MASTER OF PHILOSOPHY

An investigation into implicit and explicit learning with motor skills and the most beneficial time to give explicit rules

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Award date:
1998

Awarding institution:
University of Wales, Bangor

An Investigation Into Implicit And Explicit Learning With Motor Skills And The Most Beneficial Time To Give Explicit Rules

Dissertation submitted to the University of Wales, Bangor

for the degree of Master of Philosophy

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Acknowledgements

This thesis would never have been completed had it not been for the support and encouragement of a small group of people.

Thank you to my good friend and colleague who listened (and probably suffered) on the days when I was less than enthusiastic about finishing, and who reminded me what happens when you resort to using big or made-up words. Thank you for the humour!

Thank you to everyone who gave me a sometimes needed "arse kicking", the threat of a party upon completion and the phrase, special in its simplicity, *"just do it!"*.

Abstract

This investigation attempts to identify the most effective time to give explicit rules during the learning of a complex motor skill and adopts Reber, Lewis, Kassin and Cantor's (1980) timing strategy for giving explicit rules. Three experimental groups were used. An implicit group who received no explicit rules at all about the task. A delayed explicit group who received explicit rules exactly half way through the acquisition period and an explicit group who received the explicit rules at the onset of acquisition. However, Reber et al. used a cognitive skill whilst this experiment tests the generalisability of the results to motor skills.

The results did not reflect those of Reber et al. and only a learning effect was present. No evidence was found to suggest that any of the groups' performance was improved by giving explicit rules at the different times during acquisition. This may have been due to the nature of the task used and the type of rules given rather than specifically being a result of ungeneralisable findings. Therefore, the second experiment utilised the task and explicit rules of Verdolini-Marston and Balota (1994) which had been found to display differences in implicit and explicit memory. The procedure and explicit timing strategy remained the same as the first experiment. Results similar to those of the first experiment were found. Again there was a significant learning effect reported. Generally only partial support for the third hypothesis, that reported explicit knowledge will be greater in subjects who practised the task with explicit rules was found. Discussion of the findings focuses upon the possible causes of the statistically non-significant results. The lack of findings are in the main attributed to the subjects use of the explicit rules and the fact that they may have ignored the rules. This could have been due to subjects not believing the

explicit rules to be important, therefore they were not salient. Also there is some concern that the task of the first experiment was not complex enough, thus again the subjects may not have perceived the rules as necessary in order to complete the task.

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Introduction

Identifying the systems or modes that are used in order to learn a skill is of great importance to many people, for example teachers and coaches, the list is endless. Consider the role of the teacher. The most effective way of teaching a skill is often debated. Should a demonstration be given at the start and a "copy me" approach employed, should learners be allowed to "figure it out for themselves", or should a combination of the two approaches be employed? The next consideration must then be the skill being learnt. Does it lend itself naturally to one or other of the above methods? What sort of skill is it? Is it "ballistic", requiring a short burst of energy, for example a ball thrown at a target with a perceivable beginning and end to the skill? Or is it "continuous" as in the repetitive movements of riding a bike where there is no recognisable beginning and end? Is it an "open" skill, performed in an unstable or unpredictable environmental setting, or a "closed" skill (performed in a stable or predictable environmental setting)? One might also need to consider the experience the learner has with regard to the skill. Other factors the learner innately brings with them should also be considered as they may influence the way a skill is mastered. Examples of these would be the learners' age and sex (Krist, Fieberg and Wilkening, 1993).

Take the example of performing a backhand stoke in squash. In attempting to improve on the learners' technique what level of constraint should the instructor impose on the learning environment? Should it just be loosely constrained by the use of a visual demonstration or should specific feedback be given on shot technique? Here another question is raised regarding the nature of the feedback.

One of the ways researchers have investigated this question is to look at it from an "information use" perspective. What information does the learner use in order to master the skill? Is it information the learner is aware, or conscious of, or is it unconscious information of which the learner is not aware? Does the learner make most use of verbal or non-verbal information cues, and does this make a difference to the way in which the skill is learned?

It soon becomes apparent that the initial simplistic idea of teaching someone a skill could quickly become awash with missed or unproductive learning opportunities. Many researchers have attempted through various methods to find answers to these questions and discover the best ways of teaching skills.

As has been described above the best way of teaching skills has many elements, however it is the timing of explicit rules which is of concern in this thesis. For example when teaching someone to ski it may be advantageous to let them try it themselves first before any instruction is given so that they gain a "feel" for the skill. Alternatively, it may be considered more beneficial to provide explicit instruction immediately. Of course, the timing of explicit instruction in some tasks is crucial if only from a safety perspective, however, when this is not the case the provision of explicit rules is often at the teachers discretion. This thesis aims to investigate and inform upon the most effective time for giving explicit rules in a complex motor skill, either at the start, the middle or a combination of these. The effect this has on explicit and implicit memory and performance will then be investigated.

Definition of Key Words

Declarative Memory: Information regarding "what to do" to perform a task.

Dual-process (dissociation) model: This proposes that different processing levels distinguish implicit and explicit memory performance. Hence, explicit memory performance is primarily affected by elaborative processes. Implicit memory performance is uninfluenced by elaborative processing and is possibly best under conditions that emphasise perceptual-integrative processes (Verdolini-Marston and Balota, 1994)

Dual-task paradigm: A procedure whereby two tasks are performed at the same time. The intention is to disrupt performance on one task by simultaneously performing the other task.

Elaborative Rules: Rules which relate target events to other contents of memory (Verdolini-Marston and Balota, 1994)

Explicit Knowledge: A selective, directed, controlled or deliberate reference to or recollection of a prior episode. It is achieved with awareness and is conscious, and verbalisable.

Implicit Memory: Revealed when previous experiences which are not consciously remembered facilitate performance. It gives rise to abstract or intuitive knowledge and is without awareness, i.e. unconscious.

Modelling: A demonstration of the skill so that the elements of action can be seen directly by the learners. This can be in many forms for example a live model, a videotape demonstration or photographs of a skilled performer.

Perceptual-Integrative Processes: Suggested to facilitate implicit memory in the Dual Process (dissociation) model. Verdolini-Marston and Balota (1994) directed subjects' attention to the surface characteristics of the pursuit rotor task as an exercise in concentration and attending to the rotating target and perceptual-integrative processing.

Procedural Memory: Information regarding "how to do" a task.

Quasi-memory (QM): Proposed by Hayman and Tulving (1989) as responsible for priming effects. Changes in the QM system do not record that a particular stimulus has been presented. These changes increase the probability or speed of responding to a particular stimulus.

Repetition priming: The facilitation in performance, usually implicit, from repeatedly presenting a task during the acquisition or learning phase.

Spacing effects: The phenomenon whereby items repeated after a short delay are retained more effectively than items repeated immediately (Parkin, Reid and Russo, 1990).

Transfer-appropriate processing framework: Proposes that explicit memory performance should be facilitated by explicit rules that emphasise which specific stimuli were encountered. Implicit memory performance is influenced by elaborative processes that emphasised how to perform the perceptual-motor task (Verdolini-Marston and Balota, 1994).

General Literature Review

The General Literature Review will introduce some of the factors that may be important when investigating implicit and explicit learning with a motor skill. The issue concerning the most beneficial time to give explicit rules will be addressed in the first literature review.

For many years researchers have been investigating the differences that appear to exist between knowledge reported as intuitive, or that which we "just seem to know", although we are not sure how, and knowledge we "know that we know".

The intuitive knowledge we have about a task or skill is often referred to as Implicit knowledge (Reber, 1967), and is considered to be the abstract, unconscious or non-verbalisable knowledge we have about the structure of complex stimulus environments. In contrast the knowledge we can remember is termed Explicit knowledge, and is typically verbalisable and conscious (Green and Shanks, 1993).

The implicit and explicit distinction has also been used with learning (Nissen and Bullemer, 1987), and memory (Graf and Schacter, 1985). Evidence for implicit memory has previously been gathered using tasks such as word fragment completion (Tulving, Schacter and Stark, 1982), perceptual identification (Jacoby and Dallas, 1981) and performance repetition priming (Hayman and Tulving, 1989). Explicit memory has traditionally been demonstrated using free-recall, cued-recall and recognition tests (Parkin et al., 1990).

Other terms common to this field of research are procedural and declarative distinctions (Cohen and Squire, 1980). Procedural knowledge is termed the "how to do" aspect of the task, whereas declarative knowledge is "what to do". Take the example of a triple somersault. Knowing how to do a triple somersault without specifically knowing the techniques behind each part of the movements would be procedural knowledge, however, knowing the theory and exactly where each part of the body has to be relative to the next part of the move would be declarative knowledge. The terms procedural and implicit knowledge, and similarly declarative and explicit knowledge are sometimes discussed synonymously. Although this investigation will consider the terms closely linked, they will not be addressed identically.

The distinction between the implicit and explicit learning or memory systems has been researched for many years traditionally using cognitive tasks. One of the earliest researchers was Moray (1959) who investigated attention in dichotic listening. Moray found that subjects were unable to recall words that had not been attended to, although Norman (1989) found that if there was a short time delay, recall for the unattended words improved.

Similarly, a study by Parkin et al. (1990) found evidence for a dissociation between implicit and explicit memory. Using a sentence verification task they found that recognition (explicit memory) was significantly impaired by imposing secondary processing demands during the original learning phase, although priming effects (implicit memory) were uninfluenced. Parkin et al. (1990) also found evidence for the spacing effect (Melton, 1970), a phenomenon whereby items repeated after a short delay during the learning phase, are retained better than items repeated immediately (Greene, 1989). They found that the spacing effect did not influence implicit memory during the initial learning phase but did produce a significant advantage in explicit response.

Fisk and Schneider (1984) assessed implicit and explicit learning by training subjects to categorise words semantically. Using a dual-task paradigm, they showed that although subjects demonstrated little evidence of having learned the 10-item sequence, subjects' response latencies decreased over the practice period, hence reflecting an improvement in performance. Light and Singh (1987) provided evidence for different memory systems using word completion tasks with different aged subjects. They found that memory for tasks dependent on automatic activation processes is relatively unaffected by age, whereas tasks which require conscious recollection are impaired by age. Hayes and Broadbent (1988) used what they described as two "superficially similar tasks" which required the subject to interact with a computer in order to show differences between the implicit and explicit systems. The two tasks in fact differed in terms of whether they could be accessed by the learner and verbally reported. Introducing a verbal secondary task showed that in one case, where there was a verbalisable element, the second task interfered and inhibited learning. In the other case, the verbal secondary task actually improved learning performance. The findings demonstrated a "double dissociation" between the modes of learning.

Reber (1989) using a complex grammar learning sequence also suggested that there is support for two different modes of learning. He found evidence that subjects could learn and correctly apply rules for the complex grammar learning sequence without being aware that they had learned the rules.

Neurophysiological studies show an apparent dissociation between procedural and declarative memory. Saint-Cyr, Taylor and Lang (1988) found that patients with basal ganglia damage showed procedural learning deficits, but their declarative learning remained intact. However, Green and Shanks (1993) warn of problems which may arise from studying patients with basal ganglia damage concerning their primary motor dysfunction, as this could affect their perceptual system and confound the task results.

Patients suffering from Amnesia demonstrated the opposite results. They performed normally on procedural learning tasks, but showed a deficit in performance for declarative memory (Squire and Cohen, 1984; Warrington and Weiskrantz, 1974). Nissen and Bullemer (1987) tested subjects with memory disorders resulting from Korskoff's syndrome, a severe form of amnesia where recent memory is affected more than distant memory. Sufferers are often not able to remember what they did even a few minutes previously and frequently invent stories to fill gaps in memory (Smith 1995). Nissen and Bullemer's results showed that subjects learned a repeating sequence on a serial reaction time task as reflected by their performance, despite them having no conscious knowledge of the sequence.

Results of the above studies and many more appear to show evidence for a dissociation between the implicit and explicit systems. Typically a facilitation in implicit memory is measured by repetition priming effects, whilst explicit memory is demonstrated by an increase in reportable knowledge about the task. From experiments using cognitive tasks suppositions have been made about the way the implicit and explicit systems operate with many different skills (Adams, 1983). However, when generalising to motor skills problems could arise, and it is only recently that the possible dissociation between the implicit and explicit memory systems has been considered specifically with motor tasks.

Green and Flowers (1991) investigated implicit and explicit learning in a probabilistic, continuous, fine-motor catching task. They found that providing explicit probability instructions negatively influenced task performance, as the group given explicit rules performed worse than the group that received no instruction. The usual hypothesis for such findings relates back to the reasoning provided by Hayes and Broadbent (1988). The element of the catching task that can be verbalised creates an interference in the execution of the task. In this case, however, Green and Flowers (1991) invoke reasoning which relies on establishing a qualitative difference in the modes of control of different types of task which are used in visually and verbally directed movement. Their results show that in some task contexts, what might be expected to facilitate does in fact disrupt performance and learning. They rely on the idea of processing overload to account for this and relate their findings to the logic suggested by Reber (1976, 1989). This states that when compared to implicit processes for establishing rules in probabilistic events, explicit processes have a distinctive disadvantage especially when implicit rules may not normally become expressible during learning. Stadler (1989) also highlighted the complex interaction of implicit and explicit processes and task constraints and, in considering all such findings - there are clearly strong precursors to the ideas which follow, in respect of increasing automaticity during learning (Masters, 1992; Fazey 1985).

Krist et al. (1993) showed that intuitive knowledge is present in tasks that require subjects to judge projectile motion. They tested the hypothesis that a perceptual-motor base guides skilled action and found evidence that a dissociation exists between perceptual-motor and judgmental or explicit knowledge competencies.

Masters (1992) demonstrated with a motor task, that it is possible to induce a breakdown in skilful performance by reinvesting explicit knowledge into the task. Using implicit and explicit learning groups, Masters claimed that increasing the pressure to perform well disrupted the automaticity of a skill learnt with explicit rules more than the group which received no explicit rules (the implicit group). To explain all these findings it would be necessary to hypothesise a dissociation which includes the influence of the level of expertise or extent of practice experienced, the type of task and likelihood of explicit rules emerging from the experience of learning the task.

The results from motor tasks seem to demonstrate findings similar to those of cognitive tasks, although there are some important considerations. Adams (1983) concludes that

> "verbal memory and motor memory cannot be assumed the same a priori, but that unification, if it ever happens, will come when similarities of knowledge in the domains are perceived". (pp, 3)

and suggests that general laws about memory may exist, but the results from cognitive or verbal memory research do not necessarily generalise to motor memory research.

The level of task difficulty and not a separation of the memory systems could have caused some of the results found so far. Green and Shanks (1993) report that between two similar skills which were theorised as being learnt by "separate systems" (Hayes and Broadbent, 1988), the findings actually supported the notion that the differences in the two skills occurred in terms of their relative levels of difficulty, and not in their reliance on two different modes of learning. They attempted to replicate Hayes and Broadbent (1988) but in five experiments failed to acquire any empirical evidence to support a dissociation effect based on assumed different underlying modes of learning.

However, the two hypotheses are not mutually exclusive, Reber, Kassin, Lewis and Cantor (1980), Reber (1989), Masters (1992) and Green and Shanks (1993) all agree that in order to study implicit and explicit learning the experimental task must be sufficiently complex.

> "Implicit acquisition of complex knowledge is taken as a foundation process for the development of abstract, tacit knowledge of all kinds"
>
> (Reber, 1989, pp 219)

To examine the role of explicit rules within skill acquisition, the learner has to be placed in a situation where they would benefit from being given explicit rules. In a simple skill such as clicking your fingers, the learner could probably acquire the skill effectively without the need for explicit guidance. However, when learning a complex skill, pole vaulting for example, the learner may find it quite useful to be given some instructions. Berry and Broadbent (1988) remind us however, that it is probably the case that:-

> "...the knowledge gained as a result of interacting with a complex learning task is likely to involve both implicit and explicit aspects, rather than solely one or the other. The particular balance will depend upon both the experimental instructions and the salience of the crucial variables in the task."
>
> (Berry and Broadbent, 1988, pp271)

The method of giving instructions may also change between cognitive and motor tasks. For cognitive, verbal tasks, the most appropriate explicit rules to use may be those of a verbal nature. However, this may not be true of motor tasks. Magill (1993) demonstrated that novices acquired the co-ordination characteristics of a slalom ski simulation, a motor task, quicker when they observed a skilled model than when they were given verbal feedback. Landers (1975) used the Bachman Ladder Task to show similar findings. Three groups all received tape-recorded verbal instructions regarding how to climb as high as possible, but two of the groups also received a live modelling demonstration before any practice. Both these "model" groups performed more effectively on the first trial than the group who only received verbal instructions. The implications of these findings relate to discovering exactly what information is used in learning complex motor skills, and what roles the different types of instruction play in providing that information. Magill (1993) suggests that it is a question of "information use" and agrees with Newell's (1990) claim that

> "we need to know more about what information is important for learning motor skills. And, we need to know more about instruction and learning

strategies and techniques that enhance the acquisition of that information".

(In Magill, 1993, pp 367)

Verdolini-Marston and Balota (1994) have considered the information which is both relevant and salient for learning motor skills. Using a pursuit rotor task, they attempted to identify the role of distinct types of elaborative processing in both implicit and explicit perceptual-motor memory performance. By using different explicit, or elaborative rules, they investigated whether the implicit / explicit debate could be explained by a "transfer-appropriate processing framework" or a "dual-process (dissociation) model". The elaborative rules they used investigated the distinction between those rules that emphasised how to perform the pursuit rotor task, those that highlighted the specific stimuli subjects received, and the rules that promoted perceptual processing.

The transfer-appropriate processing framework presents the view that explicit memory performance would be facilitated by elaborative rules that emphasise which specific stimuli were encountered, whereas implicit memory performance would be primarily influenced by explicit or elaborative processes that emphasised how to perform the perceptual-motor task (Blaxton, 1989). However, the dual-process (dissociation) model proposes that different processing levels distinguish implicit and explicit memory performance. Therefore explicit memory would primarily be affected by elaborative (explicit) processes, but implicit memory performance should be relatively uninfluenced by explicit levels of elaborative processing and possibly be best under conditions that emphasise perceptual-integrative processes.

Verdolini-Marston and Balota (1994) did not find a common reliance of implicit and explicit memory on elaborative processes. Elaborative rules that emphasised which stimuli were presented produced the highest level of explicit memory performance. There was no evidence that any of the elaborative rules, including two that emphasised how to do the pursuit rotor task produced higher implicit memory performance, although a facilitation for implicit memory performance was displayed when no instructions at all were given. Thus, they found evidence to support the view that implicit and explicit memory performances in the perceptual-motor domain are affected by different processing methods. They suggest that their results provide strong evidence for a dissociation approach, especially because of the reduced or disrupted implicit memory performance found in the group who benefited from the elaborative rules, as opposed to the group that did not receive any explicit rules.

When considering the type of skill used to differentiate between the contributions of the implicit and explicit learning systems, it is important to consider the nature of the skill as this has also been hypothesised to have an effect on the results found. Not only, as was mentioned earlier, does the skill need to be sufficiently complex, but the nature of the skill can have an influence on how effective either an implicit or explicit learning method may be. Green and Flowers (1991) suggest that attention-demanding visuo-motor tasks may be

> "...particularly vulnerable to disruption by attempts to retain and apply verbally provided explicit probability information..." (pp 299)

and suggest that future research questions should

> "...determine more specifically the nature of the types of tasks that are most vulnerable to disruption by explicit instruction." (pp 299)

There are several theories about this disruption or interference effect, caused by providing explicit instructions when learning a new skill. Reber et al. (1980) identified the effect in their complex grammar learning cognitive task. By giving explicit rules half way through the acquisition period they found that an interference effect occurred. Reber et al. suggested that this could be due to the learner spending so long trying to remember the rules that the skill is not learnt properly. Green and Flowers (1991) in their probabilistic, continuous fine motor task and Masters (1992) in his analysis of complex motor skill, both suggest that the effect could be an instance of the "resource limitation effect" (Reber, 1989) that is observed as a disruption to skilful performance when explicit rules are given. The notion being, that when a new skill is learnt we have certain resources which are allocated to the learning of the new skill. However, if all the allocated resources are trying to remember the explicit rules, instead of trying to proceed with the skill, then an interference effect, or processing overload (Green and Flowers 1991) will occur as the explicit rules are in danger of inhibiting the full learning potential of the individual.

Green and Shanks (1993) have highlighted another concern regarding the task. They question the view that the implicit and explicit learning modes can be "functionally dissociable learning systems". Green and Shanks (1993) suggest that many studies assume there are independent learning systems. This in turn suggests there is a single skill that will show the existence of one learning system alone. An assumption which Green and Shanks propose could over simplify the question and fail to capture the complexities which arise when the two learning systems interact. Indeed Jacoby (1991) argues against an individual task being "process pure". Jacoby proposes that a single task may involve the contribution of more than one type of memory process.

> "Automatic and intentional processes combine to determine performance of nearly all tasks and so tasks cannot legitimately be treated as process pure." (pp 534)

There is a complex but (at one level) simple to understand relationship between the level of task difficulty, complexity or type of task and the expertise or level of learning of the performer. They stand in some sort of inverse relationship. As expertise develops the relative difficulty of performing the task decreases.

The hypothesised theoretical model that is offered to account for this uses the well established neuro-psychological frameworks (Jeanerod, 1988) that account for short and long reaction times in correcting errors and adjusting on-going movements. This has distinct parallels with implicit and explicit modes of control and suggests that in performing learned actions there is reliance on automated correction loops, which are recruited without conscious awareness, i.e. are implicit. If the performer consciously invokes a correction or modification to a practised movement the invoked change will be coarse and look much more like that or a beginner or novice.

Fazey (1985) suggests that one reason for the interference effect for highly trained performers when using explicit instructions, is merely a 'resolution' phenomenon of control. When verbalisable (explicit) modes are used it is not possible to achieve fine grain control. Thus invoking higher levels of control (verbal) inevitably leads to coarser corrections or adjustments on subsequent trials. This then inhibits the progressive reduction of variable error in trials. In fine and gross motor tasks, Fazey (1985) demonstrated that when subjects were asked to verbalise relatively small corrections following precise feedback they invariably overcompensated. The implication seems to be that there is a requirement to consider which components of the motor system are actually controlled or controllable by other components of the overall memory structure.

Heindel, Salmon, Shults, Walicke and Butters (1989) show that further components can be found within the implicit memory system. One of these components may be a perceptual representation system (PRS), distinct from a semantic memory system, which supports perceptual priming on implicit tasks (Schacter, Cooper and Delaney 1990). Whilst Tulving and Schacter (1990) have argued that conceptual priming tasks may involve the use of a third system to govern performance. Hayman and Tulving (1989) argue that a "Traceless Quasi-memory" (QM) with properties very different from the episodic system assumed to underlie explicit memory, may be responsible for mediating priming effects. They suggest that within the QM system

> "learning occurs not by the establishment of traces representing the original stimulus, as would be required for conscious recollection, but by

changes in the various procedures that operate on the stimulus when it is perceptually present".

(In Parkin et al., 1990, pp 508)

Thus changes in the QM system would increase the probability or speed of responding to a particular stimulus but would not record that a particular stimulus has been presented. Parkin et al. (1990) suggest that this theory describes why the priming phenomenon are only exhibited when some component of the original stimulus is present.

Is it possible then to separate between implicit and explicit learning or memory systems? Or assume that the findings from cognitive tasks can be generalised to motor tasks? It also appears that the nature of the task and the type of explicit rules used to identify the implicit / explicit mode of learning is very important.

The issue of when instructions are given has only been systematically addressed in cognitive tasks. In the Reber et al (1980) study, subjects received one of the five manipulations of exposure to explicit rules of task performance at different stages of practice. The intention was to show whether, and to what extent, giving explicit rules at different stages of skill development assisted or impaired performance and learning. They found that explicit rules were beneficial if given at the start of a learning episode. This presents something of a paradox, explainable in terms of a cognitive/motor task difference as Green and Flowers (1991) found that explicit rules about a probabilistic, continuous fine-motor catching task had a negative effect on performance.

To summarise these conceptual issues that have been raised by examining the literature it is necessary to consider four key constructs. These are the dissociation and separateness of implicit and explicit modes of learning, the influence of level of expertise of the learner or relative difficulty of a task, the type of task and its attentional demands or characteristics, and the likelihood of explicit rules being generated through the experience of learning. Any theoretical explanation will also have to be tested in relation to some more practical questions.

Such questions are concerned with the most efficient way of learning a skill in applied settings. To achieve a clearer understanding of the implicit / explicit distinction within motor performance these questions should be reformed as: what type of task is most affected by giving explicit rules and in what way; what are the most effective rules to give; to what level, and what age of performer should different styles of instruction be given; and when is the most advantageous time to give instruction or explicit rules? The answers to which have major implications for teachers and coaches in many different fields and should help clarify some of the underpinning theory.

EXPERIMENT ONE

Literature Review

There are many different styles of teaching. Mosston and Ashworth (1986) describe them on a spectrum from a command technique to a method whereby the learner actively engages in a process of discovery. The theoretical grounds for the different classifications are based on an hypothesised link between the responsibility for decision making and the learning outcome in terms of personal growth and development. The greater the responsibility of the learner then the greater the opportunity for overall development.

Arguably the most common teaching scenario with physical skills involves learners receiving a set of instructions before they attempt to perform the skill. The extent and timing of such instructions would, in Mosston and Ashworth's terms be a primary factory in determining learning.

At another level of analysis, different teaching styles will, by nature, require the learner to engage in differing amounts of implicit and explicit learning and use of memory processes. In these terms the question of when is the most beneficial time to give instructions in motor skill acquisition becomes addressable but has not been researched. Without doubt, there are those skills that could not be attempted without some initial guidance, but is this a general rule or is performance on some motor skills hindered by giving instructions initially. Would these motor skills show a facilitation in performance if instruction is given at some other point during learning?

