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Implicit and Explicit Awareness of a Phonics Rule in the Word Recognition of Students With and Without Learning Disabilities

This study investigates the ability of students with and without learning disabilities to learn a phonics rule implicitly and the ability of these students to report accurately about the rule verbally. Many researchers have argued that implicit learning denotes a form of learning that occurs without intention and results in adequate performance, but is not available to consciousness and so not verbalizable (Reber, 1993). Others have suggested that this inability to verbalize may not be as definite as originally thought (Ericsson & Simon, 1993). This study examined the implicit learning and explicit knowledge capabilities of students between the ages of 10 and 12 with and without learning disabilities. Students acquired knowledge implicitly about the pronunciation of pseudowords that were governed by one of two phonics rules. They were then asked to verbalize explicitly about the acquired knowledge. Results indicate that implicit knowledge capabilities for all students were not significantly different. However, there were significant differences between students with and without learning disabilities on explicit knowledge scores.

Cette étude analyse la capacité d'élèves avec et sans difficultés d'apprentissage à apprendre de façon implicite une règle de la méthode phonétique et ensuite d'en parler de façon adéquate. Plusieurs chercheurs maintiennent que l'apprentissage implicite constitue une forme d'apprentissage qui s'acquiert involontairement, qui entraîne une performance adéquate, mais dont on ne peut être conscient et qu'on ne peut pas décrire (Reber, 1993). D'autres recherches proposent que cette incapacité à verbaliser n'est pas aussi nette qu'on l'avait cru (Ericsson & Simon, 1993). Les sujets de cette étude sur l'apprentissage implicite et sur les capacités explicites étaient des élèves âgés d'entre 10 et 12 ans et qui avaient ou non des difficultés d'apprentissage. Les élèves ont acquis, de façon implicite, des connaissances sur la prononciation de logatomes régie par une de deux règles de la méthode phonétique. Par la suite, on leur a demandé d'expliciter les connaissances qu'ils avaient acquises. Les résultats indiquent que la différence dans la capacité d'acquérir des connaissances implicites n'était pas significative d'un élève à l'autre. Par contre, la différence dans la capacité d'énoncer des connaissances explicites était significative entre les élèves avec des difficultés d'apprentissage et ceux qui n'en présentaient pas.

Introduction

Psychologists have for many years examined the ability to verbalize about our internal states. Many of the educational practices in school today involve

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activities where students must learn and then verbalize about complex phenomena. Verbalization entails the use of language, which has many subsystems that incorporate sounds, letter-sound relationships, grammar, semantics, and vocabulary. Communicating through one's language entails knowing the right way to say something on a particular occasion in order to accomplish a specific purpose (Gleason, 1985). In other words, knowing the language means knowing its phonology, morphology, syntax, and semantics, as well as its rules for use. This complex process becomes even more difficult as students progress through elementary school and are inundated with a constant battery of new words and word families. Nagy and Anderson (1984) estimated that printed school English contains approximately 88,500 word families. Furthermore, it is estimated that the average grade 5 student has encountered approximately 10,000 new reading words per year. One question that follows is: How can a student learn so many words? This question becomes even more complex in the case of a student with learning disabilities (LD).

Learning of language can take place implicitly or explicitly. Implicit learning is acquisition of knowledge about the underlying structure of a stimulus environment by a process that takes place without conscious operations (Dulany, Carlson, & Dewey, 1984; Winter & Reber, 1994). This is a process whereby knowledge of structured stimulus domains is acquired largely independent of conscious operations and largely independent of explicit knowledge of both the process of acquisition and the knowledge base that is acquired. On the other hand, explicit learning is a more conscious operation where the individual makes and tests hypotheses in a search for structure.

Of relevance to the present study is the question that once information is learned, how accurately can students verbally report on internal states and social or cognitive skills? Furthermore, does this ability to report verbally differ in students with LD? To date few researchers have examined this latter question. However, in relation to the first, many researchers argue that humans have no more privileged access to their internal states or the causes of their behavior than has an observer (Berry & Broadbent, 1987; Lewicki, Hill, & Bizot, 1988; Nisbett & Wilson, 1977). This is often referred to as a dissociation between implicit and explicit knowledge. Implicit knowledge refers to knowledge that is not accessible to consciousness and cannot be verbally reported, whereas explicit knowledge refers to knowledge that is accessible to consciousness and can be verbally reported. The dissociation is usually found in a discrepancy between task performance and the ability to verbalize about what has been done. However, others such as Ericsson and Simon (1993) counter this argument by stating that although sometimes internal states are not accessible to consciousness, there are many situations in which a verbal report can be trusted.

