# Instructional Focus Does Not Effect Implicit Pattern Learning

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## Abstract

Participants performed a dual-component training procedure that combined a serial reaction time task and an artificial grammar learning task under two instructional conditions. Participants given memory-focused instructions performed at the same level as participants given motor-focused instructions on the serial reaction time test and grammar sorting task. Both groups performed better than a control (no training) group. Results suggest that only a minimal amount of attentional focus on aspects of the stimuli relevant to the pattern is needed to acquire implicit pattern knowledge.

## Introduction

Understanding and modeling the processes of human learning, memory, and cognition is the primary focus of much of research in cognitive science. A large amount of this research has focused on task performance after the effortful and intentional study of material. Subjects in these situations are aware of the relevance of the material they are learning (such as word lists, or texts) even if they are not aware of the fact that they are going to be tested on the material. Participants consciously devote attention to the learning stimuli and are aware of the knowledge they have acquired. When an individuals' performance on the testing task is improved after the learning task, it is usually due to them applying their new knowledge to this task. Such learning and its resulting knowledge are often referred to as *explicit* learning and knowledge (Seger, 1994).

However, it appears that consciously attending to materials or stimuli is not the only method by which humans are able to acquire and use knowledge. It has been shown that people can make judgments and increase task performance based on knowledge acquired without consciously attending to the relevant information during the learning phase, or being aware that any knowledge was acquired (e.g. Reber, 1967; Nissen & Bullemer 1987). This type of learning and its resulting knowledge are referred to as *implicit* learning and knowledge.

The classic example of an implicit learning paradigm is Reber's (1967) artificial grammar study. In this study subjects were asked to memorize strings of letters that were constructed using a finite-state grammar. This grammar involved a set of rules by which a sequence of letter strings was constructed. After memorizing a number of letter strings in sets of three, participants were informed that the strings were constructed using a set of grammar rules.

Subjects were given an unexpected test in which they were presented strings constructed using the grammar and random strings, and asked to indicate whether the string was constructed following the same rules as the studied list or not. It was found that subjects could identify the grammatical strings at better than chance levels even though most were unable to verbalize any of their decision criteria or accurately state the grammar rules. This study suggested that there could be a distinction between the learning mechanisms involved in explicit tasks and implicit tasks, which involves learning complex concepts without explicit knowledge of the rules.

Reber's (1967) original experiment has led to a growth in the study of implicit learning. In a recent review, Seger (1994) suggested three criteria by which to judge whether a learning task should be considered as implicit. The first criterion is that the knowledge that is gained in the task is not fully conscious to the learner. In other words, participants are unable to provide a full or accurate account of what they have learned and do not realize that they have learned anything. The second criterion is that the learned information or relationships are more complex than simple frequency counts or associations. This does not imply that implicit learning cannot take place in those types of tasks, just that in order to separate implicit learning from very rudimentary automatic explicit learning, more complex stimuli must be used. The final criterion is that the knowledge acquired in implicit learning does not come from conscious processes such as hypothesis testing, but is acquired incidentally by just processing the material. This is to say that just because in retrospect subjects may say that they noticed patterns in the material does not mean that implicit learning did not occur. The more important aspect is the process by which this knowledge came about.

Nissen and Bullemer's (1987) serial reaction time experiments are another classic example of an implicit learning paradigm. In these experiments subjects were asked to tap a series of four keys in response to the spatial position of an asterisk on a visual display. The order of the positions was either random or a complex repeating sequence. It was found that subjects who practiced in the sequenced condition had faster reaction times in responding to a spatial position than those in the random condition. These results showed that even though subjects were unaware of the sequential nature of the task they were still able to "learn" the sequence. This learning was reflected in the shorter reaction times.

Nissen and Bullemer (1987) offered further evidence that this task involved a different type of learning than traditional explicit learning tasks. In this experiment they gave the serial reaction time task to a sample of Korsakaff Syndrome patients who had severely impaired declarative memory. These patients showed the same performance on the sequenced series task as the non-patient group. The fact that these patients showed faster reaction times on sequenced tasks after practice, even though many were unable to remember the practice session itself, shows that awareness is not necessary for learning in these types of tasks. The main conclusion from the implicit learning research is that people seem be able to detect abstract patterns in material without having to explicitly, consciously search for such patterns.