As outlined earlier Reber et al. (1980) considered the question with a complex grammar learning task. They investigated the phenomenon from what they described as a "distinctly inadequate theoretical basis". Thus, they speculated that several different outcomes could emerge from introducing explicit rules at different times. Post hoc theorising provided a theoretical base which argues that if explicit rules are given at the onset of practice then subject's performances could be improved by directing their attention to the salient aspects of the task. This Reber et al. (1980) describes as being

> "akin to the common pedagogic device of giving students a general principle or rule followed by concrete instances." (pp 497)

Alternatively, providing explicit rules at the end of practice could be beneficial by formalising the implicit or tacit knowledge subjects have gained about the task. However, the most efficient learning may be demonstrated if these two different styles are combined and the rules are introduced half way through practice. From the results of previous work (Reber, 1976) they also hypothesised that introducing explicit rules half way through practice could instead have a negative effect on performance and interfere with learning. Finally, rules given at the end of the practice period may be disruptive if they conflict with the subject's own perceived rules about the task.

Reber et al. (1980) obtained results that suggested the most beneficial time to give explicit rules was at the start of a learning episode as opposed to half way through or not at all. In fact, they found that the group who received explicit rules half way through practice reported that an interference effect occurred from giving the rules at that point.

Overall they found that the group given explicit rules at the onset of practice performed best during the learning period, followed by the group given explicit rules in the middle, whilst the implicit group performed the worst. On the test part of the experiment the explicit group performed the most consistently, and hence most effectively, whereas the implicit group again performed the worst.

This is consistent with the theoretical model that dissociates implicit and explicit modes of learning and envisages differentiated effects of each mode in relation to task complexity (a relative experience) (Hayes and Broadbent, 1988; Green and Flowers, 1991). It can be argued that if this theoretical model is appropriate in terms of complex cognitive tasks (Reber, 1989) and it is a reasonable, albeit incomplete, account of motor learning (Adams, 1983) the issue of when instructions are best given in a motor learning context is testable using a modification of Reber et al. 1989.

In this study it is expected that the group who receives the explicit rules at the beginning of the learning episode will perform the best and the explicit group are expected to report the highest level of explicit knowledge at the end of the task (Verdolini-Marston and Balota, 1994). The impact of the change from a cognitive to a motor task on the delayed explicit group results of Reber et al. (1980) may not alter. The "resource limitation effect" (Reber, 1989) might suggest that an interference in performance could occur in a motor task. Masters (1992) found that performance could be disrupted with explicit rules. Although Masters found that the disruption of automaticity of a skill under pressure would be more likely if the task was learned with explicit rules.

The implicit group is not expected to perform the task as well as the other two groups because no explicit rules will be provided. With a complex motor task, it is expected that explicit rules are needed in order to achieve expertise in performance (Green and Shanks, 1993).

Hypotheses

1. During acquisition explicit rules given after implicit learning of a novel and complex motor task, will result in poorer performance time scores than explicit rules given before any implicit learning has taken place.

2. Performance time scores in the retention task will be poorer for subjects who practised the acquisition task without explicit rules.

3. Reported explicit knowledge will be greater in subjects who practised the task with explicit rules.

Methodology

Subjects

Thirty three students (male = 19 female = 14) from the University of Wales, Bangor volunteered to take part in the experiment. The majority of these were either Undergraduates or Postgraduates from the division of Health and Human Performance. The age of subjects ranged from 18 to 37 years old (mean = 23.7, SD = 3.97).

Apparatus and Task

The computer controlled bimanual co-ordination task designed by Frohlich and Elliot (1984) was used in this experiment. To control the task a compiled BASIC program was run on a Macintosh IIci computer (see Appendix 1.1 for a listing of the program). Interfaced with the computer was the National Instruments Data Acquisition software and hardware (NI-DAQ for Macintosh and NB-M10-16H data acquisition board, respectively). A constant 5 volt supply was connected to 2 potentiometers which in turn were connected to 2 control buttons. The control buttons were then used to vary the voltage between zero and 5 volts which returned binary values, after software conversion, of between 0-400 to the Macintosh IIci. Each control button could be rotated through 300°. For every location of the control button there was a corresponding value returned to the computer (i.e. Zero-order correspondence).

On the screen of the computer, a window was drawn 400 pixels wide and 400 pixels high. The binary values returned from the control buttons could be used to plot the cursor at a fixed cartesian co-ordinate within the window. The left hand control button varied the x-co-ordinate of the cursor's position, whilst the right hand control button varied the y-co-ordinate. Each unit increment in the binary value returned to the computer from either control button moved the plotting point by 1 screen pixel.

By turning both control buttons at the same time the cursor could be moved in any direction. For example, in order to guide the cursor diagonally from the top left-hand corner [co-ordinate (0,0)] to the bottom right hand corner [co-ordinate (400, 400)] of the window on the screen, the two control buttons would have to be rotated clockwise at exactly the same rate from 0° to 300°. Hence, control of the cursor was achieved through bimanually co-ordinated movement.

The task required the subject to guide the cursor along a straight rectangular path 3/4 inch wide, extended across the diameter of a 6 inch circle. To begin each trial the cursor was initially placed on the left hand side of the path, at a point near to the position where the edge of the path met the edge of the circle. One complete trial consisted of moving from the starting position to the opposite side of the circle and then returning back to the starting position, thus crossing the circle twice. The time taken to complete one trial was displayed as feedback in the top left hand corner of the screen and was labelled "Performance Time". In all trials during both the acquisition period and the retention period, the subjects received visual feedback regarding the position of the cursor along the designated path. However, when the cursor went outside the designated rectangular path the cursor became invisible (see Figure 1).

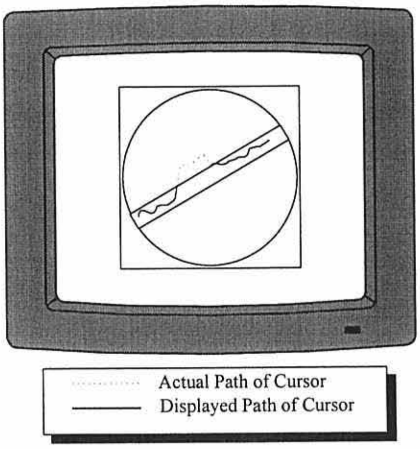

Figure 1: The path of the cursor during a typical trial

Procedure

The subjects were randomly assigned to one of 3 experimental groups (Reber, 1989), an Implicit Group, a Delayed Explicit Group and an Explicit Group (see Figure 2).

Chart Displaying the Flow of Subjects

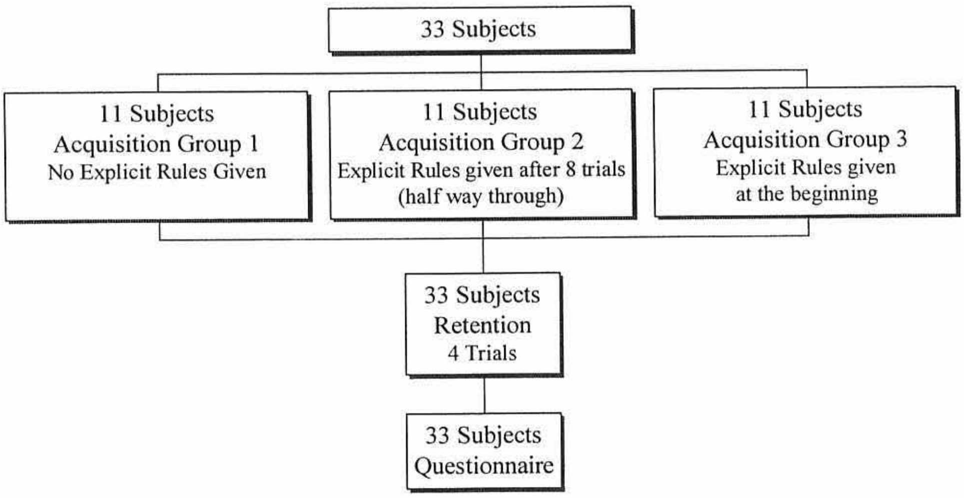

Figure 2

Before each subject participated in the experiment they were asked to read and complete a Consent From which carefully and very briefly explained the nature of the experiment (a copy of the consent form can be seen in Appendix 1.2). The subject was then informed about the task using pre-designed statements (a copy of the subject instructions for the acquisition period can be seen in Appendix 1.3).

The Implicit Group did not receive any explicit rules at any time throughout participation in the task. The Delayed Explicit Group received the rules exactly half way through the acquisition period, hence after 8 trials. However, the Explicit Group received the rules at the very start of the acquisition period, just before the subject instructions were given. Therefore the rules were not visible when the subject walked into the room or whilst they were completing the consent form. The rules were mounted onto card and attached onto the computer screen at the appropriate time for the specific group (see Figure 3).

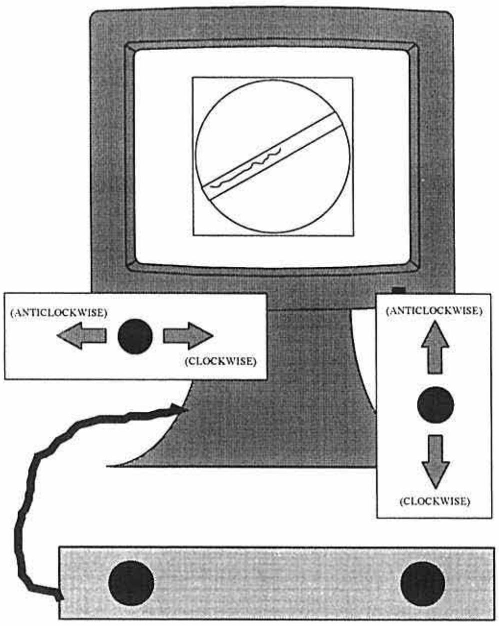

Figure 3: The Explicit Rules displayed on the screen

The acquisition period consisted of four path angles, 30°, 60°, 120° and 150° (see Figure 4). Each of the path angles were presented to the subject four times. Thus, in total, there were 16 trials in the acquisition period (4 trials × 4 path angles). The path angles were always presented in the following pattern; four trials at 120°, followed by four trials at 150°, followed by four trials at 30°, then followed by four trials at 60°. Subjects were instructed to strive to attain the quickest performance time possible during each trial.

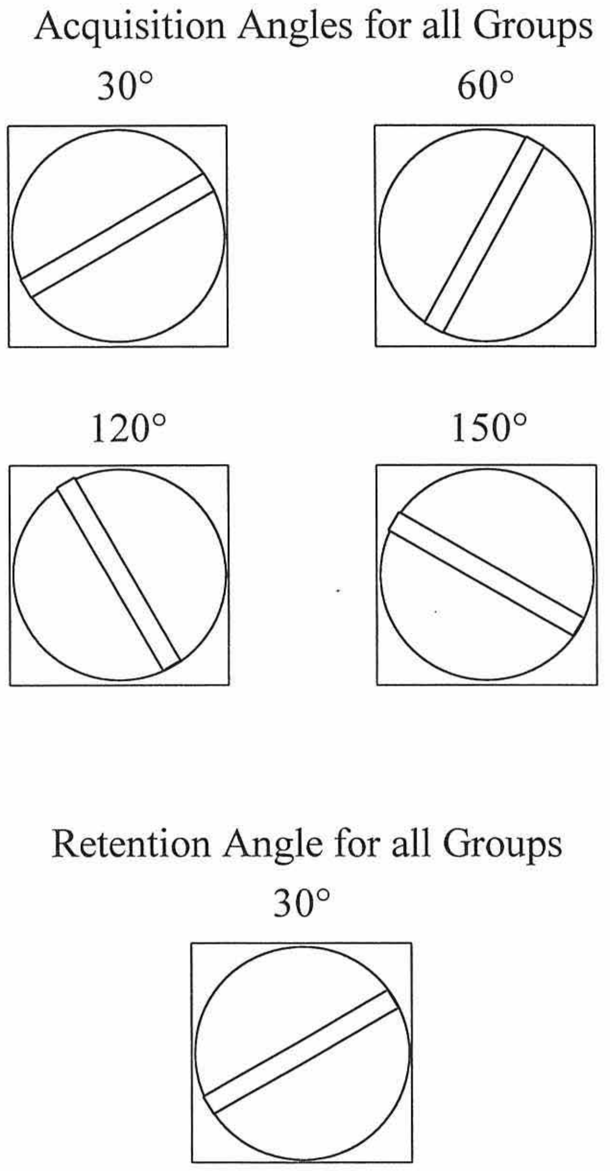

Figure 4: The Path Angles

Twenty-four hours later subjects took part in the retention task. Subjects were instructed to proceed as before during the acquisition task (see Appendix 1.3 for the instructions subjects received before the retention period). The retention period consisted of four trials at the 30° path angle only (see Figure 4). These four trials were again timed but the subject did not receive performance time feedback.

Immediately after completion of the four trials during retention the questionnaire was administered. Subjects were asked to consider both the acquisition and retention period when answering the questions. The questionnaire was carefully designed to extract any Explicit Knowledge subjects had about the task (Verdolini-Marston and Balota, 1994). Each subject was asked not to guess at an answer. If they did not know the answer they should merely indicate so. This was specifically requested because the subject had a 50% possibility of guessing correctly which could have given rise to incorrect results on the questionnaire. The questions were structured so they did not prompt subjects for any particular response. Answers were recorded on the questionnaire and care was taken to write down their exact answer. In some cases, the subject was asked to expand upon their answer but again it was very important to avoid prompting a specific response. Five scores were taken from the questionnaire and combined to form one score for the questionnaire (see Appendix 1.4 for a copy of the questionnaire). The first four of these scores consisted of the four parts of question three. Each of the parts were scored with a one if the answer was correct or a zero for any other answer. The final score, which completed the set of five, was the score from question six. As before a correct answer was given a score of one or a zero for any other answer.

A debriefing session took place after the questionnaire was completed. The experiment was explained and the different components outlined. If a discussion with the subject then ensued, their comments were also recorded. Any comments the subject made before the debriefing session were recorded and treated separately from any comments made after the debriefing.

Results

In part to reduce the potential effects on retention test analyses of large variances generated during acquisition trials and thus to determine whether effects persisted over time, the acquisition and retention performance time scores were treated separately. An Analysis of Variance (ANOVA) with repeated measures was applied to each. A One-Way (ANOVA) was performed on the questionnaire data and followed up with the Tukey's - Honestly Significant Difference (HSD) test. Finally, a correlation between the questionnaire data and the first trial of the retention data was calculated. This was intended to highlight any systematic relationship between the subject's expression of explicit rules and understanding of the control buttons and their first attempt in a new target orientation, which in each case was a form of transfer task. The dependent variable for all analyses was Performance time (as subjects' skill on the task improved their performance time decreased).

Acquisition:

A 3 (group) by 4 (block) by 4 (trial) ANOVA with repeated measures on the block and trial factors was applied to the acquisition performance time data. The raw data from the acquisition task can be seen in Appendix 1.5.

Calculating the mean of the four trials that made up one block created the block score. Thus the first block score was the mean of the first four trial scores, the second block score was the mean of trial scores five to eight, the third block score was the mean of trial scores nine to twelve and the final fourth block score was the mean of trial scores thirteen to sixteen.

The trial score was computed in four parts to allow the subjects' performance to be analysed across blocks. As stated above, there were four blocks and four trials within each block. The first trial from each block was taken and the mean of these four trials was computed as the first trial score. Similarly the mean of the second trial from each block was the second trial score, and likewise for the third and fourth trial scores. The analysis was performed in this way to identify if there was any effect of introducing explicit rules and thus a three-way interaction.

The results were corrected by the Huynh-Feldt Epsilon, where violations of sphericity occurred and main effects were found for block $F_{2.51,75.42} = 25.18$, $p<.01$ and for trial $F_{2.2,65.88} = 63.18$, $p<.01$ (see Figure 5). No group main effects were reported. Table 1 displays a listing of the trial and block means, standard deviation is shown in brackets. Post hoc follow up Tukey tests on the block main effect calculated a significant difference between means to be $T_{qv}(2.51,75.42)$ $p<.05 = 4.72$ and revealed block 1 to be significantly different from blocks 2,3 and 4; blocks 2 and 4 and blocks 3 and 4 were also significantly different. Tukey tests performed on the trial main effect revealed $T_{qv}(2.2,65.88)$ $p<.05 = 2.77$. Trial 1 was found to be significantly different from trials 2, 3 and 4 and trial 2 significantly different from trials 3 and 4.

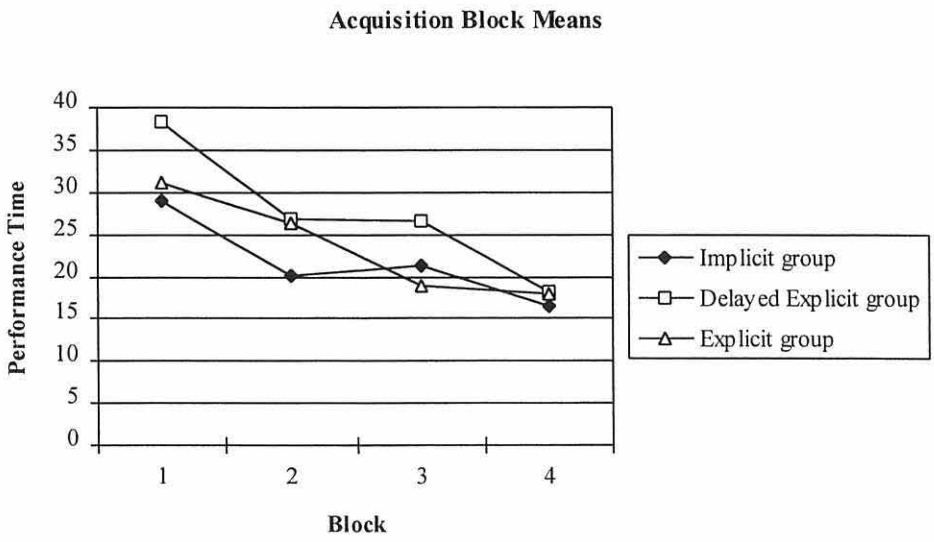

Figure 5

Table 1: Acquisition - Trial and Block Mean Scores
(Standard Deviation in brackets)

Block

	Trial	1	2	3	4	Mean
Trial	1	54.06 (29.82)	28.01 (9.59)	26.58 (10.04)	21.95 (8.84)	32.65 (14.57)
	2	30.82 (13.18)	25.51 (12.76)	22.26 (8.16)	18.17 (6.61)	24.19 (10.18)
	3	23.76 (8.21)	22.15 (9.15)	21.63 (7.72)	15.29 (5.03)	20.17 (7.53)
	4	22.4 (10.17)	22.35 (9.5)	18.69 (6.38)	14.7 (6.35)	19.53 (8.1)
	Mean SD	32.76 (15.35)	24.5 (10.25)	22.29 (8.08)	17.5 (6.71)	

A block by trial interaction was shown $F_{(2.92,87.48)} = 15.64$ $P<.05$ (see Appendix 1.8 for a listing of the SPSS output). Follow up Tukey tests were performed on the interaction effect across trials. A significant difference between means was calculated as $T_{qv}(2.92,87.48)$ $p<.05 = 5.4$. Table 2 to Table 5 below, illustrate the mean differences across blocks on each trial (see also Figure 6). The shaded cells highlight the significant differences. On trial 1, block 1 was significantly different to blocks 2, 3 and 4 and block 2 from block 4. Trial 2 gave block 1 significantly different from blocks 3 and 4 and again block 2 was significantly different from block 4. However, on trial 3, block 4 is significantly different from blocks1, 2 and 3 and on trial 4, block 4 is significantly different from blocks 1 and 2.

Table 2: Mean differences across blocks on Trial 1

			Block 1	Block 2	Block 3	Block 4
			54.06	28.01	26.58	21.95
Block	1	54.06	------	26.05	27.48	32.11
	2	28.01		------	1.43	6.06
	3	26.58			------	4.63
	4	21.95				------

Table 3: Mean differences across blocks on Trial 2

			Block 1	Block 2	Block 3	Block 4
			30.82	25.51	22.26	18.17
Block	1	30.82	------	5.31	8.56	12.65
	2	25.51		------	3.25	7.34
	3	22.26			------	4.09
	4	18.17				------

Table 4: Mean difference across blocks on Trial 3

			Block 1	Block 2	Block 3	Block 4
			23.76	22.15	21.63	15.29
Block	1	23.76	------	1.61	2.13	8.47
	2	22.15		------	0.52	6.89
	3	21.63			------	6.34
	4	15.29				------

Table 5: Mean differences across blocks on Trial 4

			Block 1	Block 2	Block 3	Block 4
			22.40	22.35	18.69	14.7
Block	1	22.40	------	0.05	3.71	7.7
	2	22.35		------	3.66	7.65
	3	18.69			------	3.99
	4	14.7				------

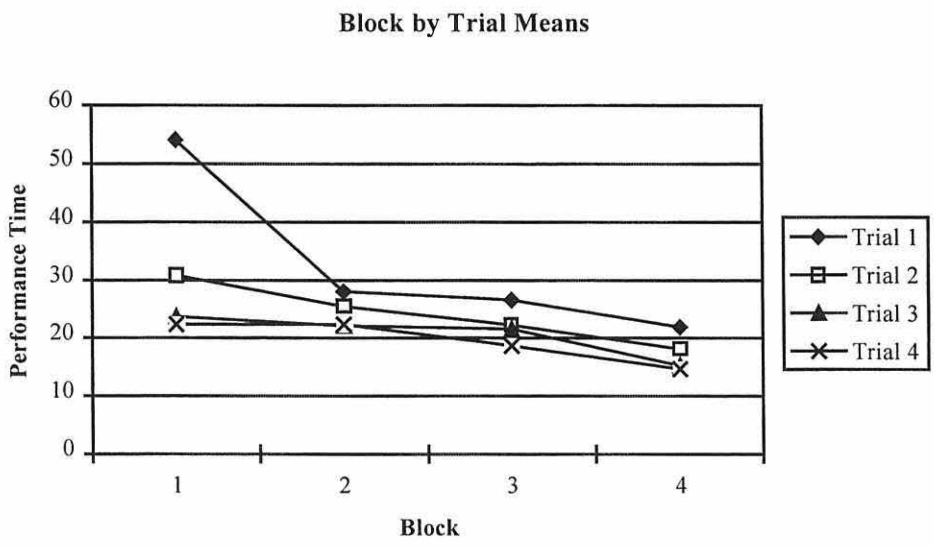

Figure 6

A planned comparison determined if there was a significant difference between the performance time scores of trials 8 and 9. This analysis investigated differences between the experimental groups after the explicit rules were introduced in the delayed explicit group. A 3 (group) by 2 (trial) ANOVA was performed on the data and found a main effect for trial $F_{1,30} = 5.09$, $p<.05$ (mean of trial 8 = 22.35, mean of trial 9 = 26.58). A trial by group interaction was also shown, $F_{2,30} = 3.5$, $p<.05$. (see Appendix 1.9). Tukey's test calculated the critical difference between means as $T_{qv}(2,30)$, $p<.05$ = 8.01. Therefore, only the implicit group (mean=18.13) and the explicit group (mean=26.87) were significantly different on trial 8. Pairwise comparisons were performed on each group's performance time across trials 8 and 9, to discover if the delayed explicit group's performance decayed more than the implicit and explicit groups. Only the implicit group revealed a significantly different performance time on trial 8 than trial 9, $t(10)= -3.05$, $p<.05$, although the delayed explicit group came close to reaching significance, $t(10)= -2.14$, $p=.058$.

Table 6: Planned Comparison between trials 8 and 9 - Mean Scores
(Standard Deviation in brackets)

Trial	8	9	Mean
Implicit group	18.13 (8.21)	25.61 (11.52)	21.87 (9.85)
Delayed Explicit group	22.06 (5.56)	30.04 (11.95)	26.05 (8.76)
Explicit group	26.87 (14.73)	24.09 (6.66)	25.48 (10.7)
Mean SD	22.35 (9.5)	26.58 (10.04)	

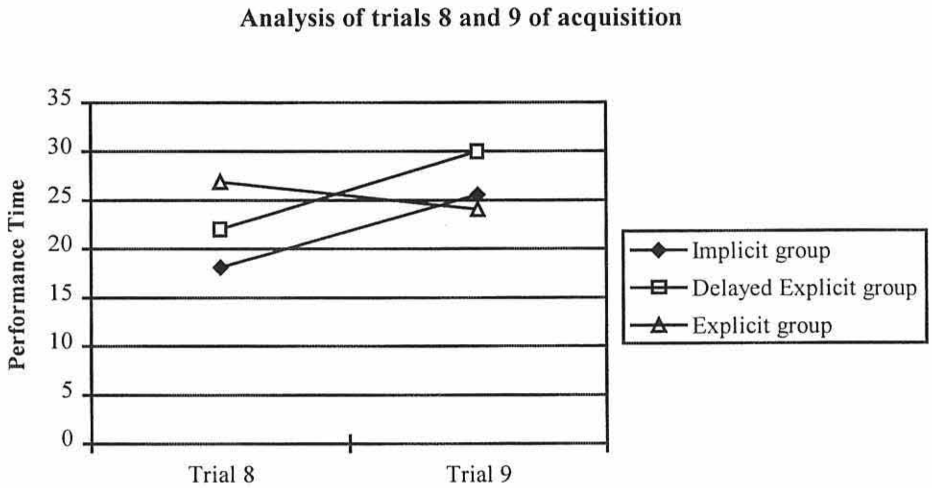

Figure 7

Retention:

The raw data from the retention task can be seen in Appendix 1.6. A 3 (group) by 4 (trial) ANOVA with repeated measures on trial was performed on the data.

A significant main effect for trial was found, $F_{2.51,75.42} = 25.18$, $p<.01$ (see Figure 8). Tukey's post hoc test calculated the critical mean difference as $T_{qv}(2.51,75.42)$,

$p<.05 = 4.72$, therefore trial 1 (mean=20.61) was significantly different than trials 3 (mean=14.93) and 4 (mean=15.06). Table 7 displays the trial mean scores, standard deviation is shown in brackets. Neither the group main effect nor the group by trial interaction were statistically significant, $p>.05$ (see Appendix 1.10 for a listing of the SPSS output).

