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A STIMULUS CONTROL ANALYSIS OF THE PICTURE-WORD PROBLEM IN CHILDREN WHO ARE MENTALLY RETARDED: THE BLOCKING EFFECT

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Conditioning to one member of a compound stimulus can be blocked by the presence of a second member to which the response was previously conditioned. This account of selective stimulus control can be used to explain the finding that pictures inhibit learning of written words if the relevant pictures and their verbal equivalents have been paired previously. We tested the blocking explanation of the picture-word problem with 8 mentally retarded students. Following baseline, each student was presented daily with four conditions in an alternating treatments design. In Condition A (blocking), a picture was presented alone and then was followed by the presentation of a picture and written word compound stimulus; in Condition B (blocking/control), a word was presented alone; in Condition C (blocking minimized), a word was enhanced in size and presented alone followed by the word and a picture; and, in Condition D (blocking minimized/control), the enhanced word was presented alone. Each stimulus was presented for 15 s. All students had the lowest percentage of words read correctly in the blocking condition, and all improved when blocking was minimized. Six of 8 students reached their highest percentage of words read correctly in the two control conditions when the words were presented as a single stimulus without pictures. These results indicate that pictures inhibit some students' learning of new words; this may be due to the blocking of conditioning to written words by prior conditioning to pictures.

DESCRIPTORS: stimulus control, blocking, overshadowing, picture, word, children

In the initial stages of reading instruction, children usually are taught to read by pairing new words with extra stimulus prompts (e.g., the printed word is paired with a picture of the word). Although most children eventually learn to read the word in the absence of the picture, experimental studies suggest that, contrary to accepted practice, pictures may not facilitate word recognition and, indeed, may have an inhibitory effect on rate of learning (Miller, 1937; Samuels, 1967).

A number of explanations have been advanced to account for this problem, including the focal attention hypothesis (Samuels, 1967) and the theory of limited processing capacity (Lang & Solman, 1979; Saunders & Solman, 1984). However, the most parsimonious explanation of this problem can be derived from the classical and operant conditioning literature on selective stimulus control and, in particular, on compound conditioning. Kamin (1968, 1969) reported that, given a Compound Stimulus AB, sufficient training on Element A alone before AB compound training may result in virtually no conditioning occurring to B. He referred to the effect as the "blocking" of one element (B) of a compound (AB) by prior training on the other element (A). This finding has been replicated in a number of experiments with nonhumans, using both classical and operant conditioning paradigms (Mackintosh, 1975; Rescorla & Wagner, 1972).

The picture-word problem can be viewed as a problem in compound conditioning; that is, given

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a compound stimulus (picture plus written word), the prior conditioning of one element (i.e., picture) blocks conditioning to the other element (i.e., written word). Therefore, the associations that result when children are learning to read written words with pictures as prompts parallel those that occur when nonhumans are conditioned to a compound stimulus. The previously learned association between the picture (prior conditioned stimulus) and the response (spoken word) may act to block the formation of a new association between the written word (novel stimulus) and the response (spoken word), thus causing difficulty in learning written words when they are paired with pictures.

Although the concept of blocking was originally developed to explain the behavior of animals during discrimination learning, it has direct applications in applied settings. The primary purpose of the present study was to demonstrate an application of the concept of blocking in the analysis of an educational problem. Instruction in beginning reading is based on the premise that the pairing of words with pictures enhances learning, although some research data indicate that the presence of pictures may have an inhibitory effect on the rate of learning. These findings have important implications in the teaching of written words to students who are mentally retarded (see Singh & Singh, 1985), given that the rate of their learning is slow to begin with. The present study was designed to provide an empirical test of the blocking hypothesis of the picture-word problem by including conditions in the intervention phase that would either support or discredit this explanation. In particular, it was hypothesized that the two word-only conditions would produce the fastest learning, followed by the condition in which the blocking effects of the picture were reduced by enhancing the salience of the word, and that the condition in which the salience of the picture was increased would produce the slowest learning.