With substantial support that there are mental processes in which individuals are able to extract and use abstract information without awareness, the focus of implicit learning research has begun to move away from simply attempting to verify the existence of the phenomena. More researchers have begun to look at the role attention plays in implicit learning and have been trying to discover the nature and properties of the processes involved. For example, Deines, Broadbent, and Berry (1991) had subjects produce random digits while memorizing artificial grammar strings. It was shown that this divided attention task interfered with subjects' ability to make grammatical judgments between random and structured strings. It was postulated that both the memorization of the strings and random digit production both involved the phonological loop, and therefore not enough attentional resources could be devoted to the strings to extract the pattern.

Divided attention procedures have also been conducted in the serial position tasks. Nissen and Bullemer (1987) added a tone counting task to the original position location tasks. They found that this eliminated reaction time advantages on the sequenced trials when compared to the random trials. Here as well, it was shown that an attentionally demanding task interferes with implicit learning. This suggests that while awareness is not necessary in incidental learning attention is. It appears that materials must be perceived, encoded, and perhaps processed in order for patterns to be extracted.

Separating the concepts of attention and awareness is a difficult process. Curran and Keele (1993) conducted a group of experiments using the serial reaction time task and the tone counting task to separate the effects of attention from those of awareness. In one experiment they informed one group of participants about the existence of the pattern of positions and did not inform another group. After a training period they found that both groups showed faster reaction times on sequenced trials as opposed to random trials. They also found that the aware group had faster reaction times on sequenced trials than the unaware group. When both trained groups then performed the serial reaction task while completing a tone counting task, the sequenced trial performance was still faster than the random trial

performance. However, the aware group performed the same as the unaware group in the dual task situation. These results suggest that explicit and implicit learning can happen in parallel. In situations in which explicit resources are taxed, implicit knowledge can still be detected.

Salidas, Willingham, and Gabrieli (2000) created a serial reaction time task to explore the separation between attention and awareness. This procedure was similar to the original serial reaction task, only the stimuli were four colored boxes that corresponded to the keys. Participants were informed that when the boxes appeared in red they followed a certain sequence. They were told that when the boxes appeared in blue they were randomly sequenced. Unknown to the subjects, certain trials in blue actually followed a second sequence. This allowed the researchers to separate explicit (red) from implicit (blue) learning.

After the training period subjects were tested on trials that were either the explicit sequence in red, the explicit sequence in blue, the implicit sequence in blue, or a random sequence in blue. The results revealed that the explicit sequence in red led to the shortest reaction times. The more unexpected finding was that the performance on the second implicit sequence was equal to the explicit sequence when it was presented in blue, and both were faster than reaction times on random sequences.

These findings were backed up by fMRI results that showed activation in the primary motor cortex for the implicit sequence and the explicit sequence when presented in blue. The fMRI results showed similar activation in the primary motor cortex for the explicit sequence when presented in red, with added activation in areas of the prefrontal cortex. These results are intriguing for several reasons. First, they are powerful support that explicit and implicit learning can proceed in parallel. The fact that the performance levels on the explicitly learned sequence dropped down to the implicit level when the explicit cue was removed is clear support for this parallel learning. The second intriguing result is that subjects were able to implicitly learn two separate sequences. This may suggest that when attention paid to the different stimuli is equal, people are capable of learning multiple patterns implicitly. This would mean that implicit learning might not follow the same rules of interference as explicit learning. In explicit tasks, the learning of multiple associations of concepts at once will cause lower performance on tasks involving those concepts (e.g., the fan effect). This may not be the case in implicit learning.

Although Salidas et al.'s (2000) serial reaction time design suggests that people can implicitly learn multiple patterns at once, there are some limits to this paradigm. First, subjects are exposed to only one pattern per trial. Consequently, it cannot truly be inferred that people are simultaneously learning multiple patterns. Second, while this paradigm does allow for the manipulation of the subject's level of awareness, it does not allow one to manipulate the amount of attention paid to the different implicit patterns. Due to these facts, this experimental

approach is not the ideal way to investigate how multiple implicit patterns are processed and the role that attention plays in implicit learning.

In order to investigate an individual's ability to process multiple patterns, one must create an implicit learning task in which two separate patterns must be processed simultaneously. Another key aspect of an effective task is that the amount of attention paid to each pattern must be able to be manipulated without having to manipulate the subject's awareness of the existence of either pattern. The present study introduces an implicit learning procedure that allows for the systematic investigation of the role of consciously focused attention on implicit learning of multiple patterns.