Implicit and Explicit Awareness: A Theoretical Framework

The process of reading involves recognizing words efficiently with comprehension. That is, students must fluently and automatically process the word and its appropriate meaning. This process requires that students learn letter-sound correspondences that occur as patterns across words. As students mature, their knowledge of the relationships between letters and sounds may evolve to a degree that allows advanced phonetic rules to be understood. Furthermore, as students become skilled in understanding a letter-sound correspondence, they may transfer this knowledge to a novel exemplar of the initial word. This transfer of knowledge may be beneficial in that it may reduce the amount of cognitive processing initially required to understand the novel exemplar, thus increasing processing efficiency, freeing cognitive space that may now be used for a more advanced cognitive task (i.e., comprehension or verbalization). Many traditional approaches to teaching letter-sound correspondences treat them as learning that involves explicitly and consciously identifying the letter-sound correspondences as a pattern or a rule. However, initial letter-sound correspondences may be encoded at an implicit unconscious level during word recognition. In fact, many sight-word or whole-word instructional approaches often leave the letter-sound relationships in words at an implicit level. Although implicit, this learning may also result in transfer of the knowledge to novel exemplars in word recognition (Van Orden, Pennington, & Stone, 1990). As students implicitly learn and develop an understanding of the letter-sound correspondence, they also may begin to develop a conscious explicit awareness of the correspondence (Berry, 1994; Smith, 1994; Stanley, Mathews, Buss, & Kotler-Cope, 1989). This conscious awareness may be the result of the learner's attempt to construct a model of the underlying implicit processing rule, and this model may be based on those fragments of implicit processing that are salient enough to be made conscious (Berry, 1994; Berry & Broadbent, 1988; Broadbent & Fitzgerald, 1986). Conscious rule descriptions may also depend on the metalinguistic language capabilities the student can bring to bear in order to describe his or her implicit processing rule (Karanth & Suchitra, 1993). We believe that students both with and without LD should show some evidence of implicit letter-sound correspondence and phonics rule acquisition in their ability to read new exemplars of the rule. However, we also expect that students without LD will outperform students with LD in this implicit rule acquisition process. The reasoning behind this expectation is examined in the following section.

Students both with and without LD should be able to make some (although not all) of their implicit learning conscious in the form of verbal reports. However, as with the implicit learning task, students without LD are expected to do considerably better on this task. In our examination of earlier research in this area we found that many of the researchers who examine verbal reports fail to embed their work in any solid theoretical framework. We believe that if researchers are to examine accurately students' ability to verbalize their internal cognitive processes, it is critical that they examine how students produce a verbal report and explain what this demands of their internal processing system. The present study adopts a theoretical framework of a human information processing theory in order to propose a model for the verbalization process. Perhaps the most widely accepted information processing model of memory is the modal model of Atkinson and Shiffrin (1968). Assuming this theoretical framework, two types of verbalization are possible: concurrent and retrospective (Ericsson & Simon, 1993). When verbalization is concurrent with the task, two things must occur; the task must be completed and the verbalization must occur concurrently. When concurrent verbalization is a direct articulation of information that is active in short-term memory (STM) and stored in a verbal code, this is referred to as Level 1 verbalization. This type of verbalization occurs as the task is being completed and the information is focused on in STM. When this occurs, no interfering variables enter the equation, and so verbalization is accurate and often complete. An example of this is a think-aloud procedure. Level 2 concurrent verbalization refers to the verbalization of information that is not originally available in a verbal code. As this occurs the information must be recoded into a verbal code so that it may be verbalized. In following the assumptions of the information processing theoretical framework, when information in STM is not verbally encoded, making a verbal report requires the corresponding verbal representations of the information to be constructed. This recoding process will make at least modest demands on processing capacity and processing time. This means that some relevant information may be lost, making verbalization difficult and possibly inaccurate.

A second method of verbalization is referred to as retrospective verbalization. The current research incorporates this method of verbalization because many current educational practices elicit verbal reports after the initial exposure to the information. Retrospective verbalization is the most general type of verbalization, in which students are asked to report everything they can remember about the cognitive process studied. If the subject is asked immediately after performing the process, this model predicts that some previously processed information will still be in STM, permitting some verbalization. However, in many retrospective situations, information must be retrieved from long-term memory (LTM). This may be problematic in that retrieval may not only fail to access the previously processed information, but may on occasion access information that is confused with the events being queried.

In sum, this model of verbalization assumes that only information in focal attention can be verbalized (Ericsson & Simon, 1993). In accordance with this model, three causes of the lack of or incomplete verbalization are predicted. First, the appropriate information may not be accurately retrieved from LTM, hence not stored in STM and consequently not accessible for verbal report. Second, the information initially processed in STM may not be appropriately stored in LTM and hence cannot be retrieved. Third, the information available in STM at the time of the report may not be accurately reported.

Students with Learning Disabilities

Perhaps the most frequent empirical findings in research on LD record qualitative differences in cognitive functioning of students with LD compared with their non-LD peers (Swanson, 1998). However, it is assumed that these differences are specific to certain cognitive processes. Phonological awareness and memory processing are two cognitive functions that are presumed to contribute to the academic difficulties experienced by a sizable portion of students with LD. Phonological awareness may be defined as a set of cognitive skills that enable children to use information about the sound structure of their own oral language in learning how to read (Wagner & Torgesen, 1987). The phonological awareness difficulties experienced by students with LD are often manifest in a discrepancy between chronological age level and reading age level.