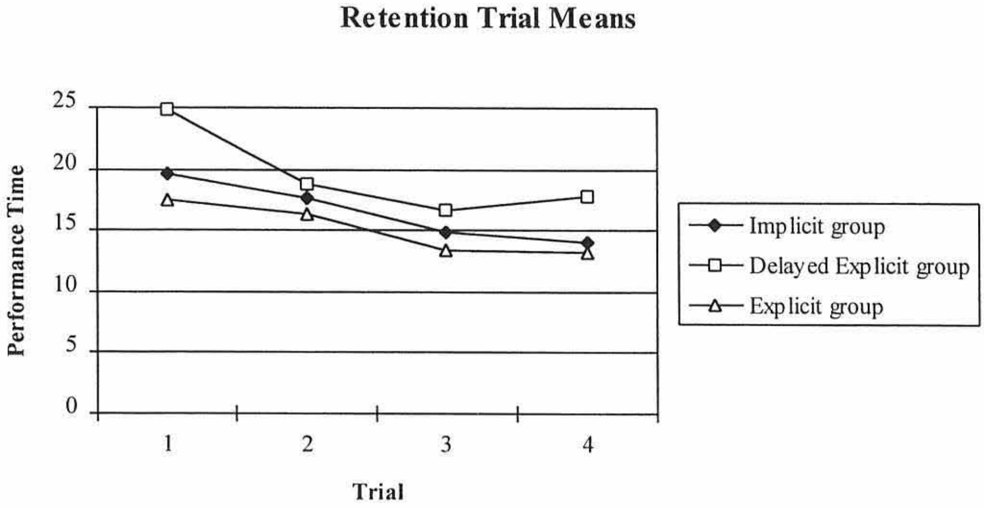

Figure 8

Table 7: Retention - Trial Mean Scores
(Standard Deviation in brackets)

Trial	1	2	3	4	Mean
Implicit group	19.58 (7.2)	17.65 (7.46)	14.88 (6.4)	14.12 (6.35)	16.56 (6.85)
Delayed Explicit group	24.8 (7.36)	18.75 (6.11)	16.59 (6.2)	17.79 (7.08)	19.48 (6.69)
Explicit group	17.44 (5.3)	16.38 (6.92)	13.32 (4.56)	13.27 (5.17)	15.1 (5.49)
Mean SD	20.61 (6.62)	17.59 (6.83)	14.93 (5.72)	15.06 (6.2)	

Questionnaire:

A One-Way ANOVA performed on the questionnaire scores identified any differences between groups (see Appendix 1.7 for the questionnaire raw data). Table 8 displays the questionnaire scores.

Table 8: The Questionnaire Scores
(1 = poor explicit knowledge, 5 = good explicit knowledge)

Subject	Implicit group	Delayed Explicit group	Explicit group
1	0	0	1
2	1	1	1
3	1	1	3
4	1	1	3
5	1	2	3
6	1	2	4
7	2	2.5	4
8	2.5	3	4
9	3	3	5
10	4	3	5
11	4.5	3.5	5
Total	21	22	38
Mean	1.91	2	3.45
SD	1.43	1.12	1.44

A significant group main effect was elicited $F_{2, 30} = 5.73$, $p<.05$. Tukey's - HSD post hoc test then identified the locus of the group differences (see Appendix 1.11 for a listing of the SPSS output). A significant difference between the implicit group (mean=1.91) and the explicit group (mean=3.5) and between the delayed explicit group (mean=2) and the explicit group was found ($p<.05$).

Finally, the questionnaire data and the first trial from the retention data were analysed to identify any significant correlation between the two. No correlation was found, r=-0.066, indicating that there was no relationship between explicit knowledge and performance score (see Appendix 1.12).

Exploratory re-analysis:

There was concern that some subjects had chosen to ignore the explicit rules and thus confounded the results. An investigation into the number of subjects who reported using the explicit rules throughout the experiment showed the following findings. Only two subjects in the delayed explicit group reported to have used the explicit rules. However of these two subjects one scored 0 and the other scored 1 on the questionnaire. In the explicit group four of the eleven subjects reported to have used the explicit rules, however these four subjects scored 3, 4, 4 and 5.

In order to enforce an implicit / explicit structure on the groups the data was re-analysed. "Real" implicit and explicit groups were therefore created from the original experimental groups. The "real" implicit group was taken from the original implicit group but only included those subjects who scored one or less on the questionnaire. Similarly, the "real" explicit group was taken from the original explicit group but only contained subjects who scored four or more on the questionnaire. There were now six subjects in the implicit group and six subjects in the explicit group, whilst the delayed explicit group remained unchanged. The analyses performed on the "real" groups were identical to the analyses performed on the original experimental groups.

A 3 (group) by 4 (block) by 4 (trial) ANOVA with repeated measures on block and trial was performed on the acquisition data (see Appendix 1.13). Table 9 displays a listing of the trial and block means, standard deviation is shown in brackets (see also Figure 9). Main effects were again found for block $F_{3,60}$ =13.22, p<.01 and for trial $F_{3,60}$ =39.11, p<.01 (see Figure 9). A group main effect was not shown. A follow up Tukey test calculated the critical mean difference across blocks to be $T_{qv}(3,60)$, p<.05 = 4.91. As in the original analysis blocks 2, 3 and 4 were significantly different from block 1 as was block 2 from block 4. The follow up Tukey test on the trial main effect calculated a critical mean difference of $T_{qv}(2.66,53.1)$, p<.05 = 2.76. This identified trial 1 to be significantly different to trials 2, 3 and 4 and trial 2 significantly different to trials 3 and 4.

A block by trial interaction was again shown, $F_{9,180}$= 4.04, p<.05. Follow up tests calculated $T_{qv}(3.65,73.08)$, p<.05 = 2.32 and revealed that across all trials, block 4 was significantly different to blocks 1, 2 and 3 (see Appendix 1.13).

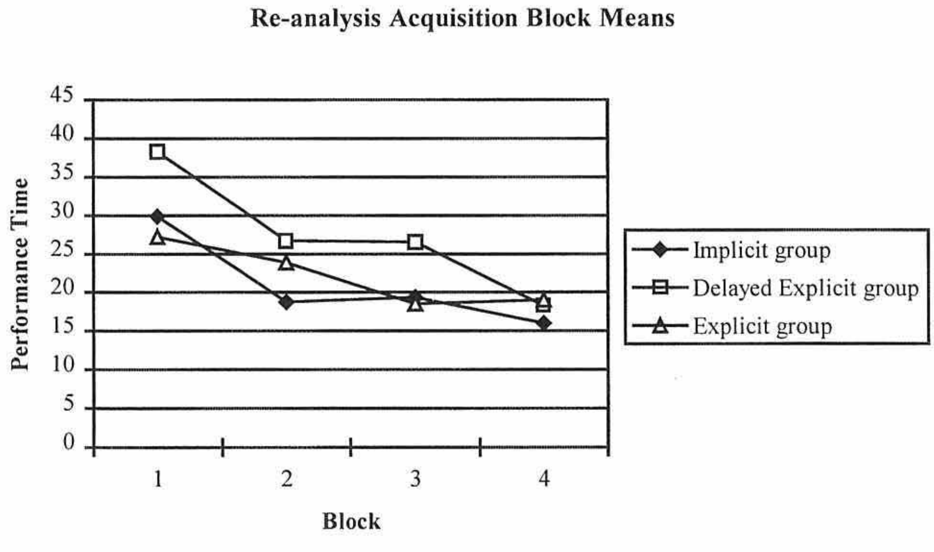

Figure 9

Table 9: Re-analysis Acquisition - Trial and Block Mean Scores

(Standard Deviation in brackets)

Block

		1	2	3	4	Mean
	1	55.20 (28.92)	28.39 (10.45)	26.42 (10.38)	22.81 (9.82)	33.21 (14.89)
Trial	2	31.23 (13.41)	24.08 (13.40)	22.69 (9.06)	18.27 (6.82)	24.07 (10.67)
	3	23.43 (9.46)	21.58 (9.11)	22.52 (10.56)	15.32 (5.4)	20.71 (8.63)
	4	23.08 (11.53)	21.63 (9.8)	18.71 (7.13)	15.18 (7.31)	19.65 (8.94)
	Mean SD	26.39 (15.83)	18.38 (10.69)	17.19 (9.28)	13.37 (7.34)	

The planned comparison between trials 8 and 9 did not elicit any significant findings (see Appendix 1.14).

A 3 (group) by 4 (trial) ANOVA with trial as a repeated measure was performed on the retention data (see Appendix 1.15 and Figure 10). A main effect for trial was again reported $F_{3,60}=13.22$, $p<.01$. A follow up Tukey test showed blocks 2, 3 and 4 to be significantly different from block 1. Block 2 was also significantly different from block 4. As with the original analysis, there were no further significant findings.

Re-analysis Retention Trial Means

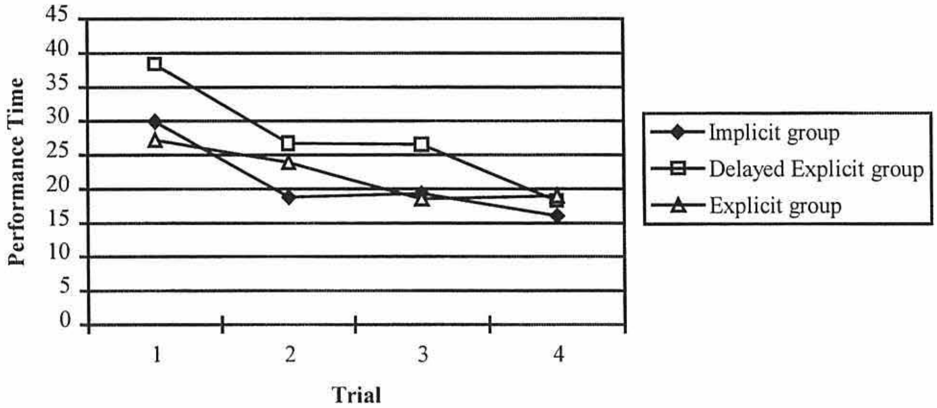

Figure 10

Table 10: Re-analysis Retention - Trial Mean Scores

(Standard Deviation in brackets)

Trial	1	2	3	4	Mean
Implicit group	29.92 (18.45)	18.79 (4.73)	19.34 (8.69)	16.05 (8.46)	21.02 (10.09)
Delayed Explicit group	38.32 (11.19)	26.72 (8.56)	26.57 (7.08)	18.29 (4.38)	27.48 (7.8)
Explicit group	27.24 (9.89)	23.91 (11.02)	18.5 (4.93)	19.02 (7.41)	22.17 (8.31)
Mean SD	31.82 (13.18)	23.14 (8.11)	21.47 (6.9)	17.78 (6.75)	

The One-Way ANOVA performed on the re-analysis questionnaire scores revealed a significant main effect for group, $F_{2,20}$ =28.91, p<.01 (see Appendix 1.16). Tukey's - HSD post hoc test identified that all groups were, as expected, significantly different (Implicit, mean=0.83; Delayed Explicit, mean=2; Explicit, mean=4.5). Again, there was no correlation, r = -0.25, between the questionnaire data and the first trial from the retention data (see Appendix 1.17).

Discussion

This discussion examines the support for the experimental hypotheses and attempts to explain the differences between the findings of Reber et al. (1980) and the present experiment.

The experiment attempted to replicate the findings of Reber et al. (1980). They investigated the most effective time to give explicit rules when learning a complex cognitive task, at the start, in the middle or a combination of these. The cognitive task they used investigated the complex rule structure governing the grammar of a synthetic language. This experiment approached the problem using a similar experimental procedure but a complex bimanual motor task. Landers (1975), with the Bachman Ladder task (a complex motor task), showed similar findings to that of Reber et al. (1980). Landers found that giving a modelling demonstration once at the start of the learning episode was more beneficial than giving the demonstration once at the mid-point. However, giving the demonstration at the start and at the mid-point, as opposed to the start alone, did not facilitate more effective performance.

One of the main findings of Reber et al. (1980) was that the optimum time to give explicit rules was at the start of the learning episode (if followed by an implicit learning period), they termed this the "explicit - implicit" group. The explicit group of the present experiment is comparable to this group because of the nature of the task. In this present experiment the explicit rules were presented either at the start or the middle of acquisition and displayed throughout the remainder of the period. Although the subject had the explicit rules available, they were not imposed on subjects, and there was the opportunity for the explicit group to perform as an implicit group.

Given the results, the third hypothesis of this experiment will be discussed first, as there are implications for the remainder of the discussion. The third hypothesis was that reported explicit knowledge would be better in subjects who practised the task with explicit rules. The questionnaire data confirmed this, to the extent that the explicit group achieved a significantly higher degree of explicit knowledge of the task than either the implicit or the delayed explicit group. There was no significant difference between the implicit and the delayed explicit group. The rank order of the group means does match with the naive expectation that 'delayed explicit rules' should raise the level of reported explicit knowledge above that of the implicit groups.

A possible explanation for this finding could be the reported lack of use of the explicit rules in the delayed explicit group. After analysing the results there was concern that subjects had chosen not to use the explicit rules and thus confounded the results. Only two of the delayed explicit group and four of the explicit group reported using the explicit rules throughout the experiment. However, the two subjects in the delayed explicit group displayed less explicit knowledge in the post-test questionnaire than the rest of the group who reported not having used the rules. Most of the subjects in this group stated that providing explicit rules half way through the acquisition period was confusing and proved to be an interference. The delayed explicit group was in effect, performing as another implicit group in the majority of cases by ignoring the explicit rules.

This was considered a factor in the lack of significant findings. Therefore, further exploratory analyses were performed which attempted to eliminate the problem. By inspecting the groups and eliminating any subjects who did not show the expected questionnaire score for their group, what were considered real groups were formed. For the implicit group, this meant disregarding any subject who scored two or more. Whilst any subject who scored less than four in the explicit group was disregarded. Both the implicit and explicit groups now consisted of six subjects in each. The delayed explicit group remained unchanged throughout this re-analysis.

It should be noted that in the questionnaire data subjects had a 50% chance of answering correctly. The potential for high scores due to chance may have affected the results by hiding real differences. Any attempts to replicate the findings should use a modified scale against which explicit knowledge can be scored.

The following interpretation will consider both the original analysis of performance measures and the later exploratory re-analysis together to identify if the use of explicit rules was confounding the results.

The first hypothesis of the experiment states that during acquisition, explicit rules given after implicit learning of a novel and complex motor task, will result in poorer performance time scores than explicit rules given before any implicit learning has taken place. Therefore, the group given explicit rules at the start of the learning episode were expected to perform better, showing a lower performance time score than the group given explicit rules half way through the acquisition period.

Analysis of the acquisition data did not find any support for this hypothesis. None of the groups performed significantly better than others. Main effects were found for both block and trial and a block by trial interaction was reported. The block main effect suggests that all subject's performance times significantly improved over the 16 trials, apparently displaying a classical learning effect (see Figure 5). Follow up tests showed subjects' performance on block four to be significantly better than blocks one, two and three. The trial main effect represents the subjects' averaged learning within each block. This main effect suggests that introducing new path angles at the start of each new block had a negative effect on subjects' performance. This is supported by the follow up tests, which show performance on the first trial of each block to be significantly worse than on trials two, three and four. Follow up tests on the block by trial interaction generally revealed blocks one and two to be significantly worse than block four across each trial. As there were no significant interactions involving the groups, the observed differences can be explained as a warm up decrement or orientation effects.

The lack of a significant three-way interaction between group, block and trial showed that introducing the explicit rules half way through the acquisition period did not facilitate a significant change in subjects' performance. However, exploratory planned comparisons determined any significant differences between performance time scores on trials eight and nine created by an interference effect due to giving delayed explicit rules. A two-way (group by trial) analysis of variance found a significant main effect for trial, with trial nine producing a significantly worse performance time than trial eight. This clearly could also be the result of introducing a new task angle on trial nine, which has already been shown to depress performance. The significant trial by group interaction that was reported and the follow up tests showed the explicit group to be performing significantly worse than the implicit group on trial eight. There were no significant other differences between the delayed explicit and both the other two groups. The pairwise comparisons between trials 8 and 9 on each group did not show the delayed explicit group's performance time to be decaying significantly from trial 8 to trial 9. Only the implicit group displayed a performance time on that was significantly worse on trial 9 than on trial 8 although the delayed explicit group approached significance ($p=.058$). This suggests that an interference effect was not evident from introducing the explicit rules during the middle of practice

The two potentially confounded effects created by giving delayed explicit rules and adjusting the stimulus on trial nine cannot be disentangled easily using the results. It can be said that performance did deteriorate (although not significantly) when both factors were present (delayed explicit group) and that when only the stimulus changed (implicit and explicit groups) it did not lead to a significant loss of performance for the explicit group. The changes in performance associated with the two treatments do not appear to be additive but it cannot be determined whether providing explicit rules at this stage is sufficient to interfere without the confounded effect of changing the stimulus. There is an encouraging indication that the explicit group was better able to cope with the change of stimulus, as there was no deceleration of their progress in improving their scores over these two trials, as was evident in the implicit group. Providing explicit rules could therefore, be viewed as a benefit to performance, as the delayed explicit group (who were identical to the implicit group prior to the explicit rules being introduced) avoided the significant deterioration in performance from trial 8 to trial 9 that the implicit group suffered.

The re-analysis (with a reduced number of subjects) could not add anything further to the above findings. Main effects were again found for both block and trial, and an interaction for block by trial. The follow up tests could not provide any further support for the hypotheses and the planned comparison between trials eight and nine did not elicit any significant findings.

The second hypothesis of the experiment proposed that the performance time scores of the retention task would be poorer for subjects who practised the acquisition task without explicit rules. Therefore, the implicit group was expected to perform worst on the retention task. The retention analysis did not support the hypothesis. There were no significant group differences over the retention trials.

Again, as in the acquisition task analysis, the main effect for trial was significant. Subjects improved over the four trials with the first trial having a significantly worse performance time than trials two, three and four (see Figure 8). Re-analysis of the retention data supported a main effect for trial, but the follow up tests did not add anything further to the original findings. As with the original analysis, there were no significant interactions.

Given that there was very little support in favour of the above hypotheses, the findings cannot be considered similar to those of Reber et al. (1980). One of the main reasons for this was originally considered to be the problem concerning the three groups' actual use of the explicit rules during acquisition. This may have been due to subjects not believing the rules to be important to become better performers at the task. However the re-analysis was expected to have controlled for some of this effect by enforcing an implicit / explicit structure on the groups. Even with this structure enforced there were no significant findings to report that had not been contained in the original analysis.

Whilst the problem with the questionnaire data has been identified and controlled, the results have remained unchanged. It would seem that an alternative explanation is necessary for the lack of significant findings. The fundamental difference in the two experimental tasks could provide this answer. Reber et al. (1980) used a complex cognitive task whereas this experiment used a complex motor task. It may be that the findings of Reber et al. (1980) cannot be generalised to a motor task.

The task used by Reber et al. (1980) did not specifically require motor performance. Whereas, the task used in this experiment required accurate bimanual co-ordination. Fazey (1985) stated that using a verbal (explicit) mode would not facilitate fine grain control of a motor task. Whilst Magill (1993) found that verbal knowledge of results can in some circumstances disrupt the efficient control of the motor system. Green and Flowers (1991) with their continuous fine motor task and Masters (1992) with his complex motor skill, both refer to the "resource limitation effect", or the interference effect of explicit rules (Reber et al., 1980) when learning a new skill. Green and Flowers (1991) suggest that some tasks may be more prone to this interference effect, particularly attention-demanding visuo-motor tasks.

This research suggests that a motor task should display the same disruption of performance under explicit control, as did the cognitive task. However, Reber et al. (1980); Reber (1989); Masters (1992) and Green and Shanks (1993) also stated that the experimental task should be complex. The present task may not be sufficiently complex to reflect Reber's et al. results (1980). Smith (1992) suggests that because the task contains only one degree of freedom (Turvey, 1990) the link between perception and action was not difficult to create. Thus, a variety of solutions from which to draw an answer was not available to the subject. Therefore, verbal monitoring of performance, to ensure bad habits did not develop, was unnecessary. In support of this a large number of subjects said that they only looked at or took notice of the explicit rules once, if at all. After which they did not feel the need to use the rules as a guide to aid performance. This suggests that the task was not sufficiently complex. One other possible factor to consider may be the reliability of the task in displaying the effects of the disruption in performance with explicit rules.

The second experiment attempts to eliminate some of the paradigmatic problems identified above. The entire methodology and task of Verdolini-Marston and Balota (1994) was used in an attempt to prevent subjects from ignoring the explicit rules. Verdolini-Marston and Balota showed that explicit rules can be displayed with a motor task and a similar experimental paradigm to that of Reber et al. (1980). However, they suggest it is the type of processing which is important to facilitate explicit rules and that their task required subjects to adopt the processing style which invoked the explicit rules.

EXPERIMENT TWO

Literature Review

Some of the problems of the first experiment related to questions about the effectiveness of the bimanual task used. It is possible that the task was not sufficiently complex to replicate the findings of Reber et al. (1980) and that subjects did not believe the explicit rules to be important enough for them to need. Another possibility could be that the task may not have been very reliable in displaying the effects of the disruption in performance with the explicit rules.

In order to try to overcome some of these problems, it is necessary to adopt a methodology and task that has already been shown to display differences between the implicit and explicit memory systems. The pursuit rotor perceptual-motor task of Verdolini-Marston and Balota (1994) will be used.

The aim of Verdolini-Marston and Balota's (1994) experiment was to provide evidence regarding the dissociation between explicit and implicit memory, particularly in a perceptual-motor task. This they proposed to do by using different types of elaborative processing in order to show evidence for either the transfer-appropriate framework, or the dual-process (dissociation) mode of implicit / explicit processing. They adopted a pursuit rotor task because they considered it had qualities useful for distinguishing between implicit and explicit memory.

The first of these qualities arises from perceptual-motor theorist claims that elaborative processes can enhance implicit type memory in the perceptual-motor domain. Verdolini-

Marston and Balota (1994) suggest that there is anecdotal evidence which supports the claim that

> "metaphoric images, which relate target productions to other contents of memory, promote benefits in perceptual-motor performance without reference to previous training episodes." (pp 740)

The second quality also concerns implicit memory. Verdolini-Marston and Balota (1994) suggest that if implicit memory depends on knowing how to do the skill, then its importance should be greater for a perceptual-motor task as opposed to a verbal task.

The third quality originates from the lack of research up to now into implicit / explicit memory with a motor task. Verdolini-Marston and Balota (1994) reported that only a few studies so far have assessed the mental processes that mediate explicit and implicit memory beyond the verbal domain. However, they suggest that the perceptual-motor domain may be better able to identify any relationship that does exist.

Verdolini-Marston and Balota (1994) were able to show evidence for a dissociation between the implicit and explicit memory systems. They observed a performance facilitation for previously encountered stimuli which suggests evidence of implicit memory. However, they also found that implicit memory was inhibited when subjects received explicit rules, although it was evident when the explicit rules were absent. The album style explicit rules, which encouraged subjects to relate the stimuli to other contents of memory, demonstrated the best explicit memory performance.

As Verdolini-Marston and Balota (1994) were able to show evidence for a dissociation between the implicit and explicit systems, the design of the present experiment needs to change to reflect the design of Verdolini-Marston and Balota so that subjects are given the best opportunity to make use of the explicit cues. By making the cues more salient, subjects will hopefully make use of the explicit rules and possibly not ignore them as was the case in the first experiment. During retention subjects will also be asked to recognise old and new stimuli and their time on target performance will be measured on both. Thus, there will be more opportunity for detecting implicit facilitation in time on target performance to new tasks. The measure of explicit knowledge will be to report the recognition of previously seen trials, which should be easier if subjects make use of the explicit rules.

The first and third hypotheses of this experiment remain the same as the before. The aim is still to determine the most effective time for administering explicit rules during motor skill acquisition. However, the second hypothesis has changed due to the results of Verdolini-Marston and Balota (1994) and their evidence which supported a dissociation of the implicit / explicit memory systems. Verdolini-Marston and Balota found a facilitation for implicit memory performance when no explicit instructions were given.

Hypotheses

1. Explicit Rules given in the middle of a learning episode will prove an interference to skill acquisition.

2. Performance score facilitation's will be increased during retention in the group which did not receive any explicit instructions (i.e. the implicit group).

3. The amount of reported explicit knowledge will be greater in subjects who practised the task with explicit rules available.

Methodology

Subjects

Thirty six subjects (16 male, 20 female) from the University of Wales, Bangor volunteered to take part in the experiment. Subjects' age ranged from 19 to 57 years old (mean = 28.2, SD = 9.4). Of the 36 subjects, 34 reported they were right handed and 2 reported they were left handed.

Apparatus and task

The "Forth Photoelectric Rotary Pursuit" apparatus was used in this experiment (see Figure 11). The pursuit rotor was 44.5cm long by 31.5cm wide by 13cm high. When the target on the pursuit rotor was activated the light spun in a clockwise direction and appeared on the transparent circular path as a target 2cm by 1.7cm. A hand held wand was used to track the target. A digital counter was activated when the photoelectric sensor, embedded in the end of the wand, was directly above the light. The counter recorded how long, in seconds, the subject tracked the target on each trial.

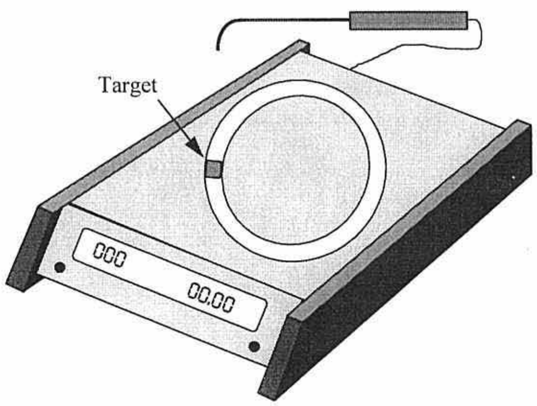

Figure 11

Stimulus Materials

Five templates were used as stimuli. Each template was made from black card with a transparent circular path 2cm wide of radius either 6cm, 8cm, 9.5cm, 11cm or 13cm (plates 1, 2, 3, 4 and 5 respectively). The radius of each circular path was taken from the centre of the 2cm path. The speed of light rotation of the paths could be varied from 15rpm to 66rpm. The three target rotation speeds used in this experiment were 15rpm, 37.5rpm and 66rpm.