METHOD

Subjects and Setting

Eight students with mental retardation, 4 boys and 4 girls, participated in this study. They were between 7 and 9 years of age and were able to read about 10 words each. Two students had Down Syndrome and one had arrested hydrocephalus. All students were diagnosed as moderately mentally retarded based on the American Association on Mental Deficiency criteria (Grossman, 1983). The participants did not have seizures and did not take psychotropic medication during the study.

The study was conducted in a special resource room at the subjects' school. Each subject had received approximately 10 to 15 min of individualized reading instruction three times per week on word recognition by a teacher or teacher's aide during the previous 3 months. This procedure was discontinued for the duration of the study.

Stimulus Materials and Equipment

A pool of 70 five-letter nouns was chosen from the instructional reading level of the students. All students were tested twice on these words for recognition, and any word recognized at least once by any student was deleted. Then, the students were tested twice on the corresponding black-and-white pictures of the remaining words for recognition, and those pictures not identified correctly twice by all students were discarded. From the remaining words, 16 were chosen as the stimulus words for the study; each word began with a different letter of the alphabet. The words were *knife, lemon, money, radio, fence, nurse, bread, stamp, chalk, queen, giant, piano, eagle, jelly, train,* and *zebra.* Each word was printed in lowercase black letters and, along with its corresponding picture, was made into a slide. A random access slide projector was used to project the words and pictures onto a screen situated 1 m in front of the seated student. When projected onto the screen, the words from Conditions A and B were 2.5 cm high (criterion size) and the words from Conditions C and D were 5 cm high (enhanced size). The words were allocated in a random manner, four per condition, for each child. No 2 children had the same set of words in any one condition.

Response Definitions

A response was recorded as correct if the student's verbal response corresponded with the writ-

ten word. Any mismatch between the written word and the spoken word was recorded as an error. Responses were also recorded as correct if the student corrected an error without assistance from the teacher. Only the first attempt at self-correction, before response feedback was provided, was recorded as correct.

Recording and Reliability

Two elementary school teachers were provided with additional training by the experimenters in the implementation of the experimental procedures. Baseline assessments were initiated only after the teachers and an independent rater reached at least 95% agreement on response recording (either correct or error) and 100% agreement on the implementation of the experimental procedures.

An independent rater recorded 35% of experimental sessions to assess the reliability of the dependent and independent variables. Interrater reliability on the dependent variable, computed by using a word-by-word analysis, ranged from 95% to 100%, with an average agreement of 98% per session. The interrater reliability on the independent variable (i.e., accuracy in implementing the experimental procedures) was 100%.

Design

An alternating treatments design (Barlow & Hayes, 1979) was used to compare the effects of four experimental conditions on word recognition by children with mental retardation. The experimental conditions were:

Blocking of the word by the picture (Condition A). In this condition, two slides were presented, one after the other. The first slide was of a single stimulus, a picture. In the second slide, a compound stimulus was presented, with the picture on the top two thirds of the slide and the word on the bottom third. When compared to the word, the salience of the picture was enhanced (in terms of size) in the compound stimulus.

Control for Condition A (Condition B). In this condition, the word was presented as a single stimulus on the bottom third of the slide, as in Condition A, but without the picture. The word was of criterion size.

Reduction of the blocking effect of the picture (Condition C). As in Condition A, two slides were presented, one after the other. The word was presented in this condition as a single stimulus on the first slide. In the second slide, the word and picture were again presented as a compound stimulus, but in this condition the word was on the top two thirds of the slide and the picture was on the bottom third. When compared to the picture, the salience of the word was enhanced (in terms of size) in the compound stimulus.

Control for Condition C (Condition D). In this condition, the word was presented as a single stimulus on the top two thirds of the slide, as in Condition C, but without the picture. Although both control conditions (B and D) involved words alone as single stimuli, the words in Condition D had an enhanced salience because they were twice the size of the words in Condition B.