Memory processing is also a significant cognitive function that contributes to the difficulties experienced by students with LD. Of particular importance to this study is the concept of working memory (WM). Baddeley and Hitch (1974) and later Baddeley (1986) suggested that the processes attributed to WM reflect a multi-process activity in which processing capacities are allocated over a variety of systems. WM is a dynamic system that emphasizes both processing and storage. Its capacity is limited and considered to reside in the limitations of simultaneously satisfying both the processing and storage demands that a given task imposes (Daneman & Carpenter, 1980). The central executive component of WM regulates and controls information flow within the memory system, the retrieval of information from LTM, and the processing and storage of information. The processing resources used by the central executive have limited capacity.

Verbal Reports and Students With Learning Disabilities

Retrospective verbalization about cognitive processes, a methodology often incorporated into the elementary classroom, may be a successful method of eliciting verbal reports if it occurs immediately after the initial learning session. However, even if this does occur, this method may be problematic for students with LD, who may have particular difficulties in verbalizing about their cognitive processes due to specific cognitive difficulties that may impair the very information processing system that acts as a framework for this model of verbalization.

In keeping with the modal model of information processing (Atkinson & Shiffrin, 1968), the rate of decay of information in STM can be brought under the control of the individual. For example, if a student rehearses information by repeating it subvocally, the rate of decay may decrease. Tactics such as rehearsal are control processes governed by the central executive component that help information to stay in STM. Students with LD, who experience deficits in WM capacity or processing, may be less aware of the appropriate tactics that act as such control processes in STM (Wong, 1982). Swanson (1993) found that students with LD rarely used an appropriate organizational tactic when they were required to rehearse information. It may be that the inability of students with LD to employ rehearsal tactics does not reflect an inability to rehearse. Rather, it reflects the failure to produce the appropriate tactics spontaneously. Research suggests that this in turn may be the outcome of developmental lag, in that students with LD may be delayed in their production of the appropriate rehearsal tactics (Stanovich, 1988; Tarver, Hallahan, Kaufman, & Ball, 1976).

Retrospective verbalization is also reliant on the ability to retrieve information from LTM. This retrieval process is certainly fallible, but particularly for students with LD. Retrieval problems have been found to be primary sources of individual difference in LTM performance (Swanson, Ashbaker, & Lee, 1996). Wong (1982) found that students with LD tend to select less efficient retrieval strategies, conduct a less exhaustive search for retrieval cues, and lack self checking skills in the selection of retrieval cues.

WM is a relatively new focus in the area of information processing and students with LD. This memory system is a dynamic and active system that facilitates the processing, storage and retrieval of information (Baddeley &

Hitch, 1974). The executive component of WM coordinates and orchestrates a student's cognitive processes. Verbalization requires the movement of information from LTM to STM. WM may be the component that coordinates this movement of information. Swanson et al. (1996) found that students with LD experience difficulties recalling information from LTM particularly when processing demands are high. As demands decrease, recall becomes less difficult. Current research in this area tends to support the notion that WM difficulties are related to deficits in executive processing (Swanson, 1998). Furthermore, although not previously examined, executive processing deficits may contribute to the cause of inaccurate or incomplete verbal reports in students with LD.

In sum, students with LD experience difficulties in many areas of information processing. The ability to verbalize is greatly dependent on this processing system, so it was predicted that students with LD would show poor performance in their ability to verbalize about their cognitive processes.

The Present Study

In the present study we compared implicit learning and the verbal reports of students with and without LD. Specifically, we measured students' ability to learn implicitly a phonics rule followed by a measurement of their ability to verbalize their own cognitive processes in learning this rule. A phonics rule paradigm was used because as students progress through elementary grades they are consistently exposed to new rules that govern language. Learning a new phonics rule requires students to assimilate and accommodate novel information. The cognitive processes involved in this activity include many of the processes previously described in the information processing model of memory.

Furthermore, verbal reports were elicited through a role-reversed teaching technique. This technique is one that is recommended by earlier researchers (Stanley et al., 1989). We believe that the dissociation between implicit and explicit knowledge of cognitive processes may not be as great as suspected when better measures of verbalization are used. Many researchers have attempted to obtain verbalization scores through the use of a written questionnaire. Such techniques are often unsuccessful and may be poor predictors of verbal knowledge. Allowing students to verbalize by giving instruction to a naive subject may be a more advantageous method of eliciting verbal reports. Mathews et al. (1989) described a teach-aloud procedure where participants were asked to give verbal instructions to someone else in order that they perform the task. This procedure provides an opportunity for students to make overt their competence in completing the task, at the same time revealing the cognitive processes that they may have employed.

As mentioned above, the role-reversed teaching technique was employed immediately after the initial learning session. A retrospective verbalization technique is commonly used in many classrooms. However, in order to ensure that information is not lost from STM, this technique was employed immediately after the initial task.

Based on the current theoretical framework and methodological issues, three hypotheses were made. First, it was hypothesized that there would be some dissociation between what was implicitly learned and what could be verbalized in students both with and without LD. This result was expected because the verbal reports were elicited in retrospect and the retrieval process that students must use may be fallible. Second, it was hypothesized that students without LD would have more complete and correct verbal reports than would students with LD. This prediction is based on the assumption that students with LD may have specific information processing difficulties that may affect their ability to retrieve the appropriate information to be verbalized. Third, it was hypothesized that the process of attempting to teach someone else a phonics rule would facilitate a further understanding of the initial phonics rule. This prediction was based on the assumption that in order to teach the phonics rule to a naive subject, students must reflect on their own understanding of the material. This reflection should elicit deep processing of the information, which may consolidate and expand their initial understanding of the phonics rule.