Our methodology combines the artificial grammar procedure with the serial reaction time task. In this design, strings of letters were presented in a visual display in one of four spatial locations. Subjects were assigned to one of two learning conditions. The memory focused learning condition instructed participants to focus on memorizing the letter strings while reacting to the screen locations as the secondary task. It was presumed that the subjects would devote more attention to the grammar stimuli in this condition. In the motor focused learning condition participants were instructed to focus on reacting to the screen locations as quickly as possible and reading the letter strings as a secondary task. This would presumably cause the subject to devote more attention to the reaction time task. After training, subjects were given an unexpected test of their ability to make judgments of the grammaticality of new strings made using the same grammar rules. They were also tested on serial reaction time on sequenced trials and random trials. The training groups were compared to a no training control group that only completed the testing phase. By using this approach we investigated what role consciously focused attention plays in implicit learning.

## Methods

### Participants

Sixty-one participants (memory $n = 28$, motor $n = 18$, control $n = 15$) from the Subject Pool at the University of Illinois at Chicago participated in the study as part of a course requirement in their introductory psychology class.

### Materials and Apparatus

All material was presented on a microcomputer with a SVGA monitor.

The grammar strings were constructed using a finite-state grammar used by Reber (see Reber, 1967 for details). This particular grammar generates 43 permissible letter sequences of three to eight letters in length, which were used as the structured material. Fifteen of the 43 grammatical strings were selected for the learning phase of the experiment.

The strings were presented as the stimuli in the serial reaction task. The serial reaction time task was similar to the task used by Nissen and Bullemer (1987). The stimulus appeared in one of four quadrants of the screen. Each stimulus remained on the screen for two seconds regardless of how quickly the subject reacted, to equate exposure time. The positions on the screen corresponded to four keys matching the positions. Participants were assigned to one of six different sequences to control for any effect of sequence order. The sequences consisted of six elements. Two of the four possible positions were repeated while the other two positions appeared only once. The four spatial positions from left to right, top to bottom were labeled 1, 2, 3, and 4. The six sequences were: 1-2-3-2-4-3, 1-2-3-1-3-4,1-4-3-1-3-2, 1-4-2-3-1-2, 1-3-2-4-1-2, and 4-2-3-2-1-3 (Curran & Keele, 1993). The training session consisted 60 repetitions of the six-location sequence for a total of 360 learning trials.

**Test Materials.** The test letter strings either were new strings constructed using the same grammar as the training strings, or were constructed with rules that violated the grammar. The serial position test presented strings of asterisks in place of the grammar strings used in the training materials. The test consisted of two portions. The sequenced portions presented the asterisks in serial locations that followed the pattern of the training materials. The random portion presented the asterisks in serial locations that were randomly determined.

### Procedure

Participants were assigned to one of three training groups, memory focused, motor focused, and no training control. The experiment involved two phases. Memory and motor focused groups first completed a learning phase. All groups then completed a testing phase. Prior to beginning the experiment training group subjects were given instructions for their learning condition. All other aspects of the experiment were the same for both training groups.

**Instructions for memory focused group:**
In this study you will be asked to complete a memory task. A series of letter strings (such as XWSTV) will appear in various locations on the computer screen. Your task is to memorize these letter strings. Each string will only appear on the screen for a short period of time, so please concentrate on memorizing each string as it appears. After the training session you will be tested for your memory of these strings.
During this time you will also be asked to respond to the location of the string by hitting one of the four corresponding keys on the keyboard. Please respond to each location as quickly as possible without sacrificing accuracy. As you do this remember to read each string with the intent of learning it for the later recognition test.
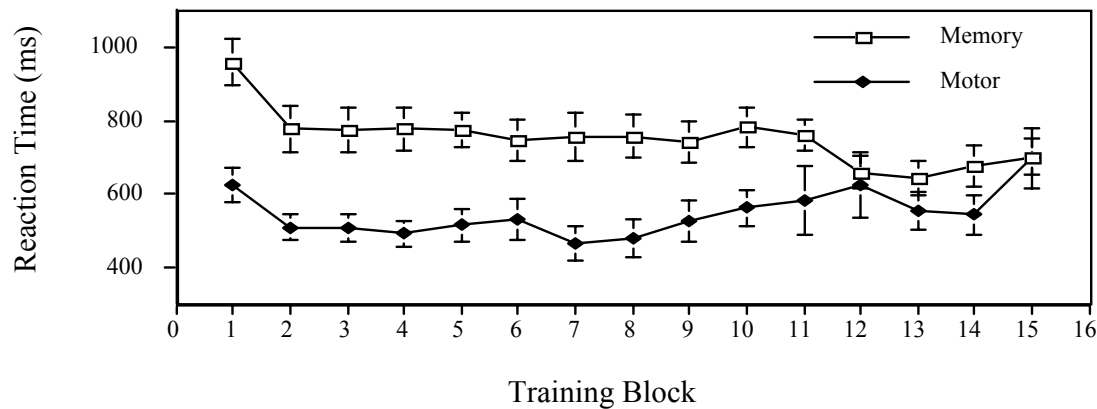
Figure 1: The effect of instructional focus on learning trial reaction times.