Before the acquisition period began there were three warm up trials which involved plate 1 at target rotations 15rpm, 37.5rpm and 66rpm. For the acquisition and retention periods there were eight possible stimuli in total (plates 2, 3, 4 and 5 at target rotation speeds of 37.5rpm and 66rpm). During acquisition each subject was presented with four stimuli, repeated four times to make a total of 16 trials. The four stimuli were selected from the pool of eight and fulfilled the criteria below (adapted from Verdolini-Marston and Balota, 1994).

(1) The average target tangential velocities across stimuli ranged from approximately 54cm/s to 59cm/s; (2) the four different stimuli included one exemplar each of plates 2,3,4 and 5; (3) a given plate was always presented with the same rpm (37.5rpm or 66rpm); (4) two of the four stimuli had rotations of 37.5rpm and two had rotations of 66rpm; (5) the same stimulus was not repeated on successive trials, and each of the four different stimuli appeared at least once within the first five trials.

During retention all eight possible stimuli appeared. In each half of the retention period two old and two new stimulus were presented. Each stimuli was counterbalanced and randomly presented so that it appeared on an equal number of trials as an old and as a new stimuli. There were similar average tangential velocities for stimuli in the first and second halves of each test phase, which ranged from 54cm/s to 59cm/s.

Procedure

The subjects were assigned to one of three experimental groups (Reber 1989), an Implicit Group, a Delayed Explicit Group and an Explicit Group (see Figure 12).

Chart Displaying the Flow of Subjects

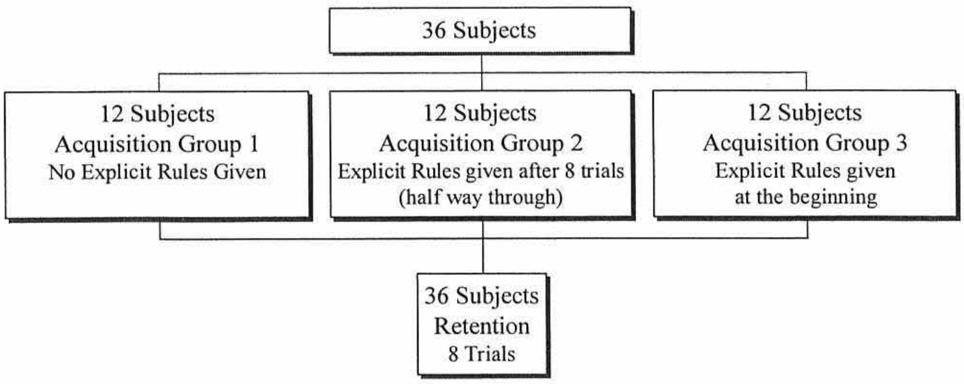

Figure 12

Before each subject participated in the experiment they were asked to read and complete a Consent Form that carefully and very briefly explained the nature of the experiment (a copy of the consent form can be seen in Appendix 2.1). The subject was then informed about the task using pre-designed statements (a copy of the subject instructions for the acquisition period can be seen in Appendix 2.2).

The Implicit Group did not receive any explicit rules at any time throughout participation in the task. The Delayed Explicit Group received the rules exactly half way through the acquisition period, hence after eight trials. However, the Explicit Group received the rules at the very start of the acquisition period.

The explicit rules were adapted from the "album" instructions in the second experiment of Verdolini-Marston and Balota (1994). These rules required the subject to mentally consider the pursuit rotor as an album on a record player. The subject was required to imagine the different paths as different songs on the album and to imagine the songs played at the speed they saw the target rotating. Thus each different stimulus should correspond to an individual song. Before each explicit trial in both the delayed explicit and explicit groups, subjects were reminded to use the explicit rules.

All individual trials, whether in the warm up, the acquisition or the retention period lasted for one minute and there was a one minute rest between each trial.

None of the subjects received the explicit rules during the warm up period. This warm up was the same for all groups. The total time for the warm up was 5 minutes (3 minutes stimuli and 2 minutes rest).

During the acquisition period subjects were given 16 trials. Thus the acquisition period took 31 minutes in total (16 minutes stimuli and 15 minutes rest). The subject was instructed to track the target for the maximum amount of time during each one minute stimulus presentation. On completion of the acquisition period there was a 12 minute rest.

During the retention period subjects received eight trials. Each subject was instructed to proceed as before, during the acquisition period (see Appendix 2.2 for the instructions subjects received before the retention period). The total time for the retention period was 15 minutes (8 minutes stimuli and 7 minutes rest). After each trial the subject was asked to identify, by answering yes or no, whether they had been presented with the stimuli during acquisition. The subjects were not aware they had previously only been exposed to four of the eight stimuli.

A debriefing session took place after the retention period was completed. The experiment was explained and the different components outlined.

Results

The performance or time on target, scores from acquisition and retention were treated independently and Analyses of Variance (ANOVA) with repeated measures were applied. Each individual group's explicit knowledge score was analysed using a Chi-Squared test. A One-Way ANOVA was performed on the explicit knowledge scores for all groups and was followed up with the Tukey's - Honestly Significant Difference (HSD) test. An investigation for a correlation between the explicit knowledge scores and the first trial on retention was performed. The dependent variable for all analyses was Time on Target (as skill on the task improved, the time on target increased).

Acquisition:

A 3 (group) by 4 (block) by 4 (trial) ANOVA with repeated measures on the block and trial factors was applied to the acquisition time on target data. The raw data from the acquisition period can be seen in Appendix 2.3.

The sixteen stimuli were presented in blocks of four, therefore each block was treated separately during analysis. Block one was the first four trials, block two was trials five to eight, block three was trials nine to twelve and block four was trials thirteen to sixteen.

The trial score was computed in four parts in order to allow subjects' performance to be analysed across blocks. The first trial from each block was taken and the mean of these four trials was computed as the first trial score. Similarly the mean of the second trial from each block was the second trial score, and likewise for the third and fourth trial scores.

The results were corrected by the Huynh-Feldt Epsilon, where violations of sphericity occurred. A main effect for block $F_{2.6,85.93} = 57.58$, $p<.01$, and a block by trial interaction, $F_{9,297}=2.28$, $p<.05$, were found (see Appendix 2.4 for a listing of the SPSS output). No trial or group main effects were elicited. Follow up Tukey's tests on the block main effect calculated a critical mean difference of $T_{qv}(2.6,85.93)$, $p<.05 = 1.52$. This revealed block 1 to be significantly different to blocks 2, 3 and 4 and block 2 to be significantly different to block 4. Table 11 displays a listing of the trial and block means, standard deviation is shown in brackets

Table 11: Acquisition - Trial and Block Mean Scores
(Standard Deviation in brackets)

		Block 1	Block 2	Block 3	Block 4	Mean
Trial	1	16.53 (10.07)	22.06 (10.49)	24 (10.47)	25.69 (10.15)	22.07 (10.29)
	2	16.56 (11.24)	21.03 (13.02)	21.97 (12.61)	23.11 (13.07)	20.67 (12.48)
	3	18.5 (10.92)	20.42 (10.79)	22.92 (11.75)	24.06 (11.85)	21.47 (11.33)
	4	17.69 (9.78)	21.64 (9.64)	23 (10.18)	23.64 (10.09)	21.49 (9.92)
	Mean SD	14.5 (10.5)	17.06 (10.98)	18.1 (11.25)	18.79 (11.29)	

To identify the locus of the interaction effect on trial across blocks Tukey's post hoc test for comparing means was performed. The critical value for a significant difference between the means was calculated as $T_{qv}(9,297)$ $p<0.05= 2.06$. Table 12 - Table 15 display the mean differences across blocks on each trial (see also Figure 13). The shaded cells highlight the significant differences. Blocks 2, 3 and 4 are significantly different from block 1 on trials 1, 2 and 4 however, block 1 was only significantly different from blocks 3 and 4 on trial 3. On trials 1, 2 and 3 block 2 was also significantly different to block 4. On trial 3 alone, block 2 was significantly different to block 3.

Table 12: Mean differences across blocks on Trial 1

Block			1	2	3	4
			16.53	22.06	24	25.69
	1	16.53	------	5.53	7.47	9.16
Block	2	22.06		------	1.94	3.63
	3	24			------	1.69
	4	25.69				------

Table 13: Mean differences across blocks on Trial 2

Block			1	2	3	4
			16.56	21.03	21.97	23.11
	1	16.56	------	4.47	5.41	6.55
Block	2	21.03		------	0.94	2.08
	3	21.97			------	1.14
	4	23.11				------

Table 14: Mean difference across blocks on Trial 3

Block			1	2	3	4
			18.50	20.42	22.92	24.06
	1	18.50	------	1.92	4.42	5.56
Block	2	20.42		------	2.5	3.64
	3	22.92			------	1.14
	4	24.06				------

Table 15: Mean differences across blocks on Trial 4

		Block 1	Block 2	Block 3	Block 4
		17.69	21.64	23	23.64
Block 1	17.69	------	3.95	5.31	5.95
Block 2	21.64		------	1.36	2
Block 3	23			------	0.64
Block 4	23.64				------

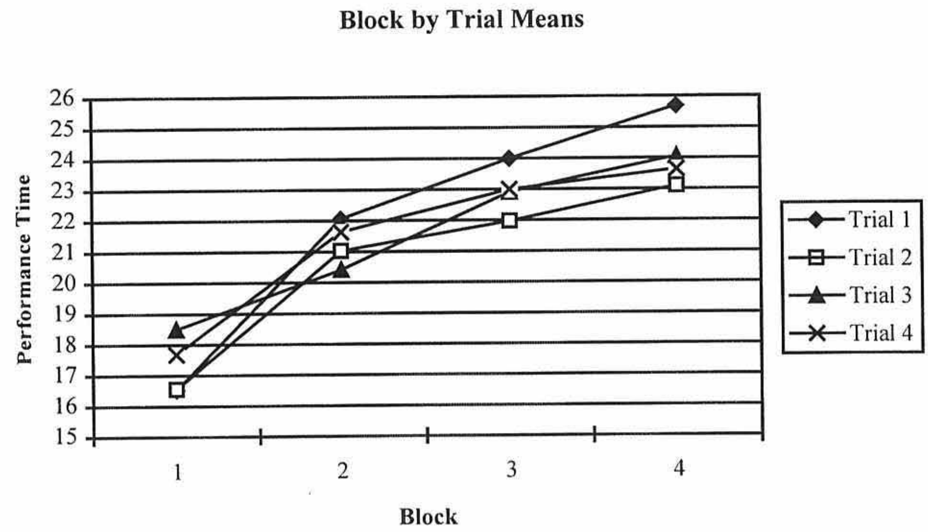

Figure 13

As in Experiment 1, a planned comparison between the time on target scores of trials 8 and 9 was conducted. This analysis investigated differences between the experimental groups after the explicit rules were introduced in the delayed explicit group. A 3 (group) by 2 (trial) ANOVA performed on the data failed to elicit any significant findings (see Appendix 2.5).

Retention:

The raw data from the retention task can be seen in Appendix 2.3. A 3 (group) by 2 (old or new) by 4 (trial) ANOVA with repeated measures on old or new and trial was performed on the data.

No significant main effects or interactions were reported (see Figure 14). Table 16 displays the trial mean scores, standard deviation is shown in brackets. (see Appendix 2.6 for a listing of the SPSS output).

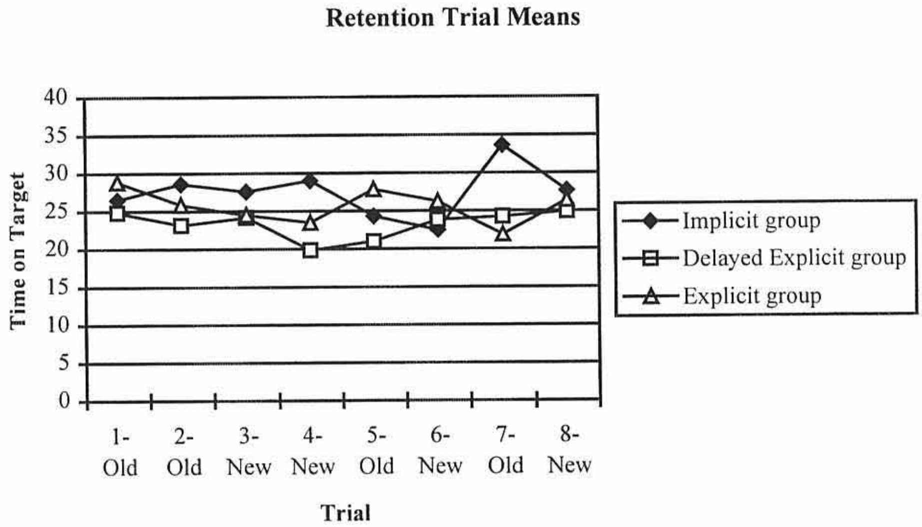

Figure 14

Table 16: Retention - Trial Mean Scores
(Standard Deviation in brackets)

Trial	1	2	3	4	5	6	7	8	Mean
Implicit group	26.5 (13.06)	28.58 (12.37)	27.58 (13.27)	29 (11.87)	24.33 (10.13)	22.5 (10.81)	33.67 (10.24)	27.67 (13.18)	27.48 (11.87)
Delayed Explicit group	24.83 (13.64)	23.17 (11.95)	24.17 (12.76)	19.83 (11.58)	21 (9)	23.83 (10.04)	21.25 (12.15)	24.92 (14.29)	22.88 (11.93)
Explicit group	28.33 (11.16)	25.83 (11.23)	24.5 (10.33)	23.5 (9.59)	27.83 (10.89)	26.25 (13.88)	21.92 (17.43)	26.42 (9.7)	25.57 (11.78)
Mean SD	26.72 (12.62)	25.86 (11.85)	25.42 (12.12)	24.11 (11.01)	24.39 (10.01)	24.19 (11.58)	25.61 (13.27)	26.33 (12.39)	

Explicit Knowledge

The individual group data for the reported explicit knowledge was analysed by the Chi-Squared test. Both the explicit group, $\chi^2(1)=13.88$, and the implicit group $\chi^2(1)=6$ were found to be significant at $\alpha=.05$. Thus in both these groups subjects had reported an amount of correct answers that were significantly above those which could have been gained by chance alone.

A One-Way ANOVA was performed on the explicit knowledge scores to identify if the three groups were significantly different from each other. Table 17 displays the explicit knowledge scores.

Table 17: Reported Explicit Knowledge Scores
(1 = lowest, 8 = highest)

Subject	Implicit group	Delayed Explicit group	Explicit group
1	3	2	3
2	3	3	4
3	3	3	4
4	3	3	5
5	5	4	5
6	5	4	5
7	5	4	6
8	6	5	6
9	6	5	6
10	6	6	7
11	7	6	7
12	7	7	8
Total	59	52	66
Mean	4.92	4.33	5.5
SD	1.56	1.5	1.45

No significant differences were found amongst the groups (see Appendix 2.7). The explicit knowledge score and the first trial from the retention data were analysed to identify any significant correlation between the two. No correlation was reported, r=0.42 (see Appendix 2.8).

Exploratory re-analysis:

It became apparent that some of the subjects were experiencing difficulties using the explicit rules and as with the first experiment, there was concern that subjects had not actually used the explicit rules in the required manner. Unfortunately, subjects were not required to report the extent to which they had used the explicit rules. Therefore, the decision to re-analyse the results was taken as a consequence of observing the subjects performing the task and inspecting the subjects' explicit knowledge scores.

An Implicit / Explicit structure was enforced on the groups and the data re-analysed. "Real" Implicit and Explicit groups were created from the original experimental groups. The "real" Implicit group was taken from the original implicit group but only included those subjects who scored five or less on the explicit knowledge test. Similarly, the "real" explicit group was taken from the original explicit group but only contained subjects who scored six or more on the explicit knowledge test. There were now seven subjects in the implicit group and six subjects in the explicit group, whilst the delayed explicit group remained unchanged. The analyses performed on the "real" groups were identical to the analyses performed on the original experimental groups.

A 3 (group) by 4 (block) by 4 (trial) ANOVA with repeated measures on block and trial was performed on the acquisition data (see Appendix 2.9). A main effect was again found for block $F_{2.53,55.57}=31.96$, $p<.01$, but the block by trial interaction was not significant in this re-analysis. There were no further significant findings. The post hoc Tukey's test on the block main effect calculated a critical mean difference of $T_{qv}(2.53,55.57)$, $p<.05 = 1.62$. Therefore, blocks 2, 3 and 4 were significantly different from block 1 as was block 2 from block 4.

Table 18: Re-analysis Acquisition - Trial and Block Mean Scores
(Standard Deviation in brackets)

		Block 1	Block 2	Block 3	Block 4	Mean
Trial	1	17.84 (10.74)	23.76 (11.34)	19.08 (10.71)	17.8 (9.77)	19.62 (10.64)
	2	23.76 (11.57)	21.88 (12.7)	21.2 (10.91)	22.28 (9.92)	22.28 (11.28)
	3	24.68 (11.81)	22.56 (12.72)	23.24 (11.7)	23.72 (9.85)	23.55 (11.52)
	4	26.2 (11.58)	23.56 (13.12)	24.52 (12.23)	23.96 (9.97)	24.56 (11.73)
	Mean SD	23.12 (11.43)	22.94 (12.47)	22.01 (11.39)	21.94 (9.88)	

The 3 (group) by 2 (trial) ANOVA performed to show any differences between trials 8 and 9 in acquisition, when the delayed explicit group received the explicit rules, failed to show significant findings (see Appendix 2.10).

A 3 (group) by 2 (old or new) by 4 (trial) ANOVA with old or new and trial as repeated measures was performed on the retention data (see Table 19). A main effect for old or new was reported $F_{1,22}= 4.53$, $p<.05$, with old (mean=27.2) being performed significantly better than new (mean=25.87). It is worth noting that the group by "old or new" interaction $F_{2,22}=3.04$, $p=0.068$, was approaching significance. The trend of this borderline interaction is displayed below (see Figure 15) There were no further significant findings (see Appendix 2.11).

Table 19: Re-analysis Retention - Trial Mean Scores
(Standard Deviation in brackets)

Trial	Old 1	Old 2	New 3	New 4	Old 5	New 6	Old 7	New 8	Mean
Implicit group	28.14 (15.6)	32.43 (11.76)	26.43 (12.19)	32.86 (11.57)	24.71 (12.34)	24.57 (9.61)	34.86 (9.79)	29.43 (13.67)	29.05 (12.07)
Delayed Explicit group	24.83 (13.64)	23.17 (11.95)	24.17 (12.76)	19.83 (11.58)	21 (9)	23.83 (10.04)	21.25 (12.15)	24.92 (14.29)	22.88 (11.93)
Explicit group	29 (7.43)	30.33 (11.79)	24.5 (9.33)	24.67 (5.39)	30.67 (12.58)	28.17 (16.89)	26 (18.75)	28.17 (10.91)	27.69 (11.63)
Mean SD	27.33 (12.22)	28.64 (11.84)	25.03 (11.43)	25.45 (9.51)	25.46 (11.31)	25.52 (12.18)	27.37 (13.56)	27.5 (12.96)	

Table 20: Re-analysis Retention – Old /New Mean Scores
(Standard Deviation in brackets)

Trial	Old	New	Mean
Implicit group	30.35 (12.37)	28.32 (11.76)	29.34 (18.25)
Delayed Explicit group	17.81 (11.69)	23.19 (12.17)	20.5 (11.93)
Explicit group	29 (12.64)	26.38 (10.63)	27.69 (11.64)
Mean SD	25.72 (12.23)	25.96 (11.52)	

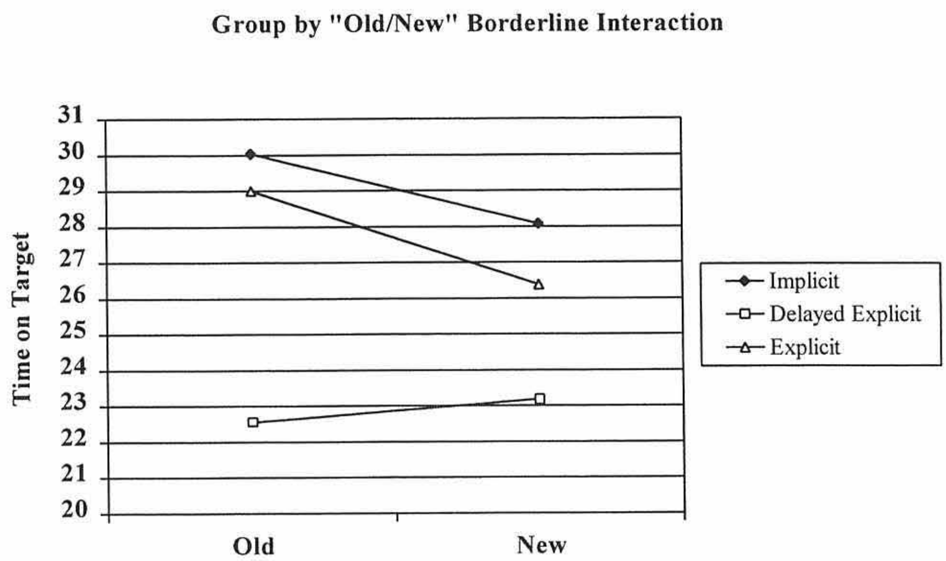

Figure 15

The One-Way ANOVA performed on the explicit knowledge scores to identify if the three groups were significantly different from each other revealed the explicit group (mean=6.67) to be significantly different to both the implicit (mean=3.86) and the delayed explicit groups (mean=4.33). The implicit and delayed explicit groups were not, as expected, significantly different in the re-analysis (see Appendix 2.12). The correlation between the explicit knowledge score and the first trial on retention did not reach significance, r=0.17 (see Appendix 2.13).

Discussion

This experiment was based on the work of Verdolini-Marston and Balota (1994) and designed to overcome some of the problems that occurred in the first experiment. The intention was still to provide results that would demonstrate the most effective time to give explicit rules when learning a complex motor skill.

Unlike Reber et al. (1980), Verdolini-Marston and Balota (1994) used a pursuit rotor task (a motor task) to test their hypotheses. Verdolini-Marston and Balota also demonstrated that certain types of explicit rules appear to be more efficient than others. The present experiment was designed to incorporate the explicit rules that were found to be most effective in Verdolini-Marston and Balota's experiment. The nature of the experimental groups remained the same as those used in the first experiment.

The differences in group performances on the motor task failed to reach statistical significance. However, similar patternings of results to those found in the first experiment are present if scores on the test of explicit knowledge are examined. As might be expected reported explicit knowledge is higher in the explicit group, but the delayed explicit group scored the lowest. The fact that the explicit group scored highest on the test for explicit knowledge partially supports the third hypothesis that, the amount of reported explicit knowledge will be greater in subjects who practised the task with explicit knowledge. Paradoxically, the explicit knowledge scores of the delayed explicit group are lower than the implicit group's score. This contradicts the intuitive hypothesis that subjects given explicit information will exhibit higher levels of explicit knowledge than those who are not.

Reasons for this may be located in the subject's use of the explicit rules. Although responses were not obtained from all, subjects who volunteered additional information reported that they found the explicit rules an interference when administered half way through the acquisition period. Also, the nature of the explicit rules, although found to be the most effective in the experiment by Verdolini-Marston and Balota (1994), could on reflection have been a problem. It soon became clear that a number of subjects felt uncomfortable with the notion of mentally attaching a song to the different stimuli. In informal discussions after the task had finished it became more apparent that subjects had not utilised the rules effectively because many reported they had felt "silly" with the idea. Therefore, some devised their own rules, whilst others completely ignored the use of any strategy.

Whilst speculative, it may be that a failure of the experiment was that subjects were not required to report the confidence with which they had used the explicit rules. At the beginning of the experiment, steps were taken in an attempt to ensure that subjects did indeed use the explicit rules as required. Unfortunately, this may not have been the case.

Before each explicit trial of the delayed explicit group and explicit group it was stressed that adopting the explicit strategy would make performance of the task easier in the second part of the experiment (retention). Although care was taken never to divulge any more. A small number of subjects obviously used the explicit rules as they sang songs out loud for each stimuli, even though this was not specifically requested. It is interesting to note that these subjects scored full marks (eight) or seven on the explicit knowledge test and blatantly obvious that they could indeed recognise each individual stimuli during acquisition. Thus, these subjects recognised that stimuli were presented in the same pattern for each of the four blocks. Often it appeared that if subjects could recognise this pattern they scored higher on the explicit knowledge test. Subjects also seemed able to recognise the largest circle at the fastest speed and the smallest circle at the slowest speed better than the ones in between.

Obviously, these observations are a purely subjective report of what looked to be happening during the acquisition period. However, they may be important in explaining the lack of significant findings for this hypothesis. Due to the results of the explicit knowledge test the groups were once again re-formed into "real" implicit and explicit groups. The "real" implicit group consisted only of those subjects who scored five or less. Although the score of five is one above that of chance, it was included so that the number of subjects in this group would almost match the number in the explicit group. The "real" explicit group was created from those subjects who scored six or above. The delayed explicit group remained unchanged during re-analysis. Throughout the remainder of this discussion the results of the original analysis and the re-analysis will be considered together to identify if the subjects' use of the explicit rules was responsible for the lack of significant findings.

The first hypothesis states that explicit rules given in the middle of a learning episode will prove an interference to skill acquisition. Statistically this was not found to be the case with no significant main effects evident between any of the groups. A block by trial interaction and a main effect for block was found. Follow up tests investigated the interaction and showed the scores from block one to be significantly different from blocks two, three and four on trials one, two and four. On trial three, block one was only significantly different from blocks three and four. This interaction demonstrates that for the majority of time subjects were achieving significantly increased time on target scores on blocks two, three and four than they scored on block one. Although this is interesting, it does not provide any more support for the hypotheses.