Method

Participants

Thirty-six students (16 girls, 20 boys) aged 10-12 years old from medium sized schools in an urban area were included in the study. Parental consent was obtained for each participating student. Twenty-four students were classified as having a learning disability and 12 students were classified as not having a learning disability. Students with LD were randomly assigned to one of two groups. LD Positive (Pos) consisted of 12 students with LD who were exposed to all three phases of the experiment. LD Negative (Neg) consisted of 12 students with LD who were exposed to only Phases 1 and 3 of the experiment. Students without LD were assigned to the normally achieving (NA) Positive (Pos) group and were exposed to all three phases of the experiment. All students in this study were matched for chronological age and had an IQ between 85 and 115. A one-way analysis of variance revealed that there was no significant difference in age between groups, $F(2,33)=.203, p=.818$, MS=.047. For the purpose of this study, students with learning disabilities were operationally defined as having a reading grade score two grades below their non-LD peers. This discrepancy was confirmed first by reviewing the educational files of all students with LD. All students identified as LD had an Individualized Education Plan (IEP) and reading data, as well as IQ scores reviewed by the primary researcher under the supervision of the relevant Regional Board of Education Office. Further to this, the primary researcher interviewed each of the students' teachers. All teachers confirmed the reading age level and ability status of the students identified as LD. In order to fortify this data further, each student, both with and without LD, was administered the Word Attack and Word Identification subtests of the Woodcock Mastery Test of Reading Ability. The Word Attack subtest is a test of phonetic decoding ability. The Word Identification subtest is a test of sight word recognition and of phonetic decoding ability. Two tests were administered in order to ensure that both phonetic decoding and sight word reading processes were accounted for when measuring reading ability.

Because reading ability is an independent variable in this experiment, it was decided that a single reading grade score variable would enable reading level to be examined as a single entity. In accordance with the standardized procedures of the Woodcock Johnson Testing Manual, the Word Attack score and the Word Identification score were combined to form an overall Reading score. A within-group paired samples t-test indicated no significant difference between Word Attack scores and Word Identification scores, LD Pos $t(1,11)= 0.0277$, $p=.876$; LD Neg $t(1,11)= 0.1018$, $p=.812$; NA Pos, $t(1,11)= 1.9234$, $p=.645$. The Word Attack and Word Identification scores were recorded individually, but were then combined in order to indicate a reading grade score for each student. In order to obtain a reading grade score, all students were administered the Woodcock Johnson Word Attack and Work Identification subtests. Results of these subtests are shown in Table 1.

The Phonics Rule

In this study students were exposed to sentences that contained pseudowords that were governed by one of two phonics rules.

Rule 1 Each pseudoword contained an initial consonant. This consonant could be any letter in the alphabet (C, B, T, S, etc.). This was followed by a vowel digraph, always an *ai* (C*ai*, T*ai*, S*ai*, V*ai*, etc.). The vowel digraph was followed by a second single consonant. Again, this consonant could be any letter in the alphabet (Cai*t*, Sai*v*, Tai*s*, etc.). This in turn was followed by a single vowel. In the case of Rule 1, this vowel was always an *a* (Cait*a*, Tais*a*, Saiv*a*, etc.). The pseudoword was then completed with a single consonant. This consonant was always an *r* (Caita*r*, Taiva*r*, Saiva*r*, etc.). In accordance with this, each pseudoword had two syllables. Pseudowords that conformed to Rule 1 were pronounced using basic phonetic principles. However, the first digraph (ai) was pronounced as a short *ai* sound, as in the word *said*. Thus this rule was characterized as follows: if the vowel letter in the second syllable of the pseudoword was an *a* the vowel digraph of the first syllable was pronounced as a short *ai* (said).

Rule 2. Each of these pseudowords also contained an initial consonant. This consonant could be any letter in the alphabet (B, D, K, M, etc.). This was followed by a vowel digraph, always an *ai* (B*ai*, T*ai*, K*ai*, V*ai*, etc.). The vowel digraph was followed by a second consonant digraph. This consonant was a basic *ph*, *sh*, *th*, or *ch* blend (Cai*th*, Sai*ph*, Tai*ch*, Bai*sh*, etc.). This in turn was followed by a single vowel. In the case of Rule 2, this vowel was always an *e* (Caiph*e*, Taith*e*, Saith*e*, etc.). The pseudoword was completed with a single

Table 1
Word Attack, Word Identification and Reading Grade Means and Standard Deviations (SD).

	Word Attack		*Word Identification*		*Reading Grade Score*	
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*
LD Pos	4.06	0.51	4.04	0.50	4.04	0.44
LD Neg	3.99	0.33	3.92	0.35	3.98	0.34
NA Pos	7.00	0.79	5.28	0.61	6.16	0.70

consonant, always an *r* (Caither, Taisher, Saipher, etc.). Pseudowords that conformed to Rule 2 were also pronounced using basic phonetic principles. However, the first digraph (ai) was pronounced as a long *ai* sound as in the word *paid*. This rule can be characterized as follows: if the vowel letter in the second syllable of the pseudoword was an *e* the first vowel digraph was pronounced as a long *ai* (paid).