**Instructions for motor focused group:**

In this study you will be asked to a complete motor skills task. A series of letter strings (such as XWSTV) will appear in various locations on the computer screen. Your task is to respond to the location of the string by hitting one of the four corresponding keys on the keyboard. Please respond to each location as quickly as possible without sacrificing accuracy. After the training session you will be tested for how quickly your can respond to various locations on the screen.

During this time you will also be asked to read each letter string. Each string will only appear on the screen for a short period of time. So, be sure to attend to and read each string as it appears. As you do this remember to respond to the location of the string as quickly as possible with the intent of improving speed and accuracy for a motor skills test.

**Learning Phase.** For each trial, one of the fifteen training grammar strings was presented in one of the four serial locations. The order of screen locations followed one of the six sequenced patterns. Participants responded to the location by pressing the key that corresponded to the location. Participants were first given a fifteen trial warm-up to familiarize them with the task. Then the participants completed the learning phase. The learning phase consisted of 15 blocks. Each block consisted of four repetitions of the six-location pattern. In total participants were presented with 360 trials (60 repetitions of the location pattern, 24 presentations of each grammar string). The total learning phase took approximately 12 minutes. The reaction times to the spatial locations were recorded during the learning phase to assess the effects of instructional manipulation.

**Test Phase.** The grammar-sorting task was identical to the methods used by Reber (1976). Subjects were informed that the letter strings presented in the learning phase had been constructed using a set of rules. Twenty-two of the remaining grammatical items not used in the learning phase were randomly mixed with 22 non-grammatical strings. The letter strings were presented one at a time in the center of the screen. Each of the 44 items was presented twice for grammaticality judgments. This resulted in a total of 88 responses. The dependent measure was the number of correctly sorted strings.

The serial reaction time test phase consisted of a sequenced block and a random block. The sequenced block followed the same serial location pattern as the training phase. Participants received 10 repetitions of the six-location sequence. For the random block participants received 60 trials for which the screen location was randomly determined. Participants responded by pressing the key that corresponded to the screen location. The dependent measure was the average reaction time on sequenced and random blocks.

## Results

### Learning Phase

**Learning Trial Reaction Times.** In order to investigate the effects of instructional focus on serial position learning rate a 2 instructional focus (motor vs. memory) X 15 training block mixed design analysis of variance (ANOVA) was conducted on average location reaction times. Results revealed a main effect of instructional focus, $F(1, 43) = 10.84$, $MSE = 632,710.47$, $p < .001$. There was also a main effect of training block, $F(14, 602) = 2.91$, $MSE = 33,361.77$, $p < .001$. These results were best explained by the significant instructional focus X training block interaction, $F(14, 602) = 3.22$, $MSE = 33,361.77$, $p < .001$ (see Figure 1). Follow-up analysis on the memory focused instruction group revealed a simple main effect of training block, $F(14, 350) = 4.42$, $MSE = 31,775.42$, $p < .001$. A linear trend analysis revealed a linear decrease in reaction times across training blocks $F(1, 25) = 8.99$, $MSE = 128,306.70$, $p < .01$. Follow-up analysis on the motor focused instruction group revealed a simple main effect of training block, $F(14, 252) = 2.10$, $MSE = 35,565.02$, $p < .05$. In contrast to the memory focused group, the motor focused group did not exhibit a significant linear decrease in reaction times, $F(1, 18) = 1.57$, $ns$.

