was a significant difference on the test trial between groups (F(1,19) = 8.51, p [less than] .05).

Participants appeared to complete the dual task appropriately as judged from the experimenter monitoring the random letter generations. It was rate that the shout of

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'order' was needed to prevent them from generating' non-random' sequences in this or the previous experiment. On average this occurred less than once per participant in either study. Many participants commented at the end of the experiment how hard they had found it thinking of letters.

Discussion

The results replicate the effects found in Expt 1 and the pattern found by Masters. As hypothesized, the performance increase was larger for the HDT group than the EDT group. This provides some support for our argument that the putting skill contains a significant explicit component that is influenced by the dual task conditions.

Conclusions

Masters (1992) observed a dissociation in performance between what he regarded as an implicit putting task and an explicit putting task. Increases in anxiety at test appeared to impair the explicitly trained group, but had no effect on the implicitly trained group. We replicated these results in Expt 1, but argued that the apparent dissociation in performance of the groups could be explained more adequately in terms of the dramatic improvement of the implicit groups at test due to the removal of the dual task requirement. We failed to find differential effects of stress on the implicitly and explicitly trained groups and question whether Masters' reported stress interaction is in fact an artifact of the dual task manipulation. Our analysis failed to demonstrate an effect of stress on any individual learning group, yet our pattern of results are identical to those reported by Masters. In our second experiment we demonstrated that performance improvements at test are more dramatic when participants are released from carrying out a harder dual task compared to an easier one. This is consistent with the view that it is the dual task manipulation which is responsible for the effects observed here and by Masters.

We argue that the results reported here and those in Masters (1992) do not require recourse to a theory of separate implicit and explicit learning systems. Rather our data are consistent with an explicit learning account of the putting task. The task would appear to be characterized as susceptible to the effects of dual task interference but relatively robust in the face of modest increases in anxiety levels.

In many respects our conclusions are not surprising given the difficulty of demonstrating the existence of implicit learning under any circumstances. In a recent review of the literature Shanks & St John (1994) argue that no convincing demonstration of the phenomenon existed. Typically, demonstrations of the phenomena have rested on single dissociations between performance and (conscious) verbalizable knowledge. Other than the difficulty that such dissociations need not entail separate systems, many researchers have claimed that these dissociations do not exist (e.g. Perruchet & Amorim, 1992). The one study to show differential effects on implicit and explicit learning (Hayes & Broadbent, 1988), has failed to replicate (Green & Shanks, 1993).

Whilst our results would appear to fall into the long tradition of questioning the existence of implicit learning, they are inconsistent with several recent studies that demonstrate a difference in the effects of anxiety on implicit and explicit learning. For instance, the Rathus et al. (1994) study mentioned earlier suggests that a cognitive task such as artificial grammar learning has implicit and explicit components that are differentially affected by anxiety. It is possible that our failure to find such an effect may be due to the inadequacy of our stress intervention. Given the dramatic effect that the dual task procedure has on performance, it may be that subtler implicit effects are masked. We accept that this is a possibility, but it remains that implicit effects have not yet been demonstrated here or in Masters (1992). In order to demonstrate these effects using the dual task methodology, it would be necessary to ensure that the stress intervention was sufficiently powerful to be measured in terms of putting performance independent of the dual task effects. We wonder whether, ethically, this is realistically possible.

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1 Although this is not particularly rigorous, Masters did not attempt any pre-testing of participants to avoid preempting explicit knowledge.

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