All pseudowords were always found in the form of a proper name (Mr. or Mrs. Caisar). This was done in order to make the pseudowords as meaningful as possible. It is important to note that the children in the study had no trouble treating the pseudowords as surnames set in sentence contexts.

It is also important to note that these rules were more complex than the average phonics rule. Normally, pronunciation of a vowel digraph is not conditionalized on a following suffix. However, by constructing the phonics rule so that the pronunciation of the target letters was a function of the following letters *er* or *ar*, it can be argued that the rule was made more salient, but at the same time unfamiliar. This was important as it is difficult to find a phonics rule that is completely new to every student, particularly in the age group that was tested. Thus the construction of a rule of this nature controlled as much as possible for previous learning experience with the vowel digraph *ai*. Of course, we realize that no such rules exist in our language. Nevertheless, it should be noted that the pronunciation of *ai* in *said* and *paid* is in fact conditionalized on the surrounding letter context.

Procedure

The experiment was divided into four phases: Phase 1, the implicit rule acquisition phase; Phase 2, the isolated implicit testing phase; Phase 3, the role reversed teaching phase; and Phase 4, the posttest of the phonics rule knowledge. Before starting Phase 1 of the testing, each student was administered the Woodcock Word Analysis Test and the Woodcock Work Identification Test. These tests were designed to give an accurate reading grade score for each student. This was necessary to compare implicit and explicit functions between reading age matched groups. Testing took place in the schools, usually in the resource room or the library. Each student was tested individually for approximately one hour.

Phase 1. In Phase 1 of the experiment, LD Pos, LD Neg, and NA Pos were all exposed to the original implicit learning session. Implicit learning was used in order to account for the vast amount of information that students encounter independent of direct instruction. Also, many whole-word educational practices use this type of learning. During this session, each group was exposed to sets of 12 sentences. The first set was labeled Introduction. Each of the sentences in this set contained one pseudoword. The pseudoword followed one of the two possible phonics rules. Six of the 12 sentences containing pseudowords that followed phonics rule 1, whereas the other 6 followed phonics rule 2. An example of each type of sentence is, "Mr. Taivar is cutting the grass," or "I saw Mrs. Saipher at the Blue Jays game." The first example sentence contains a pseudoword that follows phonics rule 1, whereas the second example sentence contains a pseudoword that follows phonics rule 2. It is important to note that all of the words, other than the pseudowords, were at a reading level that did not place high decoding demands on any of the students. For the introduction set, the researcher read each sentence, pronouncing the pseudoword correctly. The student was then asked to repeat the sentence. The researcher corrected the student if the pseudoword was pronounced incorrectly. This continued until all 12 sentences of the introduction set were read. At no time during this phase was the student told the rule. They were simply asked to read the sentence and words they heard and give corrective feedback.

Students were then exposed to a second similar set of 12 sentences. Again, this set contained 12 sentences, 6 of the 12 containing a phonics rule 1 pseudoword and 6 containing a phonics rule 2 pseudoword. The difference here was that students were asked to read each sentence on their own. After reading each sentence, students were given feedback on whether they had pronounced the pseudoword correctly. If the students pronounced the word correctly, they were told to continue on to the next sentence. On the other hand, if the students pronounced the pseudoword incorrectly, they were given the correct pronunciation and asked to read the next sentence. When the students had read 12 sentences they had completed one trial. They were then asked to read sentences in trial 2, which contained 12 more sentences, each containing a phonics rule 1 or phonics rule 2 pseudoword. Students continued to read through sets of sentence appropriately labeled trial 1, trial 2, trial 3, and so forth. This continued until students had reached criterion, which was defined as students reading through two consecutive trials pronouncing the pseudoword in 10 of the 12 sentences correctly. Again, at no time during this phase were students told the particulars of the rule. This ensured that if learning did in fact occur, it occurred implicitly. Once the student reached criterion, the first phase was complete. Trials and errors to criterion were recorded.

Phase 2. Phase 2 consisted of a test of implicit knowledge. This test was administered approximately 10 minutes after Phase 1. All three groups were administered two tests of implicit knowledge. The first contained 12 sentences similar to those the students experienced during Phase 1. The second contained 12 isolated pseudowords. The first test measured the implicit knowledge that each student acquired during Phases 1 and 2. The second test measured whether the context of the sentence played a role in the implicit learning of the pseudoword.

Phase 3. Phase 3 involved the role-reversed teaching technique. This was a measure of students' ability to verbalize about internal states pertaining to the phonics rule. Only LD Pos and NA Pos were involved in the role-reversed teaching phase. LD Neg was excluded in order to test the third hypothesis of the study. However, in order to control for practice effects, LD Neg was exposed to the target sentences. The students in this group were simply asked to quietly read the sentences to themselves for the approximate duration of the verbalization session (approx. 15 minutes).

During Phase 3 students in LD pos and NA pos had to explain verbally and teach the newly acquired phonics rule to a naive subject. In this study the researcher acted as the naive subject for three reasons. First, at this point of the study the student had time to become comfortable working with the researcher. Second, the consistent responses of one naive subject should increase the internal reliability of the verbal report measurement. Third, the use of a classmate or schoolmate may infringe on the privacy that was ensured to each of the students participating in this study.