**Testing Phase**

**Grammar-Sorting Task.** In order to investigate the effects of training group (motor-focused, memory-focused, and no training) on implicit grammar learning, a one-way ANOVA was conducted on the percentage of correctly sorted strings. Results revealed a significant effect of training group, $F$ (2, 58) = 9.03, $MSE$ = 50.64, $p < .001$ (see Figure 2). Post hoc analyses revealed no difference in sorting performance between the motor and memory focused groups, $F < 1$. However, both motor and memory focused performed significantly better than the no training group at the sorting task (motor vs. no training $F$ (2, 58) = 12.21, $MSE$ = 50.64, $p < .001$, memory vs. no training $F$ (2, 58) = 16.24, $MSE$ = 50.64, $p < .001$).
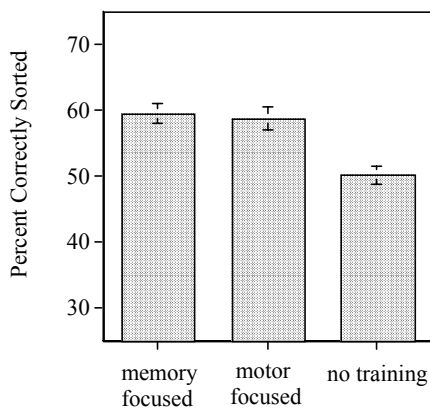


Figure 2: The effect of training group on grammar sorting.

**Serial Reaction Time Task.** In order to investigate the effects of training group (motor-focused, memory-focused, no training) on serial position learning a 3 training group X 2 test (sequenced vs. random) mixed design ANOVA was conducted on mean reaction times. Analysis revealed a main effect of test, $F$ (1, 58) = 37.73, $MSE$ = 7,918.17, $p < .001$. Overall reaction times were faster on the sequenced block ($M$ = 433.49; $SD$ = 140.15) than on the random block ($M$ = 548.19; $SD$ = 133.60). Analysis also revealed a training group X test interaction, $F$ (2, 58) = 4.20, $MSE$ = 7,918.17, $p < .05$ (see Figure 3). Follow-up analyses for sequenced block revealed a simple main effect of training group, $F$ (2, 58) = 4.57, $MSE$ = 7,918.17, $p < .05$. Analyses revealed no difference between memory and motor focused instruction groups on sequenced block reaction times, $t$ (44) < 1. However, analyses did reveal faster reaction times for the memory and motor groups when compared to the no training group (memory vs. no training, $t$ (41) = -3.92, $p < .001$; motor vs. no training, $t$ (31) = -1.73, $p < .05$). Follow-up analyses for the random block revealed no simple main effect of training group, $F$ (2, 58) < 1.

**Discussion**

We argued that in order to investigate an individual's ability to process multiple patterns, one must create an implicit learning task in which two separate patterns must be processed simultaneously. Also the amount of attention paid to each pattern must be able to be manipulated without having to manipulate the subject's awareness of the existence of either pattern. The present study introduced an implicit learning procedure that allowed for the systematic investigation of the role of consciously focused attention on implicit learning outcomes.

This design combined the artificial grammar procedure with the serial reaction time task. Three types of evidence of implicit learning can be examined in this design; learning trial reaction times, grammar-sorting performance, and serial reaction time task performance.

The learning trial reaction times provide evidence that instructional focus effected location response behavior during the learning phase. Recall that both training groups received the exact same dual-component stimuli (i.e., grammar strings and sequenced locations). The difference between the training groups was the instructional focus. The memory focused instructions were designed to focus participants' attention on memorizing the grammar strings while making identifying screen locations a secondary task. The motor focused instructions were designed to focus participants' attention on reacting as quickly as possible to the screen locations while making reading the grammar strings the secondary task. Those in the memory focused group showed a linear decrease in reaction times to screen locations throughout the training task. On the other hand the motor focused group showed a sudden decrease in reaction times that remained constant through the rest of the training
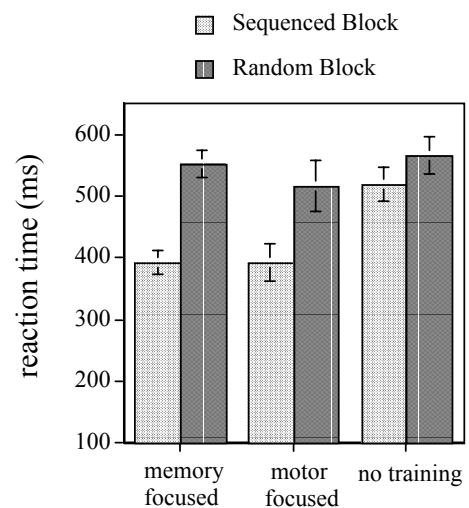


Figure 3: Effect of training group on reaction time on sequenced and random blocks.

task. This sudden drop in reaction times indicates that the motor focused instructions caused participants to attend more to the serial position aspect of the dual-component stimuli. Unfortunately the nature of the artificial grammar learning paradigm does not enable a complementary measure of on-line learning performance. Therefore, we have no similar manipulation check of the effects of instructional focus on grammar acquisition during the learning phase.