A significant three-way interaction between group, block and trial was not shown. Thus introducing the explicit rules at different times during acquisition did not significantly affect subjects' time on target scores. Also, a two way ANOVA exploratory planned comparison did not find any support for performance differences between subjects' time on target scores on trials 8 and 9 of acquisition, the point where explicit rules were introduced. This only serves to reinforce the findings that no significant differences were observed as a result of introducing the explicit rules at the mid-point of the acquisition period. Although the exploratory re-analysis could not find any further significant evidence to support this hypothesis, the group by "old/new" interaction in the retention data was bordering on being significant. This result, however, must be treated with caution as the number of subjects in this re-analysis was small. Even so, the trend from the interaction (see Figure 15) could possibly indicate that some sort of interference effect occurred in the delayed explicit group, as the time on target scores from both the implicit and explicit groups were higher than the delayed explicit group on old stimuli during retention. The re-analysis block main effect was again reported although the block by trial interaction was not.

Although the results do not statistically support the hypothesis, many subjects in the delayed explicit group did report that introducing the explicit rules proved an interference (as explained above). This could be due to subjects perceiving the explicit rules as an interference and deciding consciously to ignore them.

The second hypothesis of the experiment states that the implicit group's retention performance would be superior to that of the other two groups. Although this hypothesis contradicts the second hypothesis of the first experiment it has been designed to show whether the dissociation of the implicit / explicit memory systems, as found by Verdolini-Marston and Balota (1994), are evident in this experiment.

The retention data failed to report significant findings as all groups performed statistically alike. No significant main effects or interactions were displayed. Therefore, there is no evidence to support the results of Verdolini-Marston and Balota (1994) that a dissociation exists between the implicit and explicit memory systems.

However, when the experimental re-analysis was performed on the retention data a main effect for "old versus new" stimuli was present. Thus performance scores were found to be significantly different between those stimuli which were old and those which were new, with old being performed slightly better than new. The trend of the borderline group by "old/new" interaction may tentatively suggest that the implicit group's retention performance was superior to that of the other two groups. If the groups had originally been implicit and explicit as determined by their explicit knowledge score, this hypothesis may have been supported.

Based on these results it is not clear if the problems concerning the first experiment were indeed controlled for. The task problem of the first experiment should have been solved in this experiment by using the task utilised by Verdolini-Marston and Balota (1994). The explicit rules used were shown to be effective in Verdolini-Marston and Balota's experiment. However, that success has not generally been mirrored in this experiment. Possible reasons for the lack of significant results could once again lie with the salience of the explicit rules and the belief subjects had about them being important in order to complete the task effectively.

There follows a general discussion of the two experiments that will attempt to bring together the findings and address the factors that may have played a part in the lack of significant results.

General Discussion

This investigation was designed to provide information about the most effective time to give explicit rules during complex motor skill learning. Experiments to date, that have researched this area, have often used the findings from verbal memory to investigate motor memory (Verdolini-Marston and Balota, 1994). Some investigators of motor memory assume that verbal memory and motor memory are governed by one set of laws. This investigation sought to examine the validity of this viewpoint.

The first experiment was designed around Reber et al. (1980). They found, with a complex grammar learning sequence, that explicit rules were most effective if they were given at the start of the learning episode. The present investigation expected to replicate the findings of Reber et al. whilst using a motor task. The second experiment used the same procedure as the first, but adopted the task and design of Verdolini-Marston and Balota (1994) in an attempt to overcome some of the problems of the first experiment.

Given the careful design of the experiments, the results of this investigation are surprising. Some results do not meet the usual criteria for significance, but are worthy of consideration.

During acquisition, the analysis showed that subjects were able to learn the tasks and improve their performance although there were no differences between any of the groups. Thus administering the explicit rules at different times throughout acquisition did not statistically affect performance.

During the retention period of the first experiment, the analysis showed that subjects' performance improved over the four trials although this was not statistically different between groups. The retention data from experiment two did not produce any statistically significant results.

The measure of explicit knowledge in experiment one was a test of identifying steps in motor output, whereas in experiment two it was the proportion of correct identifications on the recognition test. The measure of implicit memory was the facilitation in performance for previously encountered stimuli without recognition of novel stimuli.

The explicit knowledge scores in both experiments are interesting. In the first experiment, there was a significant difference between the explicit knowledge scores of the implicit and the explicit group, and of the delayed explicit and explicit group. In the second experiment, both the explicit and implicit groups produced explicit knowledge scores that were significantly above those which could have been obtained by chance, although none of the groups were significantly different from each other. This patterning of scores is interesting as it was not predicted and is not easily explained.

A possible explanation could lie with the extent to which subjects actually used the explicit rules. During the first experiment, many subjects in the delayed explicit group reported that providing explicit rules half way through the acquisition period was an interference. Of these, a number of subjects from the delayed explicit group admitted they had ignored the rules. They were in fact performing as another implicit group.

A major failing of the second experiment was that subjects' confidence when using the explicit rules was not examined, although some subjects again reported that introducing explicit rules was an interference. In hindsight, it seems to have been incorrect to assume that the experimental methodology would ensure that subjects did indeed use the rules as required. The delayed explicit group's lower explicit knowledge score could have resulted from a rejection of the offered explicit rules if they were perceived to have a potential for interfering with performance (Reber, 1989). Equally, it could have been expected that interference would have been reflected in lower performance scores. It was not.

Due to the problem of subjects apparently ignoring the rules, the data were re-analysed. The groups used for this re-analysis were termed "real" implicit and explicit groups. These groups were created from the original groups although they only included subjects who reported an explicit score considered indicative of their group. The delayed explicit group remained the same throughout re-analysis. This procedure was repeated during the re-analysis of the data in experiment two.

Re-analysis of the data from the first experiment revealed no new findings. Whilst re-analysing the second experiment's data showed evidence which supported a main effect for the "old versus new" condition during retention. Performance scores in retention were significantly different on the trials in which subjects had previously seen the stimuli (trials 1, 2, 5 and 7) to the trials that were new to the subject (trials 3, 4,6 and 8), with the former being performed better than the rest. The group by "old versus new" interaction which was bordering on significance ($p=0.068$) indicates tentatively that the implicit group performed better on the old stimuli than the other two groups. It could also be possible that the scores of the delayed explicit group are lower than the implicit and explicit group because of the previously discussed interference effect taking place, which may support Reber's (1989) hypothesis. Generally though the re-analysis suggests that even if the groups were indeed performing as "real" groups, presuming that the explicit group score could predict this, there would not have been strong support for the experimental hypotheses.

Some methodological issues may account for this. One of the problems may arise from the task complexity. It is possible that the task of the first experiment was not sufficiently complex to require the subjects to make best use of the explicit rules. Smith (1992) suggests that because this task has only one degree of freedom (Turvey, 1990) the link between perception and action is not difficult to create. Thus, a variety of solutions from which to draw an answer was not available to the subject. However, it may be necessary to use a simple task so that implicit learning is possible.

A further problem that is considered to have played a major part in the first experiment is the type of explicit rules given. As was stated earlier Reber et al. (1980) demonstrated that the salience of the explicit rules was important if the instructions were to be most effectively utilised. This first experiment used somewhat uninspiring rules placed in front of the subject, which then informed them about the movement of the cursor in a rather static way. Thus the importance, or salience, of these rules was not highlighted. Subjects did not use the rules either because they had chosen not to use them, or they had been able to complete the task adequately without them.

It was hoped that the problems of the first experiment were controlled in the second experiment by using the methodology and pursuit rotor task of Verdolini-Marston and Balota (1994). They demonstrated the existence of implicit and explicit memory and were also able to identify the type of explicit rules that had been most effective in producing evidence of explicit memory performance. The procedure and experimental groups of the second experiment remained the same as the first, with the intention of the investigation still to identify the most effective time to give explicit rules in complex motor skill acquisition.

Verdolini-Marston and Balota (1994) determined that subjects were able to learn the task and show a performance facilitation for previously encountered stimuli when no explicit rules were given. When explicit rules were administered, they found that a performance facilitation did not occur. For explicit knowledge, the strategy that identified which specific stimulus was encountered was superior to an elaborative processing instruction or a perceptual processing instruction. However, performance facilitation was found to be specific to old stimuli rather than a generalised benefit.

The second experiment of the present investigation also demonstrated that subjects were indeed able to learn the task. However, the data did not highlight the most effective time to administer the explicit rules or indeed any benefit of using the explicit rules at all. Performance facilitation or priming effects were not demonstrated in this experiment. According to Verdolini-Marston and Balota (1994) priming effects should at least have been evident in the implicit group, which did not receive any explicit rules. The borderline interaction gained from re-analysing the retention data may provide tenuous support for this hypothesis. The implicit group did indeed perform better than the other two groups on the old stimuli.

It is possible that the number of trials presented to subjects were not sufficient to show an effect, thus, subjects had not become competent enough at the task. According to Schmidt (1988) there are specific stages that learners appear to pass through when learning a skill. The first of these stages is the cognitive or the verbal-motor stage (Adams, 1971). During this phase there is a great deal of cognitive activity to determine which is the appropriate strategy to use to perform the task. Performance gains are dramatic but inconsistent and improvements are verbal-cognitive or "what to do". The next progression is the associative or motor stage (Adams, 1971) which can last many days or weeks. By now learners have determined the most effective way of performing the task and need only make subtle adjustments to their performance. Performance gains are gradual and performance is generally more consistent whilst the verbal-cognitive aspects of the task have almost disappeared. Finally the autonomous stage is entered after many months or years of practice and the skill becomes automatic.

In the present investigation, subjects may not have progressed out of the verbal-motor stage as they only had sixteen trials to practice the skill. Trying to show distinct differences between the implicit and explicit memory systems whilst in the verbal-motor stage of learning may have been problematic. Also, one of the definitions of explicit knowledge or memory is that it is verbal in nature. Therefore, the verbal-motor stage could be argued to be an explicit stage by definition. This experiment used the same number of trials as Verdolini-Marston and Balota (1994). As they showed some evidence of implicit learning, it is expected that this experiment could also show a similar result. It is also strange that implicit learning can take place with a task such as that used by Verdolini-Marston and Balota, if the verbal-motor stage is always needed.

The first experiment used explicit rules that were essentially "how to do the task" whereas the second experiment used rules that identified which specific stimuli had been seen. According to the transfer appropriate framework, explicit, or elaborative rules that emphasised which specific stimuli were encountered would primarily facilitate explicit memory performance. Whereas elaborative processes that emphasised how to perform the perceptual-motor task would primarily influence implicit memory performance. Speculating therefore, the delayed explicit group of the first experiment could have shown a facilitation in implicit knowledge because the explicit rules provided information about how to do the task rather than which stimuli was presented. However, the delayed explicit group of the second experiment should have shown a facilitation in explicit knowledge. Although the lack of significant findings could have been due to an interference effect, the type of rules given during the experiment could also have affected the results. This cannot explain why the delayed explicit group's explicit knowledge scores were lower in the second experiment.

The dual process (dissociation) model states that different processing levels best distinguish implicit and explicit memory performance. Elaborative processes or the act of using an explicit rule primarily modulates explicit memory performance. Implicit memory performance should be relatively uninfluenced by distinct levels of elaborative processing and possibly be best under conditions that emphasise perceptual-integrative processes. Verdolini-Marston and Balota (1994) found that their data appeared to fit this model because of the separation that was evident between the implicit and explicit memory systems. If the dual process model is applied to the present experiments, then the explicit rules of either the first or second experiment should have had no effect on the performance of subjects. Definite differences between the performance of the implicit and explicit groups should also have been displayed.

The results of the present investigation do not fall easily into any of the models or explanations of how implicit and explicit memory fit together. There was no evidence to support either the transfer appropriate processing framework or dual process (dissociation) model of describing implicit or explicit memory performance. Notwithstanding the failure to directly support the hypotheses, these investigations raise the prospect of linking the underlying ideas in a new way. This would have to be based on the one substantive finding that when delayed explicit rules are given with a change or variation in the stimulus or task requirement, performance will be adversely affected. A change in the stimulus or task requirement can also depress performance scores for subjects who have practised (but not extensively) using only implicit rules. Subjects given explicit rules at the onset are not adversely affected by a variation in the stimulus or task as practice progresses.

In summary, the hypotheses proposed were not supported as no significant results were found to highlight the most effective time for giving explicit rules when learning a complex motor skill. The lack of significant findings could possibly be due to problems with the task or with the explicit rules used. There were some findings however, which suggested that had the tests been a little more sensitive some support for the hypotheses might have been detected. Tenuous support was found after re-analysing the data, for the interference effect discussed by Reber (1989) and the implicit priming identified by Verdolini-Marston and Balota (1994) although these results are extremely weak. Suggestions for further research will follow.

Future Research

The present investigation failed to report findings that could demonstrate the most effective time to give explicit rules in complex motor skill acquisition. However, there have been a number of experiments that have succeeded in demonstrating how explicit rules can be used most effectively.

Future research should ensure the explicit rules are monitored closely to make sure they are being used as the experiment requires. There should also be a confidence rating, completed by each subject, as a retrospective record of the confidence with which each subject personally used the explicit rules. For the explicit rules to be perceived as useful they must be salient and subjects must believe they are useful. The salience of the explicit rules could be increased by matching them more to the task. This could involve investigating different types of tasks to find out how they are affected by explicit rules, for example Green and Flowers (1991) suggest that attention demanding visuo-motor tasks may be disrupted by verbally provided explicit probability information. Verdolini-Marston and Balota (1994) also propose that different processing characteristics, either the Transfer appropriate processing or the Dual process (dissociation) model may affect the way explicit rules are used. Further research that determines specifically which is the most effective processing model to use with different motor tasks could be of benefit for determining the most effective type of explicit rules to use. It may be that explicit rules must be matched much more to a motor task than is necessary for cognitive tasks.

Although Verdolini-Marston and Balota (1994) did show explicit learning with their album group and impaired performance relative to the implicit learning group the present experiment did not show the same findings. The different results of the two experiments could possibly have been due to methodological problems encountered with the present experiment. If subjects were monitored more closely for their use of the explicit rules then findings similar to those of Verdolini-Marston and Balota (1994) may have been found. It may even be worthwhile in future studies to test a very large number of subjects and then group them according to their explicit knowledge score, so that the groups obtained could be termed "real" implicit and explicit groups. The larger number of subjects in each group would then hopefully increase the sensitivity enough to demonstrate significance for the hypotheses which has only been hinted at in the current thesis.

If the suggestions made above were implemented then the hypotheses of the current study may be worthy of further consideration. These answers could then help in understanding what, if any, sort of generalisation can be made from cognitive/verbal tasks to motor/perceptual tasks. Tied into this research would naturally be the question of how the explicit and implicit memory systems work. The interference effect (Reber, 1989) caused by introducing explicit rules into the acquisition of a skill may be further understood when the explicit rules and task are matched more closely. Finally, the learner's ability at the task or skill should be considered. Thus investigating any differences that arise from administering explicit rules to novices as opposed to skilled performers.

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Appendix 1.1
Listing of the Experimental Program

(Written in Quick BASIC 1.0 for the Macintosh)

```
toolbox "i"
sh=SYSTEM(6)
sw=SYSTEM(5)
h%=200
w%=400
LIBRARY "NIDAQMACLib"
path%=0
path%=1
Iderr&=0
ctr%=0
x%=0
y%=0
xreq%=0
yreq%=0
noise%=0
ctsound%=0
R1&=0
R2&=0
cter=0
R3&=0
R4&=0
bool%=0
ts&=0
clsctr%=0
ctr%=0
DIM poly1%(16),poly2%(16),poly3%(16),poly4%(16),mt!(20),cpath%(20)
DIM mt&(20),count&(4),r%(3),R1%(4),R2%(4),R3%(4),R4%(4)
cpath%(0)=0
RANDOMIZE TIMER
GOSUB acqretn
GOSUB demographics
startup:
ww%=400
wh%=400
sw%=SYSTEM(5):sh%=SYSTEM(6)
wl%=(sw%-ww%)\2
wt%=(sh%-wh%)\3
WINDOW 1,"",(wl%,wt%)-(wl%+ww%,wt%+wh%),4

  SetArray poly1%(0),30,375,80,24,321,375,285,353,321,24,115,46,80,375,285
  NewRgn R1&:OpenRgn
  CALL FRAMEPOLY(VARPTR(poly1%(0)))
  CloseRgn R1&
```

```
  SetArray poly2%(0),30,321,23,84,374,321,354,286,374,84,44,119,23,321,354
  NewRgn R2&:OpenRgn
  CALL FRAMEPOLY(VARPTR(poly2%(0)))
  CloseRgn R2&

  SetArray poly3%(0),30,315,21,84,378,119,378,84,355,278,21,315,42,119,378
  NewRgn R3&:OpenRgn
  CALL FRAMEPOLY(VARPTR(poly3%(0)))
  CloseRgn R3&

  SetArray poly4%(0),30,375,79,24,320,46,320,24,285,353,79,375,115,46,320
  NewRgn R4&:OpenRgn
  CALL FRAMEPOLY(VARPTR(poly4%(0)))
  CloseRgn R4&
ctsound%=0
IF session$="a" OR session$="A" THEN max=16 ELSE max=4
ON MOUSE GOSUB positioncursor
MOUSE ON

FOR trial=1 TO max
ctr%=0
CLS

'to build the circle and the target path,
'need to insert a rectangle for the path
'within the circle. This needs to be
'randomised so that it can appear at any of
'four angles (30,60,120,150)

IF trial>1 AND (trial-1)/4=INT((trial-1)/4) THEN path%=path%+1
IF max=4 THEN path%=3

Acqn:
'need to make sure the cursor is in the right place for the
'beginning of the trial
GOSUB positioncursor
rpttrl:
CALL MOVETO(x%,y%)

  x1%=INT(ww%/80)
  x2%=INT(ww%-(ww%/80))
  setrect r%(0),x1%,x1%,x2%,x2%
  CALL FRAMEOVAL(VARPTR(r%(0)))
  setrect r%(0),2,2,398,398
  CALL FRAMERECT(VARPTR(r%(0)))

SELECT CASE path%
  CASE 1
```

```
   framergn R1&
  CASE 2
   framergn R2&
  CASE 3
   framergn R3&
  CASE 4
   framergn R4&
 END SELECT

'now an attempt to make the cursor
'travel using the voltage read statement, pt by pt
    CALL PENSIZE(1,1)
    trapno&=&HA975
    t1&=0&
    t2&=0&
    ticks&=0&
    toolbox "L",trapno&,t1&
  ctr%=0
WHILE ctr%<2
  'keep reading until the cursor has gone up and back
 toolbox "L",trapno&,ts&
  CALL AI.Read(4,Iderr&,1,1,x%)
  CALL AI.Read(4,Iderr&,2,1,y%)
  x%=CINT((x%/2047)*400)
  y%=CINT((y%/2047)*400)
  setpt pt%(0),x%,y%
SELECT CASE path%
  CASE 1
  PtInRgn pt%(0),R1&,bool%
  CASE 2
  PtInRgn pt%(0),R2&,bool%
  CASE 3
  PtInRgn pt%(0),R3&,bool%
  CASE 4
  PtInRgn pt%(0),R4&,bool%
 END SELECT
 IF bool%=-1 THEN CALL LINETO(x%,y%)

SELECT CASE path%
   CASE 1
      SELECT CASE ctr%
         CASE 0
            IF x%>280 AND y%>348 THEN ctr%=ctr%+1
         CASE 1
            IF x%<120 AND y%<50 THEN ctr%=ctr%+1
       END SELECT
   CASE 2
      SELECT CASE ctr%
```

```
        CASE 0
          IF x%>349 AND y%>280 THEN ctr%=ctr%+1
        CASE 1
          IF x%<39 AND y%<125 THEN ctr%=ctr%+1
      END SELECT
    CASE 3
      SELECT CASE ctr%
        CASE 0
          IF x%>350 AND y%<124 THEN ctr%=ctr%+1
        CASE 1
          IF x%<47 AND y%>272 THEN ctr%=ctr%+1
      END SELECT
    CASE 4
      SELECT CASE ctr%
        CASE 0
          IF x%>279 AND y%<50 THEN ctr%=ctr%+1
        CASE 1
          IF x%<120 AND y%>348 THEN ctr%=ctr%+1
      END SELECT
  END SELECT

  IF ctr%=1 AND clsctr%=0 THEN GOSUB clearscreen
  MOVETO x%,y%
  WEND
  clsctr%=0
  toolbox "L",trapno&,t2&
  mt&(trial)=t2&-t1&
   SELECT CASE path%
    CASE 1
     framergn R1&
    CASE 2
     framergn R2&
    CASE 3
     framergn R3&
    CASE 4
     framergn R4&
   END SELECT
  IF max=16 THEN GOSUB feedback
    strt=TIMER
    WHILE TIMER<strt+3
    WEND
  ctsound%=0
  NEXT trial

  GOSUB SCORING
  ending:
  END
```

```
demographics:
  WINDOW 11,,((sw-w%)/2,(sh-h%)/3)-((sw-w%)/2+w%,(sh-h%)/3+h%),2
  title$="Demographics"
  TEXTFONT 0
  MOVETO (WINDOW(2)-WIDTH(title$))\2,20
  PRINT title$
  TEXTFONT 3
  setrect r%(0),10,30,w%-5,h%-15
  s$="Please give the subject # (keep a note of this!), age (in years, '21' not 'twenty-
one')"
  s$=s$+"and gender (1=male, 2=female) and gp# (1=IT, 2=ET, 3=DET). Make sure
that"
  s$=s$+" you separate the items with commas, and don't insert spaces between "
  s$=s$+"items. Once completed, press the <return> key."
  textbox s$,r%(0),0
  INPUT "Sub. #,Age,Gender,GP#: ",id%,age!,gender%,gp%
  WINDOW CLOSE 11
RETURN

SCORING:
  WINDOW 14,,(40,40)-(440,320),2
  title$="Raw scores for subject "+STR$(id%)+" (1 unit=16.7 msecs)"
  TEXTFONT 0
  MOVETO (WINDOW(2)-WIDTH(title$))\2,20
  PRINT title$
  TEXTFONT 3
  IF max=16 THEN f$="acqndta" ELSE f$="retndta"
  FOR i=1 TO max
  mt!(i)=CSNG(mt&(i)/60)
  NEXT i
  IF max=16 THEN PRINT "Trials 1-4" TAB(10) "5-8" TAB(20) "9-12" TAB(30) "13-
16"

    FOR i=1 TO 4
    IF max=16 THEN PRINT mt!(i) TAB(10) mt!(i+4) TAB(20) mt!(i+8) TAB(30)
mt!(i+12) ELSE PRINT "Retention trial " i "= " mt!(max-(4-i))
    NEXT i

'store data on disk, all on one line ready for analysis
 OPEN f$ FOR APPEND AS #1
  PRINT #1, id% CHR$(9) gender% CHR$(9) gp% CHR$(9);
  FOR i=1 TO max
   PRINT #1, CSNG(mt&(i)/60) CHR$(9);
  NEXT i
  PRINT #1,
 CLOSE #1

  WINDOW CLOSE 14
```

```
RETURN

positioncursor:
CLS
ctr%=0
clsctr%=0
   WINDOW 7,,((sw-w%)/3,(sh-h%)/4)-((sw-w%)/3+w%/2,(sh-h%)/4+h%/2),2
   title$="Cursor Error"
   TEXTFONT 0
   MOVETO (WINDOW(2)-WIDTH(title$))\2,20
   PRINT title$
   TEXTFONT 3
   setrect r%(0),20,50,230,230
SELECT CASE path%
   CASE 1
      xreq%=100
      yreq%=50
   CASE 2
      xreq%=44
      yreq%=105
   CASE 3
      xreq%=42
      yreq%=292
   CASE 4
      xreq%=105
      yreq%=350
END SELECT
WHILE ABS(xreq%-x%)>3 OR ABS(yreq%-y%)>3
  CALL AI.Read(4,Iderr&,1,1,x%)
  CALL AI.Read(4,Iderr&,2,1,y%)
   x%=CINT((x%/2047)*400)
   y%=CINT((y%/2047)*400)
   setpt pt%(0),x%,y%
  tim$="Error L= "+STR$(xreq%-x%)+", Error R ="+STR$(yreq%-y%)
  textbox tim$,r%(0),0
  WEND
  WINDOW CLOSE 7
RETURN rpttrl

feedback:
MOVETO 1,30
PRINT "TIME TAKEN= " CSNG(mt&(trial)/60)
RETURN

clearscreen:
clsctr%=1
CLS
 x1%=INT(ww%/80)
```

```
 x2%=INT(ww%-(ww%/80))
 setrect r%(0),x1%,x1%,x2%,x2%
 CALL FRAMEOVAL(VARPTR(r%(0)))
 setrect r%(0),2,2,398,398
 CALL FRAMERECT(VARPTR(r%(0)))
 SELECT CASE path%
  CASE 1
   framergn R1&
  CASE 2
   framergn R2&
  CASE 3
   framergn R3&
  CASE 4
   framergn R4&
 END SELECT
RETURN

acqretn:
   WINDOW 11,,((sw-w%)/2,(sh-h%)/3)-((sw-w%)/2+w%,(sh-h%)/3+h%),2
   title$="Acquisition or Retention Phase?"
   TEXTFONT 0
   MOVETO (WINDOW(2)-WIDTH(title$))\2,20
   PRINT title$
   TEXTFONT 3
   setrect r%(0),10,30,w%-5,h%-15
   s$="If you are about to start the acquisition phase with this subject "
   s$=s$+"then input <A>.  If you are about to start the retention phase, "
   s$=s$+"then input <R>.  "
   s$=s$+"Then press the <return> key."
   textbox s$,r%(0),0
   INPUT session$
   WINDOW CLOSE 11
RETURN
```

Appendix 1.2
Consent Form

Thank you for agreeing to take part in my experiment.