In this phase students were given a set of 12 sentences and asked to explain how to pronounce the pseudoword found in each sentence. Each pseudoword followed the rule found in Phases 1 and 2. In each case students were told to explain the rule to the researcher in their own words. During this phase the researcher remained consistent and unbiased with responses. In each case the researcher responded once that the instructions given by the student were not understood and also mispronounced 6 of the 12 pseudowords. At the end of this phase the researcher once again asked the student how to pronounce the pseudoword. This discourse was recorded for future analysis. It was believed that students able to at least partly verbalize about the mechanics of the phonics rule had some conscious knowledge of their internal cognitive state in relation to the mechanics of the rule.

Phase 4. Phase 4 included all three groups. LD Pos, LD Neg and NA Pos were administered for the second time the original test of implicit knowledge that was administered in Phase 2. The improvements in scores were of interest. Specifically, it was of interest whether the groups that were treated with Phase 3 would increase their phonics rule knowledge score when given the posttest of phonics rule knowledge.

Results

The reading grade score differences were measured between groups. Results indicate a significant difference was found between groups, $F(2,33)=36.44$, $p<.001$, $MS=18.57$. A Tukey *b* Post Hoc analysis indicated that the difference occurred between the non-LD group and both LD groups.

During Phase 1 of the study, all three groups underwent an implicit learning session where they were exposed to and implicitly learned to criterion the correct pronunciation of pseudowords that followed one of the two possible phonics rules. A measurement of trials to criterion revealed a significant difference between groups, $F(2,33)=9.55$, $p<.05$, $MS=11.86$. A Tukey *b* Post Hoc analysis showed that the difference occurred between the non-LD group and both LD groups. Trials and errors to criterion for all groups are illustrated in Table 2.

During Phase 2 of the study all three groups were administered a transfer test designed to assess whether they were using the phonics rules acquired in Phase 1. This test measured the degree to which implicit knowledge acquired in Phase 1 had been learned and transferred to memory. Two tests were administered, one consisting of isolated words and the other of sentences. This was done in order to assess to what degree the reading of the pseudoword in the sentence was a function of sentence context cueing. Each of the tests was scored out of a possible 12 marks. A paired sample *t*-test showed no significant differences between both isolated word and sentence tests in each group, LD Pos, $t(1,11)= -1.1959$, $p=.745$; LD Neg, $t(1,11)= -0.1016$, $p=.811$; NA Pos, $t(1,11)= -0.0331$, $p=.856$. Therefore, the scores on both tests were averaged together and defined as a phonics rule Performance variable. This variable was interpreted as being indicative of the amount of knowledge of the phonics rule that was implicitly acquired during Phase 1. LD Pos had a mean phonics rule Perfor-

Table 2
Trials and Errors to Criterion

	Trials to Criterion		*Errors to Criterion*	
	Mean	*SD*	*Mean*	*SD*
LD Pos	7.33	1.07	41.75	7.00
LD Neg	7.58	1.00	44.50	4.62
NA Pos	5.57	0.75	30.75	4.49

mance score of M=8.25 (1.22), LD Neg had a mean of M=8.33 (1.05), and NA Pos had a mean of M=9.38 (1.13). A one-way analysis of variance indicated that there was a significant difference between groups in their ability to transfer knowledge to memory, $F(2,33)=3.89$, $p<.05$, $MS=1.13$. A Tukey *b* Post Hoc analysis revealed that the difference occurred between the group of students without LD and both groups of students with LD.

In Phase 3 only students in LD Pos and NA Pos used the role-reversed teaching technique in order to verbalize about the phonics rule. Verbal reports were recorded and coded into three operationally defined variables. The first verbal report variable was labeled Accurate Verbal Report (AVR). In order for students to receive a score of 1 for this variable, they must have fully and accurately verbalized the mechanics of the phonics rule. Specifically, students needed to state fully that the pseudowords differed in pronunciation according to the suffix and middle consonant blend of each word. The second verbal report variable was labeled Partial Verbal Report (PVR). In order for students to receive a score of 1 for this variable, they must partly complete a somewhat inaccurate verbal report about the mechanics of the phonics rule. Specifically, students needed to state that the pseudowords were pronounced differently and that the difference was dependent on either the pseudoword's middle consonant blend or the pseudoword's suffix component. The third verbal report variable was labeled Inaccurate Verbal Report (IVR). In order for students to receive a score of 1 for this variable, they must have had completely inaccurate verbal reports about the phonics rule. Group differences for all Verbal Report variables are illustrated in Table 3.

Phase 4 of the study included all three groups. Groups were administered a posttest of knowledge of the phonics rule. The posttest was similar to the test administered in Phase 2, one test consisting of isolated words and the other consisting of sentences. The sentences were different from those presented in Phase 2 in order to control for a practice effect. On the phonics rule Performance posttest, LD Pos had a mean score of M=8.79 (1.30), LD Neg had a mean score of M=8.42 (.90), and NA Pos had a mean score of M=9.67 (1.13). Similar to the pre test, an analysis of variance indicated a significant difference between groups, $F(2,33)=4.33$, $p<.05$, $MS=1.22$. However, a Tukey *b* Post hoc analysis indicated that the posttest difference occurred between the LD Neg and both LD Pos and NA Pos. Within-group pre- posttest scores are illustrated in Table 4.