The behavioral differences observed during the learning phase did not translate into differential performance during the testing phase. On the grammar sorting task both training groups showed evidence of grammar acquisition above the no training control group. However, instructional focus did not lead to differences in grammar sorting performance between training groups. This result is surprising, both common sense and prior research in explicit learning (e.g., transfer appropriate processing, Morris, Bransford, & Franks, 1977) would suggest that focusing attention on the memorization of grammar strings should lead to a higher level of pattern learning.

The behavioral differences of the learning phase also did not transfer to differences in serial reaction time performance. Once again both training groups showed evidence of location pattern learning above the no training control group. However, no differences were detected between instructional focus groups. Once again, it would seem (and the learning results suggested) that focusing attention on reacting to the spatial locations should have led to superior location pattern learning.

In sum, our study suggests that individuals are able to implicitly extract multiple patterns from this type of dual-component stimuli. In addition, our manipulations of attentional focus did not have any effect on the nature or magnitude of this learning. This leads us to postulate that any type of processing or attentional focus above the point of apprehension may be enough to lead to implicit pattern learning.

Prior work in cognitive science has generally investigated explicit learning and the application of explicit knowledge on complex tasks. However, there is growing experimental evidence that explicit and implicit learning can take place in parallel (e.g., Curran & Keele, 1993; Willingham & Goedert-Eschmann, 1999). It has also been shown that implicit knowledge can affect task performance in situations in which individuals are not using their relevant explicit knowledge on the task. In the present study we showed that multiple implicit patterns can be acquired from a single task with minimal amounts of attention or mental processing devoted to the relevant aspects of the stimuli.

Therefore in any learning situation, outcome measure performance may be due to both the deliberate application of declarative or procedural knowledge, and the incidental application of implicit knowledge. Therefore in methodologies where the learning stimuli contain repeating or underlying structure or statistical patterns, performance differences due to implicit knowledge acquisition must be accounted for before one can make conclusions about the effects of higher-level explicit knowledge. Therefore it is important for researchers attempting to explain or model any learning phenomena to consider the potential impact of implicit learning in both the design of the learning materials/situations and the interpretation of any learning outcome results.

## References

Berry, D. C., & Broadbent, D. E. (1984). On the relationship between task performance and associated verbalizable knowledge. *Quarterly Journal of Experimental Psychology, 36A*, 209-231.

Curran, T. & Keele, S. W. (1993). Attentional and nonattentional forms of sequence learning. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 19*, 189-202.

Deines, Z., Broadbent, D. E., & Berry, D. C. (1991). Implicit and explicit knowledge bases in artificial grammar learning. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 17*, 875-887.

Knowlton, B. J., Ramus S. J., & Squire, L. R. (1992). Intact artificial grammar learning in amnesia: Dissociation of classification learning and explicit memory for specific instances. *Psychological Science, 3*, 172-179.

Morris, C. P., Bransford, J. D., Franks, J. J., (1977). Levels of processing versus transfer appropriate processing. *Journal of Verbal Learning &Verbal Behavior, 16*, 519-533.

Nissen, M. J., & Bullemer, P. (1987). Attentional requirements of learning: Evidence from performance measures. *Cognitive Psychology, 19*, 1-32.

Reber, A. S. (1967). Implicit learning of artificial grammars. *Journal of Verbal Learning and Verbal Behavior, 6*, 317-327.

Reber, A. S. (1976). Implicit learning of synthetic languages: The role of instructional set. *Journal of Experimental Psychology: Human Learning and Memory, 2*, 1, 88-94.

Salidas, J., Willingham, D. B., & Gabrieli, J. (2000, November) *fMRI of implicit and explicit sequence learning: Evidence for parallel systems*. Paper presented at the 41st annual meeting of the Psychonomic Society, New Orleans, LA.

Seger, C. A. (1994). Implicit learning. *Psychological Bulletin, 115*, 163-196.

Willingham, D. B., & Goedert-Eschmann, K. (1999). The relation between implicit and explicit learning: Evidence for parallel development. *Psychological Science, 10*, 531-534.