I am conducting an experiment which investigates learning in a Bimanual Motor Task.

The experiment is in two parts. The first a 20 minute task and the second, 24 hours after the first, a 10 minute task immediately followed by a short questionnaire about the task. The results will be treated in the strictest of confidence. At any time during the experiment you are free to end your participation as a subject and no explanation will be required as to your reasons.

I understand that I have agreed to participate in all parts of this experiment and may cease participation at any time I wish.

Signed ______________________________

Name (printed please) ______________________________

Date ______________________________

Department ______________________________

Appendix 1.3
Subject Instructions - Acquisition Period

On the screen you will see 2 values. Which show L=? and R=?

Mounted on plastic in front of you, you will see two buttons.

With your left hand turning the button on the left please slowly reduce the value of L until it is between ±3.
Repeat with your right hand slowly turning the button on the right until the value of R is also between ±3.

When both the L and R buttons are between ±3 the trial will begin.

This procedure will be repeated for each trial.

The screen will then show a circle which contains a rectangle across the diameter.

The object of the experiment is to guide the cursor with the L and R buttons across the rectangle to reach the other side of the circle and then guide it back to return to the starting position. It is important that you attempt to keep the cursor inside the rectangle at all times

If the cursor goes outside the rectangle the path it takes will not be shown on the screen. Only when the cursor is contained within the rectangle will you be able to see it's pathway

The time taken for one complete trial, i.e. crossing the circle and then returning to the start position, will be measured. The object of each trial is to get across the circle and back to the start in the quickest time whilst keeping within the rectangle.

You must always turn the left hand button with your left hand and the right hand button with your right hand.

[For groups 2 and 3 the following extra rule was given. For group 2 the rule was given half way through the trials, i.e. after 8 trials of the 16. For group 3 the rule extra rule was given at the start.]
These cards, that are stuck to the monitor, display the rules for the way the buttons control the cursor on the screen. The one on the left relates to the left button and the one on the right relates to the right.

Subject Instructions - Retention Period

The procedure for today will take the same format as yesterday. However there will be less trials than yesterday and the time for each trial will not be displayed. (no mention was made regarding the lack of explicit rules in the retention period unless the subject specifically noticed it).

After the trials have finished I will run through a quick questionnaire with you.

Do you remember what you had to do for each trial?
If the answer was "yes" the subject was asked to carry on as yesterday
If the answer was "no" - a quick recap of the trial commenced (cursor error etc.)

Questionnaire Instructions

After both the acquisition and retention periods were over a short questionnaire was administered. A few extra questions were added onto the questionnaire, which were answered on the back of the questionnaire. These included, in this order:
Are you left or right handed?
Are you dyslexic?
In which direction does the left button move the cursor?
What does the right button do?

If the subject was in groups 2 or 3, they were then specifically asked about the rules they saw displayed. They were asked if they used them and if so how; if they found them useful or if they acted as more of a distraction.

After all the questions on the questionnaire had been answered the subject was asked if they had anything further to add that I may not have specifically asked them about.

The subject was then debriefed about the experiment after which they were asked if they had any questions or if there was anything further they wanted to add (with some of the subjects a healthy discussion then ensued).

The subject was then asked not to discuss the components of the experiment with anyone else.

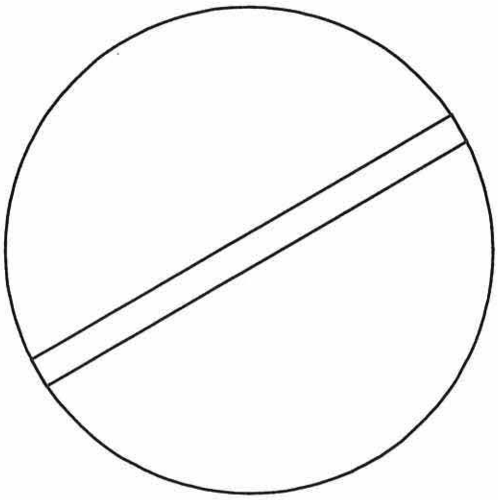
Appendix 1.4
Questionnaire

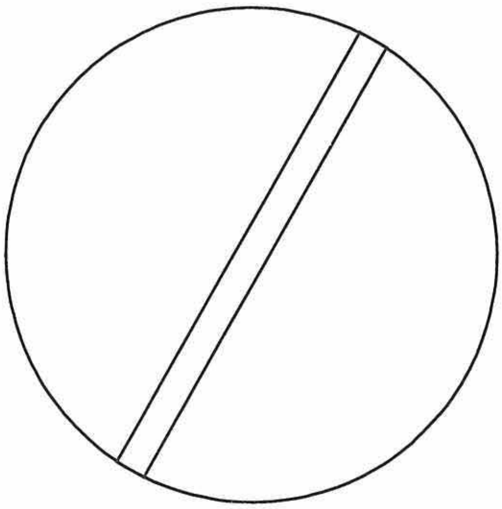
(Condensed to two pages)

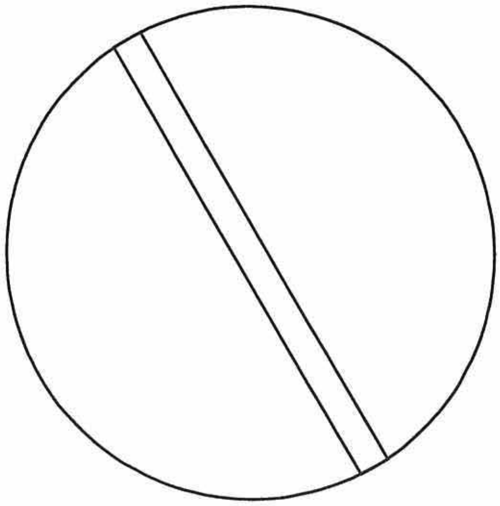
1. What did you notice about the way your hands were moving the cursor across the screen?

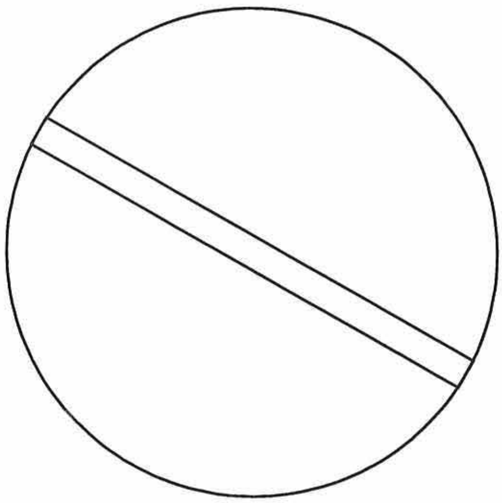
2. Did the task at any time seem to become more difficult?

3. Can you say which hand you think is used most to control the cursor in the following path angles?









4. Have you had recent experience of the game "etch - a - sketch"?

5. Are you left or right handed?

6. What does the left and right button do?

7. How much did you use the rules? (Only applicable to the Delayed Explicit and Explicit groups)

Appendix 1.5
Acquisition Task Raw Data

Subject Number: Male-1 / Female-2: Group (Implicit-1, Delayed Explicit-2, Explicit-3): Trials 1-16

1	1	1	44.7	20.21667	19.7	8.4	19.36667	11.68333	11.25	9.35
			22.98333	15.06667	11.76667	17.05	22.01667	13.5	13.1	12.23333
2	1	2	55.1	32.66667	31.35	23.78333	42.95	30.28333	29.81667	33.55
			37.6	34.55	31.78333	30.23333	20.16667	17.33333	14.66667	12.71667
3	2	3	57.43333	27.63333	20.61667	26.88333	26.55	13.38333	37.95	31.13333
			29.91667	12.95	22.55	9.766666	40.31667	25.25	28.11667	41.3
4	2	1	50.05	33.83333	28.28333	37	34.46667	30.81667	34.06667	25.16667
			47.53333	32.18333	27.51667	33.51667	24.26667	21.96667	16.7	19.1
5	2	2	67.96667	41.91667	39.35	28.78333	55.9	76.31667	40.63334	21.1
			28.85	17.35	25.6	21.73333	23.41667	11.33333	12.31667	13.05
6	1	3	104.15	52.7	29.13333	28.58333	16.48333	33.25	13.4	20.66667
			18.48333	13.78333	15.86667	10.2	13.91667	11.35	13.63333	12.48333
7	1	1	36.53333	34.8	23.06667	21.91667	27.56667	15.71667	15.11667	16.1
			17.28333	16.51667	13	13.98333	15.56667	12.61667	11.16667	9.466666
8	2	2	95.81667	43.21667	23.36667	20.63333	28.13333	22.88333	29.03333	26.63333
			27.15	30.11667	20.28333	21.23333	21.5	28	10.56667	12.2
9	2	3	75.31667	39.35	24.05	25.48333	34.15	34.75	32.8	27.3
			25.78333	19.46667	21.81667	18.3	17.91667	21.36667	19.28333	13.38333
10	2	1	78.3	65.75	35.23333	32.71667	26.76667	23.96667	20.3	24.55
			30.28333	38.16667	30.41667	31.48333	49.43333	35.31667	16.41667	14.76667
11	1	2	23.98333	20.75	20.28333	21.15	23.56667	16.11667	20.45	17.05
			22.88333	17.65	13.45	15.8	12.73333	17.26667	15.18333	15.5
12	1	3	37.96667	29	20.51667	22.7	22.56667	15.31667	14.88333	14.51667
			21.36667	20.86667	20.8	14.75	25.4	12.11667	19.65	11.41667
13	1	1	38.45	27.45	19.13333	19.4	18.78333	16.93333	15.6	13.31667
			22.55	17.25	19.11667	16.03333	15.51667	14.45	13.58333	11.26667
14	2	2	101.8	49.53333	26.61667	57.63334	19	14.15	23.8	22.45
			14.91667	18.55	19.93333	17.96667	22.76667	19.76667	19.25	13.41667
15	1	3	26.95	14.13333	15.43333	10.9	42.05	21.33333	16.46667	26.75
			33.98333	17.96667	16.36667	14.28333	14.56667	9.75	8.783334	6.45
16	1	1	13.43333	8.2	5.85	12.7	14.98333	19.2	10.21667	9.25
			11.45	10.96667	9.2	11.31667	8.733334	7.4	5.483333	7.383333
17	1	3	23.18333	13.13333	10.21667	8.65	15.91667	17.56667	12.35	9.233334
			15.58333	9.616667	6.183333	5.316667	14.83333	10.46667	17.68333	14.53333

18	1	1	22.73333	16.91667	25.46667	14.91667	19.4	13.45	12.26667	10	13.31667	19.61667	21.8	19.48333	15.2	14.21667	10.15	8.233334
19	2	2	51.11666	28.4	28.2	12.68333	23.28333	20.26667	21.16667	20.33333	20.11667	30.93333	33.41667	21.18333	18.13333	15.05	10.85	10.25
20	1	3	45.56667	16.81667	9.566667	7.35	22.31667	17.8	22.15	19.83333	13.48333	12.46667	14.96667	11.46667	18.38333	13.1	12.75	11.81667
21	1	1	121.0833	38.45	23.08333	21.56667	25.78333	27.95	21.81667	16.85	14.75	13.01667	12.91667	12.4	32.5	26.28333	17.4	17.05
22	2	2	20.35	28.1	34.16667	17.56667	28.68333	25.25	24.03333	19.15	26.58333	32.65	23.66667	25.5	24.43333	15.56667	13.66667	14.71667
23	2	3	119.95	49.93333	25.58333	22.75	37.16667	62.41667	33.6	54.91667	32.5	15.93333	17.1	21.75	29.71667	29.9	16.26667	14.76667
24	2	1	32.45	31.41667	33.25	24.76667	33.96667	31.78333	33.41667	26.11667	27.61667	28.45	23.68333	21.05	20.9	19.36667	20.93333	20.21667
25	1	2	85.11667	42.05	43.16667	35.76667	37.26667	25.85	16.9	14.91667	54.51667	25.68333	52.66667	15.15	18.25	19.7	12.45	13.18333
26	1	3	46.78333	34.86666	30.13333	25.46667	27.06667	25.51667	40.63334	28.88333	24.83333	34.21667	24.85	23.4333	26.41667	22.88333	23.86667	19.58333
27	2	1	24.95	13.51667	8.316667	5.516667	27.7	13.55	7.733333	34.13334	38.68333	39.66667	14.91667	16.93333	12.6	9.783334	8.083333	6.85
28	1	2	46.05	42.05	27.93333	31.9	27.26667	28.23333	21.38333	21.73333	26.11667	24.41667	35.33333	24.06667	31.01667	19.73333	22.61667	17.41667
29	1	3	26.8	25.3	12.65	8.916667	18.91667	11.75	11.1	11.51667	21.91667	15.35	16.51667	20.9	22.65	18.3	15.8	11.5
30	1	1	27.33333	20.75	28.73333	20.16667	19.71667	21.91667	12.91667	14.56667	35.28333	21.05	14.53333	15.35	21.01667	22.6	15.65	11.9
31	1	2	79.61667	16.51667	14.58333	22.18333	20.83333	31.13333	13.8	17.11667	23.8	16.68333	21.48333	17.01667	17.68333	25.41667	13.63333	21.46667
32	2	3	45.46667	21.78333	21.13333	29.55	51.48333	27.55	30.45	50.81667	27.16667	28.98333	25.01667	13.11667	14.26667	14.56667	9.85	16.46667
33	2	2	57.6	36.03333	25.46667	33.7	34.4	30.93333	29.36667	28.65	47.86666	32.56667	35.15	35.08333	38.26667	24.06667	25.1	28.9

Appendix 1.6
Retention Task Raw Data

Subject Number: Male-1 / Female-2: Group (Implicit-1, Delayed Explicit-2, Explicit-3): Trials 1-4

1	1	1	14.08333	9.883333	9.783334	7.133333
2	1	2	24.48333	18.26667	13.65	11.56667
3	2	3	20.76667	23.05	14.68333	16.5
4	2	1	31.38333	27.25	23.26667	17.46667
5	2	2	22.16667	17.16667	11.01667	11.25
6	1	3	16.55	16.08333	13.81667	11.85
7	1	1	13.8	12.28333	12.25	10.11667
8	2	2	35.4	17.35	23.16667	18.95
9	2	3	22.28333	28.98333	19.71667	16.66667
10	2	1	22.78333	22.83333	23.28333	19.71667
11	1	2	19.05	17.61667	14.68333	13.36667
12	1	3	17.86667	11.28333	14	13.61667
13	1	1	17.31667	18.26667	14.16667	13.75
14	2	2	34.4	26.96667	25.41667	21.73333
15	1	3	17.73333	14.83333	10.33333	10.26667
16	1	1	9.133333	8.1	7.15	6.283333
17	1	3	5.983333	5.65	4.216667	3.65
18	1	1	20.01667	13.08333	9	7.983333
19	2	2	15.98333	14.28333	11.61667	11.5
20	1	3	12.5	9.583333	11.73333	9.416667
21	1	1	20.33333	19.15	19.86667	20.96667
22	2	2	14.73333	15.38333	14.16667	12.61667
23	2	3	21.33333	15.05	15.28333	17.95
24	2	1	32.78333	32.56667	23.78333	26.21667
25	1	2	23.43333	18.01667	12.53333	22.55
26	1	3	25.66667	23.51667	20.75	22.83333
27	2	1	16.3	16.06667	10.68333	13.05
28	1	2	25.86667	17.65	16.2	15.81667
29	1	3	15.9	12.08333	10.8	9.583333
30	1	1	17.48333	14.7	10.53333	12.68333
31	1	2	22.11667	10.63333	11.41667	22.06667
32	2	3	15.33333	20.11667	11.2	13.65
33	2	2	35.16667	32.93333	28.68333	34.3

Appendix 1.7
Questionnaire Raw Data

Subject Number: Group (Implicit-1, Delayed Explicit-2, Explicit-3): 5 Explicit Responses: Explicit Total

1	1	0	0	0	0	1	1
2	2	1	0	1	0	0	2
3	3	1	1	1	0	1	4
4	1	1	0	1	1	1	4
5	2	0	0	0	0	1	1
6	3	0	0	0	0	1	1
7	1	0	1	0	0	0	1
8	2	1	0	1	0	0	2.5
9	3	1	1	1	1	1	5
10	1	0	0	1	0	0	1
11	2	1	0	0	0	0	1
12	3	1	1	1	1	1	5
13	1	1	0	1	0	0	2
14	3	1	1	0	1	0	3.5
15	1	1	0	1	0	1	3
16	2	0	0	0	0	0	0
17	3	1	1	0	1	1	4
18	1	1	1	1	1	0	4.5
19	2	1	1	0	1	0	3
20	3	0	0	0	0	1	1
21	1	0	0	1	0	0	1
22	2	0	0	0	0	1	1
23	3	0	1	0	1	1	3
24	1	1	0	1	0	0	2.5
25	2	0	0	0	0	0	0
26	3	1	0	1	0	1	3
27	1	0	0	0	0	1	1
28	2	0	1	0	0	1	2
29	3	1	1	1	1	0	4
30	1	1	1	1	0	0	3
31	2	1	1	0	1	0	3
32	3	1	1	1	1	1	5
33	2	0	1	0	1	1	3

Appendix 1.8
SPSS Listing for the Acquisition Data

3(group) by 4(block) by 4(trial) ANOVA with repeated measures on block and trial

General Linear Model

Within-Subjects Factors

Measure: MEASURE_1

BLOCK	TRIAL	Dependent Variable
1	1	A1
	2	A2
	3	A3
	4	A4
2	1	A5
	2	A6
	3	A7
	4	A8
3	1	A9
	2	A10
	3	A11
	4	A12
4	1	A13
	2	A14
	3	A15
	4	A16

Between-Subjects Factors

		Value Label	N
GROUP	1.00		11
	2.00		11
	3.00		11

Multivariate Tests[d]

Effect		Value	F	Hypothesis df	Error df	Sig.	Noncent. Parameter	Observed Power[a]
BLOCK	Pillai's Trace	.709	22.776[b]	3.000	28.000	.000	68.329	1.000
	Wilks' Lambda	.291	22.776[b]	3.000	28.000	.000	68.329	1.000
	Hotelling's Trace	2.440	22.776[b]	3.000	28.000	.000	68.329	1.000
	Roy's Largest Root	2.440	22.776[b]	3.000	28.000	.000	68.329	1.000
BLOCK * GROUP	Pillai's Trace	.374	2.222	6.000	58.000	.054	13.331	.737
	Wilks' Lambda	.650	2.243[b]	6.000	56.000	.052	13.457	.740
	Hotelling's Trace	.502	2.258	6.000	54.000	.051	13.546	.742
	Roy's Largest Root	.413	3.992[c]	3.000	29.000	.017	11.975	.782
TRIAL	Pillai's Trace	.779	32.859[b]	3.000	28.000	.000	98.576	1.000
	Wilks' Lambda	.221	32.859[b]	3.000	28.000	.000	98.576	1.000
	Hotelling's Trace	3.521	32.859[b]	3.000	28.000	.000	98.576	1.000
	Roy's Largest Root	3.521	32.859[b]	3.000	28.000	.000	98.576	1.000
TRIAL * GROUP	Pillai's Trace	.137	.712	6.000	58.000	.642	4.270	.260
	Wilks' Lambda	.867	.691[b]	6.000	56.000	.658	4.147	.252
	Hotelling's Trace	.149	.670	6.000	54.000	.674	4.022	.243
	Roy's Largest Root	.105	1.016[c]	3.000	29.000	.400	3.047	.247
BLOCK * TRIAL	Pillai's Trace	.607	3.771[b]	9.000	22.000	.005	33.939	.951
	Wilks' Lambda	.393	3.771[b]	9.000	22.000	.005	33.939	.951
	Hotelling's Trace	1.543	3.771[b]	9.000	22.000	.005	33.939	.951
	Roy's Largest Root	1.543	3.771[b]	9.000	22.000	.005	33.939	.951
BLOCK * TRIAL * GROUP	Pillai's Trace	.511	.876	18.000	46.000	.608	15.766	.511
	Wilks' Lambda	.552	.845[b]	18.000	44.000	.642	15.201	.487
	Hotelling's Trace	.696	.813	18.000	42.000	.676	14.626	.462
	Roy's Largest Root	.434	1.110[c]	9.000	23.000	.395	9.988	.409

a. Computed using alpha = .05

b. Exact statistic

c. The statistic is an upper bound on F that yields a lower bound on the significance level.

d. Design: Intercept+GROUP
Within Subjects Design: BLOCK+TRIAL+BLOCK*TRIAL

Mauchly's Test of Sphericity[b]

Measure: MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[a]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
BLOCK	.543	17.548	5	.004	.726	.838	.333
TRIAL	.451	22.867	5	.000	.643	.732	.333
BLOCK * TRIAL	.001	185.879	44	.000	.277	.324	.111

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the layers (by default) of the Tests of Within Subjects Effects table.

b. Design: Intercept+GROUP
Within Subjects Design: BLOCK+TRIAL+BLOCK*TRIAL

Tests of Within-Subjects Effects

Measure: MEASURE_1
Sphericity Assumed

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Noncent. Parameter	Observed Power[a]
BLOCK	16076.694	3	5358.898	25.181	.000	75.542	1.000
BLOCK * GROUP	1695.186	6	282.531	1.328	.253	7.965	.496
Error(BLOCK)	19153.636	90	212.818				
TRIAL	13891.138	3	4630.379	63.184	.000	189.551	1.000
TRIAL * GROUP	190.031	6	31.672	.432	.856	2.593	.171
Error(TRIAL)	6595.588	90	73.284				
BLOCK * TRIAL	10265.687	9	1140.632	15.642	.000	140.774	1.000
BLOCK * TRIAL * GROUP	1120.557	18	62.253	.854	.636	15.366	.620
Error(BLOCK*TRIAL)	19689.245	270	72.923				

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure: MEASURE_1
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Noncent. Parameter	Observed Power[a]
Intercept	310558.444	1	310558.444	459.293	.000	459.293	1.000
GROUP	3038.529	2	1519.265	2.247	.123	4.494	.421
Error	20284.972	30	676.166				

a. Computed using alpha = .05

Appendix 1.9
SPSS Listing for planned comparison between trials 8 and 9
3(group) by 4(trial) ANOVA with repeated measures on the trial factor

General Linear Model

Within-Subjects Factors

Measure: MEASURE_1

TRIAL	Dependent Variable
1	A8
2	A9

Between-Subjects Factors

		Value Label	N
GROUP	1.00		11
	2.00		11
	3.00		11

Multivariate Tests[c]

Effect		Value	F	Hypothesis df	Error df	Sig.	Noncent. Parameter	Observed Power[a]
TRIAL	Pillai's Trace	.145	5.089[b]	1.000	30.000	.032	5.089	.588
	Wilks' Lambda	.855	5.089[b]	1.000	30.000	.032	5.089	.588
	Hotelling's Trace	.170	5.089[b]	1.000	30.000	.032	5.089	.588
	Roy's Largest Root	.170	5.089[b]	1.000	30.000	.032	5.089	.588
TRIAL * GROUP	Pillai's Trace	.189	3.499[b]	2.000	30.000	.043	6.997	.608
	Wilks' Lambda	.811	3.499[b]	2.000	30.000	.043	6.997	.608
	Hotelling's Trace	.233	3.499[b]	2.000	30.000	.043	6.997	.608
	Roy's Largest Root	.233	3.499[b]	2.000	30.000	.043	6.997	.608

a. Computed using alpha = .05

b. Exact statistic

c. Design: Intercept+GROUP
Within Subjects Design: TRIAL

Mauchly's Test of Sphericity[b]

Measure: MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[a]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
TRIAL	1.000	.000	0	.	1.000	1.000	1.000

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the layers (by default) of the Tests of Within Subjects Effects table.

b. Design: Intercept+GROUP
Within Subjects Design: TRIAL

Tests of Within-Subjects Effects

Measure: MEASURE_1
Sphericity Assumed

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Noncent. Parameter	Observed Power[a]
TRIAL	294.852	1	294.852	5.089	.032	5.089	.588
TRIAL * GROUP	405.434	2	202.717	3.499	.043	6.997	.608
Error(TRIAL)	1738.216	30	57.941				

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure: MEASURE_1
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Noncent. Parameter	Observed Power[a]
Intercept	39508.774	1	39508.774	256.882	.000	256.882	1.000
GROUP	226.111	2	113.056	.735	.488	1.470	.163
Error	4614.032	30	153.801				

a. Computed using alpha = .05

Appendix 1.10
SPSS Listing for the Retention data
3(group) by 4(trial) ANOVA with repeated measures on trial

General Linear Model

Within-Subjects Factors

Measure: MEASURE_1

TRIAL	Dependent Variable
1	R1
2	R2
3	R3
4	R4

Between-Subjects Factors

		Value Label	N
GROUP	1.00		11
	2.00		11
	3.00		11

Multivariate Tests[d]

Effect		Value	F	Hypothesis df	Error df	Sig.	Noncent. Parameter	Observed Power[a]
TRIAL	Pillai's Trace	.709	22.776[b]	3.000	28.000	.000	68.329	1.000
	Wilks' Lambda	.291	22.776[b]	3.000	28.000	.000	68.329	1.000
	Hotelling's Trace	2.440	22.776[b]	3.000	28.000	.000	68.329	1.000
	Roy's Largest Root	2.440	22.776[b]	3.000	28.000	.000	68.329	1.000
TRIAL * GROUP	Pillai's Trace	.374	2.222	6.000	58.000	.054	13.331	.737
	Wilks' Lambda	.650	2.243[b]	6.000	56.000	.052	13.457	.740
	Hotelling's Trace	.502	2.258	6.000	54.000	.051	13.546	.742
	Roy's Largest Root	.413	3.992[c]	3.000	29.000	.017	11.975	.782

a. Computed using alpha = .05

b. Exact statistic

c. The statistic is an upper bound on F that yields a lower bound on the significance level.

d. Design: Intercept+GROUP
Within Subjects Design: TRIAL

Mauchly's Test of Sphericity[b]

Measure: MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[a] Greenhouse-Geisser	Huynh-Feldt	Lower-bound
TRIAL	.543	17.548	5	.004	.726	.838	.333

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the layers (by default) of the Tests of Within Subjects Effects table.

b. Design: Intercept+GROUP
Within Subjects Design: TRIAL

Tests of Within-Subjects Effects

Measure: MEASURE_1
Sphericity Assumed

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Noncent. Parameter	Observed Power[a]
TRIAL	4019.174	3	1339.725	25.181	.000	75.542	1.000
TRIAL * GROUP	423.796	6	70.633	1.328	.253	7.965	.496
Error(TRIAL)	4788.409	90	53.205				

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure: MEASURE_1
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Noncent. Parameter	Observed Power[a]
Intercept	77639.611	1	77639.611	459.293	.000	459.293	1.000
GROUP	759.632	2	379.816	2.247	.123	4.494	.421
Error	5071.243	30	169.041				

a. Computed using alpha = .05

Appendix 1.11
SPSS Listing for the One-Way ANOVA
Between group questionnaire scores

Oneway

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
SCORE	Between Groups	16.545	2	8.273	4.627	.018
	Within Groups	53.636	30	1.788		
	Total	70.182	32			

Post Hoc Tests

Multiple Comparisons

Dependent Variable: SCORE
Tukey HSD

(I) GP	(J) GP	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1.00	2.00	-9.0909E-02	.570	.986	-1.4965	1.3147
	3.00	-1.5455*	.570	.029	-2.9510	-.1399
2.00	1.00	9.091E-02	.570	.986	-1.3147	1.4965
	3.00	-1.4545*	.570	.041	-2.8601	-4.8970E-02
3.00	1.00	1.5455*	.570	.029	.1399	2.9510
	2.00	1.4545*	.570	.041	4.897E-02	2.8601

*. The mean difference is significant at the .05 level.