Table 3
Univariate t-tests for Group Differences in Verbal Reports

	LD Pos		NA Pos		t-value
	Mean	SD	Mean	SD	
Accurate Verbal Report	.08	.29	.42	.51	−1.96*
Partial Verbal Report	.25	.45	.33	.45	−0.43
Inaccurate Verbal Report	.67	.51	.25	.45	2.16*

*$p<.05$.

Discussion

Little research has been done on the role of consciousness in the acquisition of phonics rules. In this study students both with and without LD were exposed to two types of pseudowords conforming to one of two phonics rules.

Our first hypothesis examined the association between what was implicitly learned and what could be verbalized in students both with and without LD. One element of this hypothesis was students' implicit learning and implicit knowledge. As indicated in Table 1, students with LD took significantly longer to reach the phonics rule criterion and also made significantly more errors while reaching this criterion. This result is not surprising given the chronological age-match design of this study. Students with LD were matched with NA students for chronological age and, as measured by the Woodcock Johnson Test Battery, were reading significantly below the NA group. These data combined with the information from teachers and the data acquired from IEPs suggest that the students with LD in this study have a significant phonological processing problem that affects their reading ability. Assuming this, it was expected that students with LD would appear to lag in their implicit acquisition of the pseudoword phonics rule. The data in Table 1 indicate that this lag exists. However, it is important to recognize that students with LD eventually do acquire the phonics rule.

Following the implicit acquisition phase, both LD and NA groups were administered a test of implicit knowledge. The NA group had an average implicit knowledge score of 78.17% and the LD groups had an average implicit knowledge score of 69.42. These results indicate that both groups acquired the phonics rule in some implicit sense. Although students without LD did show a

Table 4
Pre- Posttest Scores of Knowledge of Phonics Rules

	Pretest		Posttest		t-value
	Mean	SD	Mean	SD	
NA Pos	9.38	1.13	9.67	1.13	−2.00
LD Pos	8.25	1.22	8.79	1.30	−3.32*
LD Neg	8.33	1.05	8.42	.90	−.34

*$p<.01$.

quicker rate of implicit learning, these results did not indicate that students with LD lack the capacity to learn the phonics rule implicitly. In fact, the groups of students with LD did reach criterion soon after the group of students without LD. There was not one case in which a LD student did not reach criterion. These results are in accordance with the findings of Winter and Reber (1994) who make three assumptions about implicit functions. First, implicit systems should be robust in the face of disorders and dysfunctions that compromise explicit cognitive systems. Second, implicit cognitive functions should show fewer effects of age and developmental level than explicit cognitive functions. Third, measures of implicit functions should show less individual-to-individual variability than corresponding measures of explicit functions. Students were able to learn to decode the pseudowords. Most students were also able to pass the transfer test, which meant that they had some implicit knowledge of the underlying rules governing the pseudowords.

Our first hypothesis also included the expectation that there would be some dissociation between what was implicitly learned and what could be verbalized. This was partly supported in that only 8% of students with LD and only 42% of students without LD were able to verbalize accurately about the phonics rule. Initially, this suggests that a dissociation exists between implicit and explicit knowledge. In other words, students both with and without LD did have implicit knowledge of the phonics rule, but had significantly less explicit knowledge of the rule. A great deal of psychological research recognizes a dissociation between conscious and unconscious functions. However, reading research has not ventured into this area. Results of this study suggest that neither the students with or without LD had a full conscious awareness of the phonics rule. We offer two possibilities to explain this finding. First, it is possible that the ability to verbalize about a learned phenomenon develops hierarchically. That is, as students continue to progress in their processing fluency and automaticity, they will reach a stage where the underlying rules governing words will become fully conscious. This explanation may result in the belief that conscious awareness of a learned phenomenon is akin to the underlying cognitive processing. This holds an important educational implication. Students' ability to verbalize about a phonics rule, or any other learned phenomenon, may be developmental in that some students will reach verbalization proficiency before others. Assuming this, educators must be aware that a student's inability to verbalize about a learned phenomenon is not perennial. With continued scaffolding students will probably develop proficiency in verbalizing about the phenomenon.

The second possibility, which is related to the first, is that the processing demands placed on students' WM precluded full verbalization of the phonics rules. In Phase 1 of the study students both with and without LD were exposed to a multitude of sentences containing a pseudoword governed by a phonics rule. Students were also focused on the feedback given to them by the experimenter. The cognitive processes associated with Phase 1 include students' implicit perception and encoding of the phonics rule, the retrieval of relevant prior knowledge about grammatical and phonics rules, and the integration of the new and prior knowledge. These processes would have certainly placed a high demand on students' WM. Given the limited capacity of WM, perhaps little cognitive capacity was available for verbalization. This explanation may also be useful in explaining the difference in verbalization between students with and without LD. Research has been successful in showing that many students with LD have difficulty with processing and storage functions associated with WM (for a review see Swanson 1998).

Although some dissociation exists, the ability to report verbally on the mechanics of the phonics rule was at least partly evident in students both with and without LD. This is somewhat contradictory to the findings of other research (Berry & Broadbent, 1988; Lewicki et al., 1988; Nisbett & Wilson, 1977). However, one might expect the current results given this study's methodological and theoretical assumptions. First, in following the practice of many classrooms, the verbal reports in the current study were retrospective in nature. However, the reports were obtained immediately following the phonics rule learning session. In accordance with the information processing model proposed by Ericsson and Simon (1993), we predicted that retrospective verbal reports obtained immediately after the acquisition phase should be relatively accurate and complete. The results of this study indicate that 42% of the students without LD had fully accurate verbal reports and another 33% had partly accurate verbal reports of the phonics rule. This may be understood in terms of the information accessible in STM when the verbal reports were elicited. Much of the information that was called on to be verbalized about may not yet have transferred to LTM. Therefore, this information would still be in STM, accessible to consciousness and able to be verbalized.

This result was not consistent with the group of students with LD. Our second hypothesis addressed whether students without LD would have more complete and correct verbal reports than would students with LD. Significant ability group differences were found in the quantity and quality of the verbal reports. Only 8% of students with LD had fully accurate and complete verbal reports, and another 25% had partly accurate verbal reports. This finding invites many possible explanations, two of which we offer here. First, this may be explained by an artifact of the methodology. In this study students with LD were matched with NA students for chronological age. This methodology was adopted purposely in order to examine the cognitive processes of students with and without LD. However, this design meant that NA students were likely to have superior reading skills and subsequently a more advanced knowledge of grammatical and phonics rules. Thus this may enable NA students to verbalize more readily about these rules. This effect is comparable to the "Matthew effects" often found when comparing students with and without LD (Stanovich, 1986). This explanation certainly holds weight. However, we believe that this explanation alone may not sufficiently explain the data because students both with and without LD did reach criterion in their implicit knowledge of the phonics rule. In fact students with LD required many more trials to reach criterion and hence had more exposure to this rule, inviting the notion that reading level may have been a greater factor in students' implicit acquisition of the phonics rule. When attempting to explain the verbalization of the rule, we felt that reading level when considered alone might not adequately explain the between-group differences.

A second explanation draws from the idea that students with LD show poor control processes in their ability to rehearse and control information (Swanson, 1998; Wong, 1982). These control processes are associated with the executive component of WM and are crucial factors in students' ability to encode information so that it can be assimilated and accommodated in LTM. The executive processing difficulties experienced by students with LD may be manifest in an inability to maintain information in STM. Following the framework of Ericsson and Simon (1993), maintenance of information in STM is a prerequisite of verbalization. Consequently, executive control difficulties experienced by students with LD may have affected their ability to report verbally about their acquisition and the mechanics of the phonics rule.

The third hypothesis of this study addressed the cognitive benefits of using a role-reversed teaching technique. This technique was considered metacognitive in that students had to monitor, question, and regulate their own understanding of the phonics rule so that they could verbalize it to a naive subject. Such internal metacognitive monitoring increases depth of cognitive processing. The NA group and one LD group (LD pos) were given the opportunity to use this technique, whereas the second LD group was not. All three groups were then given a posttest of implicit knowledge. This test was administered in order to measure the effect of the verbalization technique. Results showed that the LD group employing the technique significantly improved their posttest scores. The increase was large enough that there was no longer a significant difference between students with and without LD. This suggests that the employment of this strategy was beneficial for students with LD in their knowledge of the phonics rule. This observation holds some important educational implications. First, as stated above, this type of role reversal scaffolds students' metacognitive monitoring. Such monitoring is beneficial in that it enables students to monitor the adequacy of the information on which they will base their teaching, and this in turn increases students' depth of cognitive processing. The second implication is affective in nature. When employing the role reversal technique, students take the position of the teacher. This itself can make students feel that their input is important and also that they are responsible for the outcome of the task. Increased responsibility often leads to an internal locus of control. Students who have an internal locus of control tend to make internal causal explanations for a task and hence have increased positive reactions and reasons to persist or work hard at a task. This is particularly important for students with LD who typically experience a great deal of academic frustration and often have a low academic self-concept.

Finally, students both with and without LD were successful in the implicit learning of a phonics rule. On the other hand, when examining students' verbal reports, a significant between-group difference was found. Hence there was evidence of some dissociation between implicit learning and explicit knowledge. However, this dissociation was not absolute. Students without LD were quite efficient and accurate in their verbal reports, whereas students with LD were much less successful.

The students with LD in this study were reading significantly below their NA peers. This between-group difference in reading ability may be responsible for LD students' delayed implicit acquisition of the phonics rule as well as their poor ability to verbalize about this rule. Also, many students with LD have executive processing problems that may affect their ability to acquire and then verbalize about phenomena being learned. In this study these difficulties may have been manifested in a delay in LD students' ability to acquire a phonics rule implicitly and to verbalize about this rule.

The relationships between implicit and explicit functions are deserving of further research. Educators must be aware of the benefits of allowing implicit learning to take place in the classroom. However, educators must also be aware that verbal ability may not be a representative measure of this learning. This is especially true with the learning-disabled population.

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