Appendix 1.12
SPSS Listing for the correlation
Correlation between the 1st trial on retention and the questionnaire score

Correlations

Descriptive Statistics

	Mean	Std. Deviation	N
R1	32.7803	13.2916	33
SCORE	2.4545	1.4809	33

Correlations

		R1	SCORE
Pearson Correlation	R1	1.000	-.066
	SCORE	-.066	1.000
Sig. (2-tailed)	R1	.	.717
	SCORE	.717	.
N	R1	33	33
	SCORE	33	33

Appendix 1.13
SPSS Listing for the RE-ANALYSED Acquisition Data
3(group) by 4(block) by 4(trial) ANOVA with repeated measures on block and trial

General Linear Model

Within-Subjects Factors

Measure: MEASURE_1

BLOCK	TRIAL	Dependent Variable
1	1	A1
	2	A2
	3	A3
	4	A4
2	1	A5
	2	A6
	3	A7
	4	A8
3	1	A9
	2	A10
	3	A11
	4	A12
4	1	A13
	2	A14
	3	A15
	4	A16

Between-Subjects Factors

		Value Label	N
GROUP	1.00		6
	2.00		11
	3.00		6

Multivariate Tests[d]

Effect		Value	F	Hypothesis df	Error df	Sig.	Noncent. Parameter	Observed Power[a]
BLOCK	Pillai's Trace	.659	11.620[b]	3.000	18.000	.000	34.860	.997
	Wilks' Lambda	.341	11.620[b]	3.000	18.000	.000	34.860	.997
	Hotelling's Trace	1.937	11.620[b]	3.000	18.000	.000	34.860	.997
	Roy's Largest Root	1.937	11.620[b]	3.000	18.000	.000	34.860	.997
BLOCK * GROUP	Pillai's Trace	.387	1.518	6.000	38.000	.199	9.110	.516
	Wilks' Lambda	.627	1.577[b]	6.000	36.000	.182	9.462	.531
	Hotelling's Trace	.573	1.622	6.000	34.000	.171	9.735	.540
	Roy's Largest Root	.531	3.364[c]	3.000	19.000	.040	10.091	.667
TRIAL	Pillai's Trace	.784	21.739[b]	3.000	18.000	.000	65.217	1.000
	Wilks' Lambda	.216	21.739[b]	3.000	18.000	.000	65.217	1.000
	Hotelling's Trace	3.623	21.739[b]	3.000	18.000	.000	65.217	1.000
	Roy's Largest Root	3.623	21.739[b]	3.000	18.000	.000	65.217	1.000
TRIAL * GROUP	Pillai's Trace	.331	1.257	6.000	38.000	.300	7.540	.431
	Wilks' Lambda	.687	1.239[b]	6.000	36.000	.310	7.434	.422
	Hotelling's Trace	.429	1.216	6.000	34.000	.322	7.298	.411
	Roy's Largest Root	.355	2.248[c]	3.000	19.000	.116	6.745	.480
BLOCK * TRIAL	Pillai's Trace	.805	5.489[b]	9.000	12.000	.004	49.404	.970
	Wilks' Lambda	.195	5.489[b]	9.000	12.000	.004	49.404	.970
	Hotelling's Trace	4.117	5.489[b]	9.000	12.000	.004	49.404	.970
	Roy's Largest Root	4.117	5.489[b]	9.000	12.000	.004	49.404	.970
BLOCK * TRIAL * GROUP	Pillai's Trace	.605	.626	18.000	26.000	.847	11.265	.298
	Wilks' Lambda	.485	.580[b]	18.000	24.000	.880	10.448	.267
	Hotelling's Trace	.875	.535	18.000	22.000	.909	9.623	.237
	Roy's Largest Root	.515	.743[c]	9.000	13.000	.666	6.691	.223

a. Computed using alpha = .05

b. Exact statistic

c. The statistic is an upper bound on F that yields a lower bound on the significance level.

d. Design: Intercept+GROUP
Within Subjects Design: BLOCK+TRIAL+BLOCK*TRIAL

Mauchly's Test of Sphericity[b]

Measure: MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[a] Greenhouse-Geisser	Huynh-Feldt	Lower-bound
BLOCK	.625	8.787	5	.118	.775	.970	.333
TRIAL	.553	11.092	5	.050	.716	.885	.333
BLOCK * TRIAL	.000	129.140	44	.000	.313	.406	.111

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the layers (by default) of the Tests of Within Subjects Effects table.

b. Design: Intercept+GROUP
Within Subjects Design: BLOCK+TRIAL+BLOCK*TRIAL

Tests of Within-Subjects Effects

Measure: MEASURE_1
Sphericity Assumed

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Noncent. Parameter	Observed Power[a]
BLOCK	9010.945	3	3003.648	13.224	.000	39.672	1.000
BLOCK * GROUP	1476.073	6	246.012	1.083	.383	6.499	.394
Error(BLOCK)	13628.023	60	227.134				
TRIAL	9500.946	3	3166.982	44.197	.000	132.591	1.000
TRIAL * GROUP	413.558	6	68.926	.962	.459	5.771	.350
Error(TRIAL)	4299.361	60	71.656				
BLOCK * TRIAL	6584.658	9	731.629	9.950	.000	89.548	1.000
BLOCK * TRIAL * GROUP	697.190	18	38.733	.527	.943	9.481	.367
Error(BLOCK*TRIAL)	13235.787	180	73.532				

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure: MEASURE_1
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Noncent. Parameter	Observed Power[a]
Intercept	188341.394	1	188341.394	284.160	.000	284.160	1.000
GROUP	3237.999	2	1619.000	2.443	.112	4.885	.434
Error	13256.004	20	662.800				

a. Computed using alpha = .05

Tukey tests for the block by trial interaction, $T_{qv}(3.65,73.08)$, $p<.05 = 2.32$
(The shaded cells highlight the significant differences)

Calculations for Tukey's test:

$T = q_v \times \sqrt{MsW / N}$

Where q_v = critical value (from tables)

MsW = Mean Squares Within (from SPSS listing)

N = number of scores from which each mean is calculated

Table 21: Mean differences across blocks on Trial 1

		Block 1	Block 2	Block 3	Block 4
		55.20	28.39	26.42	22.81
Block 1	55.20	------	26.81	28.78	32.39
Block 2	28.39		------	1.97	5.58
Block 3	26.42			------	3.61
Block 4	22.81				------

Table 22: Mean differences across blocks on Trial 2

		Block 1	Block 2	Block 3	Block 4
		31.23	24.08	22.69	18.27
Block 1	31.23	------	7.15	8.54	12.96
Block 2	24.08		------	1.39	5.81
Block 3	22.69			------	4.42
Block 4	18.17				------

Table 23: Mean difference across blocks on Trial 3

		Block 1	Block 2	Block 3	Block 4
		23.43	21.58	22.52	15.32
Block 1	23.43	------	1.85	0.91	8.11
Block 2	21.58		------	0.94	6.26
Block 3	22.52			------	7.2
Block 4	15.32				------

Table 24: Mean differences across blocks on Trial 4

		Block 1	Block 2	Block 3	Block 4
		23.08	21.63	18.71	15.18
Block 1	23.08	------	1.45	4.37	7.9
Block 2	21.63		------	2.92	6.45
Block 3	18.71			------	3.53
Block 4	15.18				------

Appendix 1.14
SPSS Listing for RE-ANALYSED planned comparison between trials 8 and 9

3(group) by 4(trial) ANOVA with repeated measures on the trial factor

General Linear Model

Within-Subjects Factors

Measure: MEASURE_1

TRIAL	Dependent Variable
1	A8
2	A9

Between-Subjects Factors

		Value Label	N
GROUP	1.00		6
	2.00		11
	3.00		6

Multivariate Tests[c]

Effect		Value	F	Hypothesis df	Error df	Sig.	Noncent. Parameter	Observed Power[a]
TRIAL	Pillai's Trace	.118	2.665[b]	1.000	20.000	.118	2.665	.343
	Wilks' Lambda	.882	2.665[b]	1.000	20.000	.118	2.665	.343
	Hotelling's Trace	.133	2.665[b]	1.000	20.000	.118	2.665	.343
	Roy's Largest Root	.133	2.665[b]	1.000	20.000	.118	2.665	.343
TRIAL * GROUP	Pillai's Trace	.103	1.151[b]	2.000	20.000	.336	2.302	.224
	Wilks' Lambda	.897	1.151[b]	2.000	20.000	.336	2.302	.224
	Hotelling's Trace	.115	1.151[b]	2.000	20.000	.336	2.302	.224
	Roy's Largest Root	.115	1.151[b]	2.000	20.000	.336	2.302	.224

a. Computed using alpha = .05

b. Exact statistic

c. Design: Intercept+GROUP
Within Subjects Design: TRIAL

Mauchly's Test of Sphericity[b]

Measure: MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[a]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
TRIAL	1.000	.000	0	.	1.000	1.000	1.000

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the layers (by default) of the Tests of Within Subjects Effects table.

b. Design: Intercept+GROUP
Within Subjects Design: TRIAL

Tests of Within-Subjects Effects

Measure: MEASURE_1
Sphericity Assumed

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Noncent. Parameter	Observed Power[a]
TRIAL	161.620	1	161.620	2.665	.118	2.665	.343
TRIAL * GROUP	139.621	2	69.811	1.151	.336	2.302	.224
Error(TRIAL)	1213.064	20	60.653				

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure: MEASURE_1
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Noncent. Parameter	Observed Power[a]
Intercept	23348.582	1	23348.582	161.588	.000	161.588	1.000
GROUP	241.963	2	120.981	.837	.448	1.675	.173
Error	2889.890	20	144.495				

a. Computed using alpha = .05

Appendix 1.15
SPSS Listing for the RE-ANALYSED Retention data
3(group) by 4(trial) ANOVA with repeated measures on trial

General Linear Model

Within-Subjects Factors

Measure: MEASURE_1

TRIAL	Dependent Variable
1	R1
2	R2
3	R3
4	R4

Between-Subjects Factors

		Value Label	N
GROUP	1.00		6
	2.00		11
	3.00		6

Multivariate Tests[d]

Effect		Value	F	Hypothesis df	Error df	Sig.	Noncent. Parameter	Observed Power[a]
TRIAL	Pillai's Trace	.659	11.620[b]	3.000	18.000	.000	34.860	.997
	Wilks' Lambda	.341	11.620[b]	3.000	18.000	.000	34.860	.997
	Hotelling's Trace	1.937	11.620[b]	3.000	18.000	.000	34.860	.997
	Roy's Largest Root	1.937	11.620[b]	3.000	18.000	.000	34.860	.997
TRIAL * GROUP	Pillai's Trace	.387	1.518	6.000	38.000	.199	9.110	.516
	Wilks' Lambda	.627	1.577[b]	6.000	36.000	.182	9.462	.531
	Hotelling's Trace	.573	1.622	6.000	34.000	.171	9.735	.540
	Roy's Largest Root	.531	3.364[c]	3.000	19.000	.040	10.091	.667

a. Computed using alpha = .05

b. Exact statistic

c. The statistic is an upper bound on F that yields a lower bound on the significance level.

d. Design: Intercept+GROUP
Within Subjects Design: TRIAL

Mauchly's Test of Sphericity[b]

Measure: MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[a] Greenhouse-Geisser	Huynh-Feldt	Lower-bound
TRIAL	.625	8.787	5	.118	.775	.970	.333

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the layers (by default) of the Tests of Within Subjects Effects table.

b. Design: Intercept+GROUP
Within Subjects Design: TRIAL

Tests of Within-Subjects Effects

Measure: MEASURE_1
Sphericity Assumed

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Noncent. Parameter	Observed Power[a]
TRIAL	2252.736	3	750.912	13.224	.000	39.672	1.000
TRIAL * GROUP	369.018	6	61.503	1.083	.383	6.499	.394
Error(TRIAL)	3407.006	60	56.783				

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure: MEASURE_1
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Noncent. Parameter	Observed Power[a]
Intercept	47085.348	1	47085.348	284.160	.000	284.160	1.000
GROUP	809.500	2	404.750	2.443	.112	4.885	.434
Error	3314.001	20	165.700				

a. Computed using alpha = .05

Appendix 1.16
SPSS Listing for the RE-ANALYSED One-Way ANOVA
Between group questionnaire scores

Oneway

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
SCORE	Between Groups	42.884	2	21.442	28.911	.000
	Within Groups	14.833	20	.742		
	Total	57.717	22			

Post Hoc Tests

Multiple Comparisons

Dependent Variable: SCORE
Tukey HSD

(I) GP	(J) GP	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1.00	2.00	-1.1667*	.437	.038	-2.2725	-6.09E-02
	3.00	-3.6667*	.497	.000	-4.9246	-2.4087
2.00	1.00	1.1667*	.437	.038	6.087E-02	2.2725
	3.00	-2.5000*	.437	.000	-3.6058	-1.3942
3.00	1.00	3.6667*	.497	.000	2.4087	4.9246
	2.00	2.5000*	.437	.000	1.3942	3.6058

*. The mean difference is significant at the .05 level.

Appendix 1.17
SPSS Listing for the RE-ANALYSED correlation

Correlation between the 1st trial on retention and the questionnaire score

Correlations

Descriptive Statistics

	Mean	Std. Deviation	N
R1	33.2364	13.4996	23
SCORE	2.3478	1.6197	23

Correlations

		R1	SCORE
Pearson Correlation	R1	1.000	-.025
	SCORE	-.025	1.000
Sig. (2-tailed)	R1	.	.911
	SCORE	.911	.
N	R1	23	23
	SCORE	23	23

Appendix 2.1
Consent Form

Thank you for agreeing to take part in this experiment, investigating learning with a Pursuit Rotor Task. The whole session should take no longer than an hour.

The experiment is in three parts:
The first part will take approximately 30 minutes and will involve 16 trials on the pursuit rotor task (to be explained later)
This will then be followed by a 12 minute rest.
The final part will take about 15 minutes and will involve further 8 trials on the pursuit rotor task (again to be explained later).

The results will be treated in the strictest of confidence. You are free to end your participation in the experiment at any time without providing an explanation.

After you have completed the experiment there will be a short debriefing (if requested) when the experiment will be explained.

I understand that I have agreed to participate in all parts of this experiment and may cease participation at any time I wish.

Signed ____________________________

Name (printed please) ____________________________

Date ____________________________

Department ____________________________

Appendix 2.2
Subject Instructions - Acquisition

In front of you, you will see the pursuit rotor task. Please hold the light sensor in your dominant hand and do not during any trial swap hands.

There will be three trials as a warm up then you will be presented with 16 trials of the pursuit rotor task each lasting 1 minute. During each trial you should attempt to stay on the target for as long as possible. In between each trial there will be 1 minutes rest. At the end of the 16 trials there will be 12 minutes rest and then the retention test will begin.

Implicit group
No further instructions

Delayed Explicit Group
It will aid your performance if you now mentally consider the pursuit rotor as an album on a record player. Please imagine the different size circles as different songs on the album and imagine the songs played at the speed you see the see the target rotating.

Explicit group
It will aid your performance if you now mentally consider the pursuit rotor as an album on a record player. Please imagine the different size circles as different songs on the album and imagine the songs played at the speed you see the see the target rotating.

At all times during each trial you should attempt to stay on the target for as long as possible.

Subject Instructions - Retention

Please perform the task as you did in the period before. The goal is identical to that in the first period, i.e. you should attempt to stay on the target for as long as possible during each trial.

However this time you will only have 8 trials. At the end of each trial there will be a 1 minute rest and I will ask you if you a short question about the trial.

At the end of this second period I will inform you about the experiment and what it is hoping to find.

Question at the end of each trial:
Did you have that stimulus in the acquisition phase?

Appendix 2.3
Acquisition and Retention Raw Data

Sbj - No: Group: Age: Male / Female: Left / Right: Acquisition Trials 1-16: Retention Trials 1-8 with Explicit Knowledge Score after each trial (Yes-1, No-0): Explicit Knowledge Score Total

1	1	25	F	R	31	39	11	11	34	38	11	15	32	31	17	14	33	37	15	13	
					24	0	37	1	29	1	23	0	15	1	26	1	39	0	38	1	5
2	1	27	F	R	23	3	1	17	35	7	1	29	46	7	2	37	43	8	3	37	
					3	1	46	0	5	1	41	0	39	0	18	0	17	1	24	0	3
3	2	27	M	R	38	13	18	16	37	20	18	24	37	11	17	22	42	16	19	26	
					22	1	42	1	13	1	32	1	27	1	25	0	20	0	40	0	5
4	2	50	F	R	21	29	22	7	26	33	24	21	23	32	29	16	19	33	24	15	
					26	1	26	1	37	1	14	0	17	1	8	1	34	0	34	1	6
5	3	26	F	R	7	7	4	28	20	13	6	24	19	17	11	28	21	17	12	34	
					10	1	29	1	38	0	5	1	19	1	31	0	20	1	18	0	5
6	3	29	M	R	17	7	31	24	13	6	23	25	16	6	19	22	14	9	26	26	
					22	1	18	1	14	0	19	1	19	1	15	0	12	1	31	1	6
7	3	38	F	R	36	38	13	8	36	47	16	9	36	39	16	13	38	44	24	10	
					26	1	39	1	28	1	18	1	17	1	18	1	58	1	34	1	8
8	1	50	F	R	6	21	2	18	14	34	7	27	12	38	6	29	13	45	9	31	
					15	0	37	1	47	0	24	1	21	1	23	1	45	1	16	0	5
9	2	23	F	R	5	4	22	11	8	6	35	20	14	13	38	25	20	15	42	29	
					47	0	30	1	14	1	37	1	27	1	24	0	11	1	34	1	6
10	1	30	F	R	12	25	23	27	28	35	34	26	24	38	33	30	29	41	35	29	
					39	0	27	1	51	1	19	1	31	1	12	1	41	0	41	1	6
11	2	23	M	R	29	23	5	9	33	19	16	22	38	31	14	22	39	30	18	27	
					17	0	41	0	47	0	12	1	21	1	37	0	30	1	22	0	3
12	3	24	F	R	23	4	18	25	37	8	21	30	37	11	24	33	36	11	23	30	
					26	1	35	0	20	1	23	1	34	1	39	1	15	1	24	1	7
13	1	21	F	R	7	24	33	8	14	29	37	10	15	34	42	9	15	33	39	12	
					44	0	18	1	27	0	22	0	12	1	23	0	38	0	31	1	3
14	2	24	F	R	12	13	5	21	11	10	3	22	11	12	6	20	16	10	3	31	
					4	1	10	0	11	1	13	0	14	1	9	1	13	1	7	0	5
15	3	29	M	R	3	38	13	26	11	48	19	31	14	44	22	30	18	46	27	32	
					23	1	28	0	40	1	30	1	17	1	42	0	47	0	13	0	4
16	1	24	M	R	14	16	9	10	22	17	11	18	28	18	13	19	31	22	20	16	
					18	1	17	1	17	1	43	1	32	0	12	1	25	1	36	1	7
17	2	37	M	R	11	19	40	18	11	26	44	29	19	26	41	29	11	30	41	20	
					42	1	12	1	43	0	8	1	20	1	25	1	25	1	35	1	7

18	3	21	F	R	16	3	14	27	25	6	11	27	24	5	12	35	24	5	12	31	
					15	0	25	1	10	0	14	1	19	1	10	0	3	1	25	1	5
19	1	31	M	L	3	34	7	29	8	32	13	35	11	36	15	36	12	34	15	34	
					15	1	38	1	24	1	22	1	13	0	27	1	46	1	20	0	6
20	2	20	F	R	6	34	20	31	13	42	25	34	17	43	29	31	12	38	21	31	
					26	1	33	0	31	1	30	0	10	1	40	0	45	0	20	0	3
21	3	20	F	R	17	13	35	11	15	17	35	13	21	20	43	15	26	21	41	17	
					43	1	25	1	15	1	41	0	30	0	24	0	24	1	36	1	5
22	1	29	M	R	18	21	32	35	31	28	32	36	32	36	32	32	34	29	39	41	
					47	0	42	1	26	0	48	0	40	1	27	1	38	0	51	0	3
23	2	31	M	R	18	9	35	22	30	16	35	22	23	12	43	30	28	15	46	31	
					41	1	29	1	10	0	40	0	29	0	24	1	17	0	47	1	4
24	3	28	M	R	4	31	25	36	12	37	30	47	16	38	35	42	23	39	36	43	
					43	1	47	1	41	1	29	1	24	1	48	1	40	1	30	0	7
25	1	22	F	R	12	24	25	6	20	27	24	8	24	33	27	10	27	38	33	11	
					33	0	32	0	26	0	22	1	13	1	43	0	41	0	11	1	3
26	2	25	F	R	13	15	9	12	26	28	16	15	10	30	26	11	29	33	20	17	
					23	0	19	1	26	0	16	1	16	1	34	0	33	0	10	1	4
27	1	22	M	R	10	28	15	21	17	29	16	25	23	30	18	23	24	34	24	29	
					25	1	27	1	37	1	13	0	23	1	37	1	33	1	13	1	7
28	3	28	M	R	31	1	20	12	34	12	21	16	42	17	24	21	45	10	26	20	
					26	1	24	1	20	1	30	0	46	1	7	1	16	1	41	0	6
29	2	20	F	R	22	3	18	12	35	6	20	14	37	1	20	17	32	3	33	13	
					29	1	14	1	22	0	13	0	41	0	14	0	10	0	34	0	2
30	3	19	F	R	22	0	17	4	24	3	28	8	34	4	31	4	34	5	14	8	
					36	0	4	1	21	1	16	1	24	0	15	0	4	0	22	0	3
31	1	21	M	R	17	8	13	6	13	5	10	4	17	11	11	4	18	8	17	6	
					24	1	7	1	17	1	28	1	20	1	10	0	15	0	16	1	6
32	1	19	F	R	35	18	29	14	46	32	31	17	40	27	31	17	41	25	30	15	
					31	1	15	1	25	0	43	0	33	0	12	1	26	1	35	1	5
33	2	23	M	R	4	8	7	6	7	14	8	8	6	17	6	14	7	18	6	10	
					5	0	8	1	21	0	7	1	9	0	23	1	12	0	4	1	4
34	3	26	F	R	16	13	17	37	16	16	19	38	16	12	21	42	20	14	23	34	
					31	1	19	1	24	1	29	1	44	1	42	0	15	0	9	1	6
35	2	57	M	L	8	8	19	29	15	6	13	19	18	7	16	35	18	6	14	26	
					16	1	14	0	15	0	16	0	21	1	23	1	5	0	12	0	3
36	3	47	M	R	28	2	39	3	17	5	22	11	32	4	35	11	33	10	36	16	
					45	0	17	1	23	0	28	1	41	0	24	1	9	1	34	0	4

Appendix 2.4
SPSS Listing for the Acquisition Data

3(group) by 4(block) by 4(trial) ANOVA with repeated measures on block and trial

General Linear Model

Within-Subjects Factors

Measure: MEASURE_1

BLOCK	TRIAL	Dependent Variable
1	1	A1
	2	A2
	3	A3
	4	A4
2	1	A5
	2	A6
	3	A7
	4	A8
3	1	A9
	2	A10
	3	A11
	4	A12
4	1	A13
	2	A14
	3	A15
	4	A16

Between-Subjects Factors

		Value Label	N
GROUP	1.00		12
	2.00		12
	3.00		12

Multivariate Tests[d]

Effect		Value	F	Hypothesis df	Error df	Sig.	Noncent. Parameter	Observed Power[a]
BLOCK	Pillai's Trace	.750	31.050[b]	3.000	31.000	.000	93.149	1.000
	Wilks' Lambda	.250	31.050[b]	3.000	31.000	.000	93.149	1.000
	Hotelling's Trace	3.005	31.050[b]	3.000	31.000	.000	93.149	1.000
	Roy's Largest Root	3.005	31.050[b]	3.000	31.000	.000	93.149	1.000
BLOCK * GROUP	Pillai's Trace	.080	.442	6.000	64.000	.848	2.654	.170
	Wilks' Lambda	.922	.429[b]	6.000	62.000	.857	2.575	.165
	Hotelling's Trace	.083	.416	6.000	60.000	.866	2.496	.161
	Roy's Largest Root	.053	.563[c]	3.000	32.000	.643	1.689	.153
TRIAL	Pillai's Trace	.008	.079[b]	3.000	31.000	.971	.237	.063
	Wilks' Lambda	.992	.079[b]	3.000	31.000	.971	.237	.063
	Hotelling's Trace	.008	.079[b]	3.000	31.000	.971	.237	.063
	Roy's Largest Root	.008	.079[b]	3.000	31.000	.971	.237	.063
TRIAL * GROUP	Pillai's Trace	.168	.977	6.000	64.000	.448	5.862	.358
	Wilks' Lambda	.834	.984[b]	6.000	62.000	.444	5.904	.359
	Hotelling's Trace	.198	.989	6.000	60.000	.441	5.933	.360
	Roy's Largest Root	.188	2.009[c]	3.000	32.000	.132	6.028	.468
BLOCK * TRIAL	Pillai's Trace	.501	2.785[b]	9.000	25.000	.021	25.064	.870
	Wilks' Lambda	.499	2.785[b]	9.000	25.000	.021	25.064	.870
	Hotelling's Trace	1.003	2.785[b]	9.000	25.000	.021	25.064	.870
	Roy's Largest Root	1.003	2.785[b]	9.000	25.000	.021	25.064	.870
BLOCK * TRIAL * GROUP	Pillai's Trace	.505	.975	18.000	52.000	.501	17.551	.585
	Wilks' Lambda	.558	.942[b]	18.000	50.000	.536	16.960	.561
	Hotelling's Trace	.682	.909	18.000	48.000	.572	16.363	.536
	Roy's Largest Root	.408	1.179[c]	9.000	26.000	.349	10.608	.449

a. Computed using alpha = .05

b. Exact statistic

c. The statistic is an upper bound on F that yields a lower bound on the significance level.

d. Design: Intercept+GROUP
Within Subjects Design: BLOCK+TRIAL+BLOCK*TRIAL

Mauchly's Test of Sphericity[b]

Measure: MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[a] Greenhouse-Geisser	Huynh-Feldt	Lower-bound
BLOCK	.605	15.926	5	.007	.759	.868	.333
TRIAL	.924	2.495	5	.777	.949	1.000	.333
BLOCK * TRIAL	.206	47.124	44	.356	.752	1.000	.111

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the layers (by default) of the Tests of Within Subjects Effects table.

b. Design: Intercept+GROUP
Within Subjects Design: BLOCK+TRIAL+BLOCK*TRIAL

Tests of Within-Subjects Effects

Measure: MEASURE_1
Sphericity Assumed

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Noncent. Parameter	Observed Power[a]
BLOCK	3824.519	3	1274.840	57.581	.000	172.744	1.000
BLOCK * GROUP	64.080	6	10.680	.482	.820	2.894	.188
Error(BLOCK)	2191.839	99	22.140				
TRIAL	143.602	3	47.867	.103	.958	.310	.068
TRIAL * GROUP	2679.913	6	446.652	.964	.454	5.786	.365
Error(TRIAL)	45857.422	99	463.206				
BLOCK * TRIAL	219.141	9	24.349	2.283	.017	20.545	.902
BLOCK * TRIAL * GROUP	158.198	18	8.789	.824	.672	14.831	.602
Error(BLOCK*TRIAL)	3167.974	297	10.667				

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure: MEASURE_1
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Noncent. Parameter	Observed Power[a]
Intercept	264410.210	1	264410.210	582.058	.000	582.058	1.000
GROUP	443.253	2	221.627	.488	.618	.976	.123
Error	14990.849	33	454.268				

a. Computed using alpha = .05

Appendix 2.5
SPSS Listing for planned comparison between trials 8 and 9
3(group) by 4(trial) ANOVA with repeated measures on the trial factor

General Linear Model

Within-Subjects Factors

Measure: MEASURE_1

TRIAL	Dependent Variable
1	A8
2	A9

Between-Subjects Factors

		Value Label	N
GROUP	1.00		12
	2.00		12
	3.00		12

Multivariate Tests[c]

Effect		Value	F	Hypothesis df	Error df	Sig.	Noncent. Parameter	Observed Power[a]
TRIAL	Pillai's Trace	.024	.808[b]	1.000	33.000	.375	.808	.141
	Wilks' Lambda	.976	.808[b]	1.000	33.000	.375	.808	.141
	Hotelling's Trace	.024	.808[b]	1.000	33.000	.375	.808	.141
	Roy's Largest Root	.024	.808[b]	1.000	33.000	.375	.808	.141
TRIAL * GROUP	Pillai's Trace	.013	.218[b]	2.000	33.000	.805	.437	.081
	Wilks' Lambda	.987	.218[b]	2.000	33.000	.805	.437	.081
	Hotelling's Trace	.013	.218[b]	2.000	33.000	.805	.437	.081
	Roy's Largest Root	.013	.218[b]	2.000	33.000	.805	.437	.081

a. Computed using alpha = .05

b. Exact statistic

c. Design: Intercept+GROUP
Within Subjects Design: TRIAL

Mauchly's Test of Sphericity[b]

Measure: MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[a]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
TRIAL	1.000	.000	0	.	1.000	1.000	1.000

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the layers (by default) of the Tests of Within Subjects Effects table.

b. Design: Intercept+GROUP
Within Subjects Design: TRIAL

Tests of Within-Subjects Effects

Measure: MEASURE_1
Sphericity Assumed

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Noncent. Parameter	Observed Power[a]
TRIAL	100.347	1	100.347	.808	.375	.808	.141
TRIAL * GROUP	54.194	2	27.097	.218	.805	.437	.081
Error(TRIAL)	4095.958	33	124.120				

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure: MEASURE_1
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Noncent. Parameter	Observed Power[a]
Intercept	37492.347	1	37492.347	413.225	.000	413.225	1.000
GROUP	146.028	2	73.014	.805	.456	1.609	.176
Error	2994.125	33	90.731				

a. Computed using alpha = .05

Appendix 2.6
SPSS Listing for the Retention data

3(group) by 2(old/new) by 4(trial) ANOVA with repeated measures on old/new and trial

General Linear Model

Within-Subjects Factors

Measure: MEASURE_1

OLDNEW	TRIAL	Dependent Variable
1	1	R1_O
	2	R2_O
	3	R5_O
	4	R7_O
2	1	R3_N
	2	R4_N
	3	R6_N
	4	R8_N

Between-Subjects Factors

		Value Label	N
GROUP	1.00		12
	2.00		12
	3.00		12

Multivariate Tests[d]

Effect		Value	F	Hypothesis df	Error df	Sig.	Noncent. Parameter	Observed Power[a]
OLDNEW	Pillai's Trace	.045	1.560[b]	1.000	33.000	.220	1.560	.228
	Wilks' Lambda	.955	1.560[b]	1.000	33.000	.220	1.560	.228
	Hotelling's Trace	.047	1.560[b]	1.000	33.000	.220	1.560	.228
	Roy's Largest Root	.047	1.560[b]	1.000	33.000	.220	1.560	.228
OLDNEW * GROUP	Pillai's Trace	.092	1.679[b]	2.000	33.000	.202	3.357	.328
	Wilks' Lambda	.908	1.679[b]	2.000	33.000	.202	3.357	.328
	Hotelling's Trace	.102	1.679[b]	2.000	33.000	.202	3.357	.328
	Roy's Largest Root	.102	1.679[b]	2.000	33.000	.202	3.357	.328
TRIAL	Pillai's Trace	.046	.495[b]	3.000	31.000	.688	1.486	.139
	Wilks' Lambda	.954	.495[b]	3.000	31.000	.688	1.486	.139
	Hotelling's Trace	.048	.495[b]	3.000	31.000	.688	1.486	.139
	Roy's Largest Root	.048	.495[b]	3.000	31.000	.688	1.486	.139
TRIAL * GROUP	Pillai's Trace	.184	1.078	6.000	64.000	.385	6.468	.395
	Wilks' Lambda	.818	1.095[b]	6.000	62.000	.376	6.568	.399
	Hotelling's Trace	.222	1.108	6.000	60.000	.368	6.649	.403
	Roy's Largest Root	.215	2.292[c]	3.000	32.000	.097	6.876	.525
OLDNEW * TRIAL	Pillai's Trace	.036	.385[b]	3.000	31.000	.765	1.155	.117
	Wilks' Lambda	.964	.385[b]	3.000	31.000	.765	1.155	.117
	Hotelling's Trace	.037	.385[b]	3.000	31.000	.765	1.155	.117
	Roy's Largest Root	.037	.385[b]	3.000	31.000	.765	1.155	.117
OLDNEW * TRIAL * GROUP	Pillai's Trace	.195	1.155	6.000	64.000	.342	6.928	.422
	Wilks' Lambda	.806	1.177[b]	6.000	62.000	.330	7.060	.429
	Hotelling's Trace	.239	1.195	6.000	60.000	.321	7.172	.434
	Roy's Largest Root	.232	2.474[c]	3.000	32.000	.079	7.421	.560

a. Computed using alpha = .05

b. Exact statistic

c. The statistic is an upper bound on F that yields a lower bound on the significance level.

d. Design: Intercept+GROUP
Within Subjects Design: OLDNEW+TRIAL+OLDNEW*TRIAL

Mauchly's Test of Sphericity[b]

Measure: MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[a] Greenhouse-Geisser	Huynh-Feldt	Lower-bound
OLDNEW	1.000	.000	0	.	1.000	1.000	1.000
TRIAL	.285	39.784	5	.000	.711	.808	.333
OLDNEW * TRIAL	.360	32.383	5	.000	.602	.673	.333

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the layers (by default) of the Tests of Within Subjects Effects table.

b. Design: Intercept+GROUP
Within Subjects Design: OLDNEW+TRIAL+OLDNEW*TRIAL

Tests of Within-Subjects Effects

Measure: MEASURE_1
Sphericity Assumed

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Noncent. Parameter	Observed Power[a]
OLDNEW	28.753	1	28.753	1.560	.220	1.560	.228
OLDNEW * GROUP	61.882	2	30.941	1.679	.202	3.357	.328
Error(OLDNEW)	608.240	33	18.432				
TRIAL	155.205	3	51.735	.524	.667	1.571	.154
TRIAL * GROUP	792.785	6	132.131	1.338	.248	8.025	.502
Error(TRIAL)	9779.635	99	98.784				
OLDNEW * TRIAL	67.122	3	22.374	.132	.941	.396	.073
OLDNEW * TRIAL * GROUP	566.535	6	94.422	.557	.764	3.340	.214
Error(OLDNEW*TRIAL)	16790.969	99	169.606				

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure: MEASURE_1
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Noncent. Parameter	Observed Power[a]
Intercept	184781.337	1	184781.337	586.011	.000	586.011	1.000
GROUP	1030.965	2	515.483	1.635	.210	3.270	.320
Error	10405.573	33	315.320				

a. Computed using alpha = .05

Appendix 2.7
SPSS Listing for the One-Way ANOVA
Between group explicit knowledge scores

Oneway

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Exp-Tot	Between Groups	8.167	2	4.083	1.807	.180
	Within Groups	74.583	33	2.260		
	Total	82.750	35			

Post Hoc Tests

Multiple Comparisons

Dependent Variable: Exp-Tot
Tukey HSD

(I) GROUP	(J) GROUP	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1.00	2.00	.5833	.614	.613	-.9227	2.0893
	3.00	-.5833	.614	.613	-2.0893	.9227
2.00	1.00	-.5833	.614	.613	-2.0893	.9227
	3.00	-1.1667	.614	.154	-2.6727	.3393
3.00	1.00	.5833	.614	.613	-.9227	2.0893
	2.00	1.1667	.614	.154	-.3393	2.6727

Appendix 2.8
SPSS Listing for the correlation
Correlation between the 1st trial on retention and the explicit knowledge score

Correlations

Descriptive Statistics

	Mean	Std. Deviation	N
R1_O	26.7222	12.3765	36
Exp-Tot	4.9167	1.5376	36

Correlations

		R1_O	Exp-Tot
Pearson Correlation	R1_O	1.000	.042
	Exp-Tot	.042	1.000
Sig. (2-tailed)	R1_O	.	.807
	Exp-Tot	.807	.
N	R1_O	36	36
	Exp-Tot	36	36

Appendix 2.9
SPSS Listing for the RE-ANALYSED Acquisition Data
3(group) by 4(block) by 4(trial) ANOVA with repeated measures on block and trial

General Linear Model

Within-Subjects Factors

Measure: MEASURE_1

BLOCK	TRIAL	Dependent Variable
1	1	A1
	2	A2
	3	A3
	4	A4
2	1	A5
	2	A6
	3	A7
	4	A8
3	1	A9
	2	A10
	3	A11
	4	A12
4	1	A13
	2	A14
	3	A15
	4	A16

Between-Subjects Factors

		Value Label	N
GROUP	1.00		7
	2.00		12
	3.00		6

Multivariate Tests[d]

Effect		Value	F	Hypothesis df	Error df	Sig.	Noncent. Parameter	Observed Power[a]
BLOCK	Pillai's Trace	.705	15.920[b]	3.000	20.000	.000	47.760	1.000
	Wilks' Lambda	.295	15.920[b]	3.000	20.000	.000	47.760	1.000
	Hotelling's Trace	2.388	15.920[b]	3.000	20.000	.000	47.760	1.000
	Roy's Largest Root	2.388	15.920[b]	3.000	20.000	.000	47.760	1.000
BLOCK * GROUP	Pillai's Trace	.059	.212	6.000	42.000	.971	1.273	.099
	Wilks' Lambda	.942	.204[b]	6.000	40.000	.974	1.224	.096
	Hotelling's Trace	.062	.196	6.000	38.000	.976	1.174	.094
	Roy's Largest Root	.055	.388[c]	3.000	21.000	.763	1.165	.114
TRIAL	Pillai's Trace	.018	.124[b]	3.000	20.000	.945	.372	.069
	Wilks' Lambda	.982	.124[b]	3.000	20.000	.945	.372	.069
	Hotelling's Trace	.019	.124[b]	3.000	20.000	.945	.372	.069
	Roy's Largest Root	.019	.124[b]	3.000	20.000	.945	.372	.069
TRIAL * GROUP	Pillai's Trace	.156	.592	6.000	42.000	.735	3.551	.211
	Wilks' Lambda	.847	.576[b]	6.000	40.000	.747	3.455	.204
	Hotelling's Trace	.176	.559	6.000	38.000	.760	3.351	.197
	Roy's Largest Root	.151	1.058[c]	3.000	21.000	.388	3.175	.245
BLOCK * TRIAL	Pillai's Trace	.585	2.192[b]	9.000	14.000	.091	19.728	.649
	Wilks' Lambda	.415	2.192[b]	9.000	14.000	.091	19.728	.649
	Hotelling's Trace	1.409	2.192[b]	9.000	14.000	.091	19.728	.649
	Roy's Largest Root	1.409	2.192[b]	9.000	14.000	.091	19.728	.649
BLOCK * TRIAL * GROUP	Pillai's Trace	.657	.816	18.000	30.000	.669	14.687	.418
	Wilks' Lambda	.445	.777[b]	18.000	28.000	.708	13.979	.387
	Hotelling's Trace	1.018	.735	18.000	26.000	.748	13.233	.354
	Roy's Largest Root	.680	1.134[c]	9.000	15.000	.399	10.202	.359

a. Computed using alpha = .05

b. Exact statistic

c. The statistic is an upper bound on F that yields a lower bound on the significance level.

d. Design: Intercept+GROUP
Within Subjects Design: BLOCK+TRIAL+BLOCK*TRIAL

Mauchly's Test of Sphericity[b]

Measure: MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[a] Greenhouse-Geisser	Huynh-Feldt	Lower-bound
BLOCK	.538	12.854	5	.025	.697	.842	.333
TRIAL	.951	1.037	5	.960	.968	1.000	.333
BLOCK * TRIAL	.083	46.714	44	.386	.693	1.000	.111

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the layers (by default) of the Tests of Within Subjects Effects table.

b. Design: Intercept+GROUP
Within Subjects Design: BLOCK+TRIAL+BLOCK*TRIAL

Tests of Within-Subjects Effects

Measure: MEASURE_1
Sphericity Assumed

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Noncent. Parameter	Observed Power[a]
BLOCK	2374.187	3	791.396	31.963	.000	95.890	1.000
BLOCK * GROUP	49.840	6	8.307	.335	.916	2.013	.137
Error(BLOCK)	1634.125	66	24.759				
TRIAL	251.973	3	83.991	.168	.918	.503	.079
TRIAL * GROUP	1913.729	6	318.955	.637	.700	3.820	.236
Error(TRIAL)	33065.036	66	500.985				
BLOCK * TRIAL	153.045	9	17.005	1.501	.150	13.505	.702
BLOCK * TRIAL * GROUP	139.777	18	7.765	.685	.824	12.334	.490
Error(BLOCK*TRIAL)	2243.798	198	11.332				

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure: MEASURE_1
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Noncent. Parameter	Observed Power[a]
Intercept	186891.458	1	186891.458	450.844	.000	450.844	1.000
GROUP	1198.531	2	599.266	1.446	.257	2.891	.276
Error	9119.804	22	414.537				

a. Computed using alpha = .05

Appendix 2.10
SPSS Listing for RE-ANALYSED planned comparison between trials 8 and 9

3(group) by 4(trial) ANOVA with repeated measures on the trial factor

General Linear Model

Within-Subjects Factors

Measure: MEASURE_1

TRIAL	Dependent Variable
1	A8
2	A9

Between-Subjects Factors

		Value Label	N
GROUP	1.00		7
	2.00		12
	3.00		6

Multivariate Tests[c]

Effect		Value	F	Hypothesis df	Error df	Sig.	Noncent. Parameter	Observed Power[a]
TRIAL	Pillai's Trace	.030	.691[b]	1.000	22.000	.415	.691	.125
	Wilks' Lambda	.970	.691[b]	1.000	22.000	.415	.691	.125
	Hotelling's Trace	.031	.691[b]	1.000	22.000	.415	.691	.125
	Roy's Largest Root	.031	.691[b]	1.000	22.000	.415	.691	.125
TRIAL * GROUP	Pillai's Trace	.059	.691[b]	2.000	22.000	.512	1.382	.151
	Wilks' Lambda	.941	.691[b]	2.000	22.000	.512	1.382	.151
	Hotelling's Trace	.063	.691[b]	2.000	22.000	.512	1.382	.151
	Roy's Largest Root	.063	.691[b]	2.000	22.000	.512	1.382	.151

a. Computed using alpha = .05

b. Exact statistic

c. Design: Intercept+GROUP
Within Subjects Design: TRIAL

Mauchly's Test of Sphericity[b]

Measure: MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[a] Greenhouse-Geisser	Huynh-Feldt	Lower-bound
TRIAL	1.000	.000	0	.	1.000	1.000	1.000

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variab proportional to an identity matrix.

a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the layers (by default) of the Tests of Within Subjects Effects table.

b. Design: Intercept+GROUP
Within Subjects Design: TRIAL

Tests of Within-Subjects Effects

Measure: MEASURE_1
Sphericity Assumed

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Noncent. Parameter	Observed Power[a]
TRIAL	88.637	1	88.637	.691	.415	.691	.125
TRIAL * GROUP	177.351	2	88.676	.691	.512	1.382	.151
Error(TRIAL)	2822.649	22	128.302				

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure: MEASURE_1
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Noncent. Parameter	Observed Power[a]
Intercept	26974.827	1	26974.827	251.340	.000	251.340	1.000
GROUP	345.355	2	172.677	1.609	.223	3.218	.303
Error	2361.125	22	107.324				

a. Computed using alpha = .05

Appendix 2.11
SPSS Listing for the RE-ANALYSED Retention data

3(group) by 2(old/new) by 4(trial) ANOVA with repeated measures on old/new and trial

General Linear Model

Within-Subjects Factors

Measure: MEASURE_1

OLDNEW	TRIAL	Dependent Variable
1	1	R1_O
	2	R2_O
	3	R5_O
	4	R7_O
2	1	R3_N
	2	R4_N
	3	R6_N
	4	R8_N

Between-Subjects Factors

		Value Label	N
GROUP	1.00		7
	2.00		12
	3.00		6

Multivariate Tests[d]

Effect		Value	F	Hypothesis df	Error df	Sig.	Noncent. Parameter	Observed Power[a]
OLDNEW	Pillai's Trace	.171	4.534[b]	1.000	22.000	.045	4.534	.530
	Wilks' Lambda	.829	4.534[b]	1.000	22.000	.045	4.534	.530
	Hotelling's Trace	.206	4.534[b]	1.000	22.000	.045	4.534	.530
	Roy's Largest Root	.206	4.534[b]	1.000	22.000	.045	4.534	.530
OLDNEW * GROUP	Pillai's Trace	.217	3.042[b]	2.000	22.000	.068	6.085	.529
	Wilks' Lambda	.783	3.042[b]	2.000	22.000	.068	6.085	.529
	Hotelling's Trace	.277	3.042[b]	2.000	22.000	.068	6.085	.529
	Roy's Largest Root	.277	3.042[b]	2.000	22.000	.068	6.085	.529
TRIAL	Pillai's Trace	.037	.255[b]	3.000	20.000	.857	.765	.090
	Wilks' Lambda	.963	.255[b]	3.000	20.000	.857	.765	.090
	Hotelling's Trace	.038	.255[b]	3.000	20.000	.857	.765	.090
	Roy's Largest Root	.038	.255[b]	3.000	20.000	.857	.765	.090
TRIAL * GROUP	Pillai's Trace	.257	1.032	6.000	42.000	.418	6.194	.360
	Wilks' Lambda	.753	1.017[b]	6.000	40.000	.428	6.105	.353
	Hotelling's Trace	.316	.999	6.000	38.000	.440	5.996	.344
	Roy's Largest Root	.267	1.869[c]	3.000	21.000	.166	5.608	.414
OLDNEW * TRIAL	Pillai's Trace	.078	.561[b]	3.000	20.000	.647	1.682	.145
	Wilks' Lambda	.922	.561[b]	3.000	20.000	.647	1.682	.145
	Hotelling's Trace	.084	.561[b]	3.000	20.000	.647	1.682	.145
	Roy's Largest Root	.084	.561[b]	3.000	20.000	.647	1.682	.145
OLDNEW * TRIAL * GROUP	Pillai's Trace	.138	.521	6.000	42.000	.789	3.123	.188
	Wilks' Lambda	.862	.514[b]	6.000	40.000	.794	3.085	.185
	Hotelling's Trace	.160	.506	6.000	38.000	.800	3.035	.181
	Roy's Largest Root	.157	1.100[c]	3.000	21.000	.371	3.299	.254

a. Computed using alpha = .05

b. Exact statistic

c. The statistic is an upper bound on F that yields a lower bound on the significance level.

d. Design: Intercept+GROUP
Within Subjects Design: OLDNEW+TRIAL+OLDNEW*TRIAL

Mauchly's Test of Sphericity[b]

Measure: MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[a] Greenhouse-Geisser	Huynh-Feldt	Lower-bound
OLDNEW	1.000	.000	0	.	1.000	1.000	1.000
TRIAL	.274	26.836	5	.000	.698	.843	.333
OLDNEW * TRIAL	.377	20.225	5	.001	.623	.741	.333

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the layers (by default) of the Tests of Within Subjects Effects table.

b. Design: Intercept+GROUP
Within Subjects Design: OLDNEW+TRIAL+OLDNEW*TRIAL

Tests of Within-Subjects Effects

Measure: MEASURE_1
Sphericity Assumed

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Noncent. Parameter	Observed Power[a]
OLDNEW	80.006	1	80.006	4.534	.045	4.534	.530
OLDNEW * GROUP	107.360	2	53.680	3.042	.068	6.085	.529
Error(OLDNEW)	388.170	22	17.644				
TRIAL	104.933	3	34.978	.307	.820	.922	.106
TRIAL * GROUP	660.242	6	110.040	.966	.455	5.799	.355
Error(TRIAL)	7514.848	66	113.861				
OLDNEW * TRIAL	97.106	3	32.369	.193	.901	.579	.084
OLDNEW * TRIAL * GROUP	215.806	6	35.968	.214	.971	1.286	.102
Error(OLDNEW*TRIAL)	11078.104	66	167.850				

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure: MEASURE_1
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Noncent. Parameter	Observed Power[a]
Intercept	129079.365	1	129079.365	403.007	.000	403.007	1.000
GROUP	1584.828	2	792.414	2.474	.107	4.948	.444
Error	7046.402	22	320.291				

a. Computed using alpha = .05

Appendix 2.12
SPSS Listing for the RE-ANALYSED One-Way ANOVA
Between group explicit knowledge scores

Oneway

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Exp-Tot	Between Groups	29.703	2	14.851	9.373	.001
	Within Groups	34.857	22	1.584		
	Total	64.560	24			

Post Hoc Tests

Multiple Comparisons

Dependent Variable: Exp-Tot
Tukey HSD

(I) GROUP	(J) GROUP	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1.00	2.00	-.4762	.599	.710	-1.9800	1.0277
	3.00	-2.8095*	.700	.002	-4.5687	-1.0503
2.00	1.00	.4762	.599	.710	-1.0277	1.9800
	3.00	-2.3333*	.629	.003	-3.9143	-.7523
3.00	1.00	2.8095*	.700	.002	1.0503	4.5687
	2.00	2.3333*	.629	.003	.7523	3.9143

*. The mean difference is significant at the .05 level.

Appendix 2.13
SPSS Listing for the RE-ANALYSED correlation
Correlation between the 1st trial on retention and the explicit knowledge score

Correlations

Descriptive Statistics

	Mean	Std. Deviation	N
R1_O	26.7600	12.6993	25
Exp-Tot	4.7600	1.6401	25

Correlations

		R1_O	Exp-Tot
Pearson Correlation	R1_O	1.000	.169
	Exp-Tot	.169	1.000
Sig. (2-tailed)	R1_O	.	.419
	Exp-Tot	.419	.
N	R1_O	25	25
	Exp-Tot	25	25