Procedure

Each session, consisting of the four experimental conditions and a daily posttest, lasted no more than 20 min. This included a break of 2 min scheduled after the fourth, eighth, 12th, and 16th (last) trial. The students were provided with drinks during the breaks and an edible reward for participation at the end of the daily posttest session. The study consisted of the following phases:

Baseline. During baseline, the students were tested once per session on all 16 written words, one word at a time, until stability was reached. Slides consisting of centered words of criterion size were used for testing during baseline. Each session began with the student seated at his or her desk, 1 m away from the screen. After establishing rapport, the teacher said to the student, "I am going to show you a number of slides that have words written on them. Try to read each word." The teacher presented a word and asked, "What is that word?" The student had 15 s to respond, during which time the word was visible on the screen. If 15 s elapsed with no response, the next trial was initiated. Each response resulted in feedback on accuracy and verbal praise for correct responses.

Intervention. The four experimental conditions

were presented during each session, followed by a single posttest session. Intervention continued until each student responded correctly to all four words in any one experimental condition during three consecutive posttests. The order of the 16 words was randomized daily before presentation to the child. A rehearsal teaching strategy was used during this phase with all 16 words. Thus, the only difference between the conditions was the manner in which the stimulus words and pictures were presented. The rehearsal teaching strategy was chosen because it had been demonstrated to be effective in enhancing a number of basic academic skills of mentally retarded students (Lenz, Singh, & Hewett, 1990), including spelling (Ollendick, Matson, Esveldt-Dawson, & Shapiro, 1980), sign language (Linton & Singh, 1984), and reading (Singh, Singh, & Winton, 1984).

For words in Condition A (blocking of the word by the picture), a picture corresponding to the stimulus word was presented alone for 15 s, and the student was told, "This is a picture of _____." The slide was then removed and, 2 s later, a second slide of the sample picture plus its equivalent written word was presented for 15 s, and the student was asked, "What is that word?" In Condition B (control for Condition A), each word was presented alone for 15 s and the student was asked, "What is that word?" No pictures were used during Condition B. For words in Condition C (reduction of the blocking effect of the picture), the written word was presented alone for 15 s and the student was told, "This word is _____." The slide was then removed and, 2 s later, a second slide of the same word plus its picture was presented for 15 s, and the student was asked, "What is that word?" In Condition D (control for Condition C), the written word was presented alone for 15 s, and the child was asked, "What is that word?" No pictures were used during Condition D.

The rehearsal teaching strategy was used for error correction during all four experimental conditions. Following a correct response to the question, "What is that word?", the student was provided verbal praise, "Yes, you are right! That word is _____. That's great!" Following an error, the student was told, "No, that word is _____. Now, say the word correctly five times."

Posttest. Following the intervention session, each student was given a posttest that was the same as baseline and used the same materials.

Remediation. The experimental condition found to be most effective in the intervention phase for each student was substituted for the other three conditions in this phase. Remediation was terminated when each student correctly responded to all 16 words during three consecutive posttest sessions.

RESULTS AND DISCUSSION

As shown in Figure 1, all students had the slowest rate of learning under the maximum blocking condition (Condition A), in which the size of the picture, relative to the word, was enhanced. Six students had the fastest rate of learning when the word was presented alone, either at criterion size (2 in Condition B) or enhanced in size (4 in Condition D). The remaining 2 students had the fastest rate under Condition C, in which the effect of blocking was reduced by enhancing the size of the word. The words presented with pictures as compound stimuli were correctly named in 26% of the posttest presentations, but the percentage of correct responses for the same words presented alone as a single stimulus was 47%. Also, only 2 students reached the criterion of four words correct on three successive test trials in the compound conditions. In both cases, this occurred in the minimized blocking condition (C), in which a large word (i.e., with enhanced salience) was presented.

This study demonstrates the blocking phenomenon in an applied situation. The results indicate that prior association of the picture with its verbal equivalent inhibits the learning of an association between the same picture and its written equivalent (printed word). This was demonstrated by all 8 students, who had the lowest rates of word acquisition under Condition A, with Conditions B, C, and D resulting in very similar patterns of performance during the remediation phase.

From a conceptual standpoint, the important finding is that the blocking hypothesis provides a

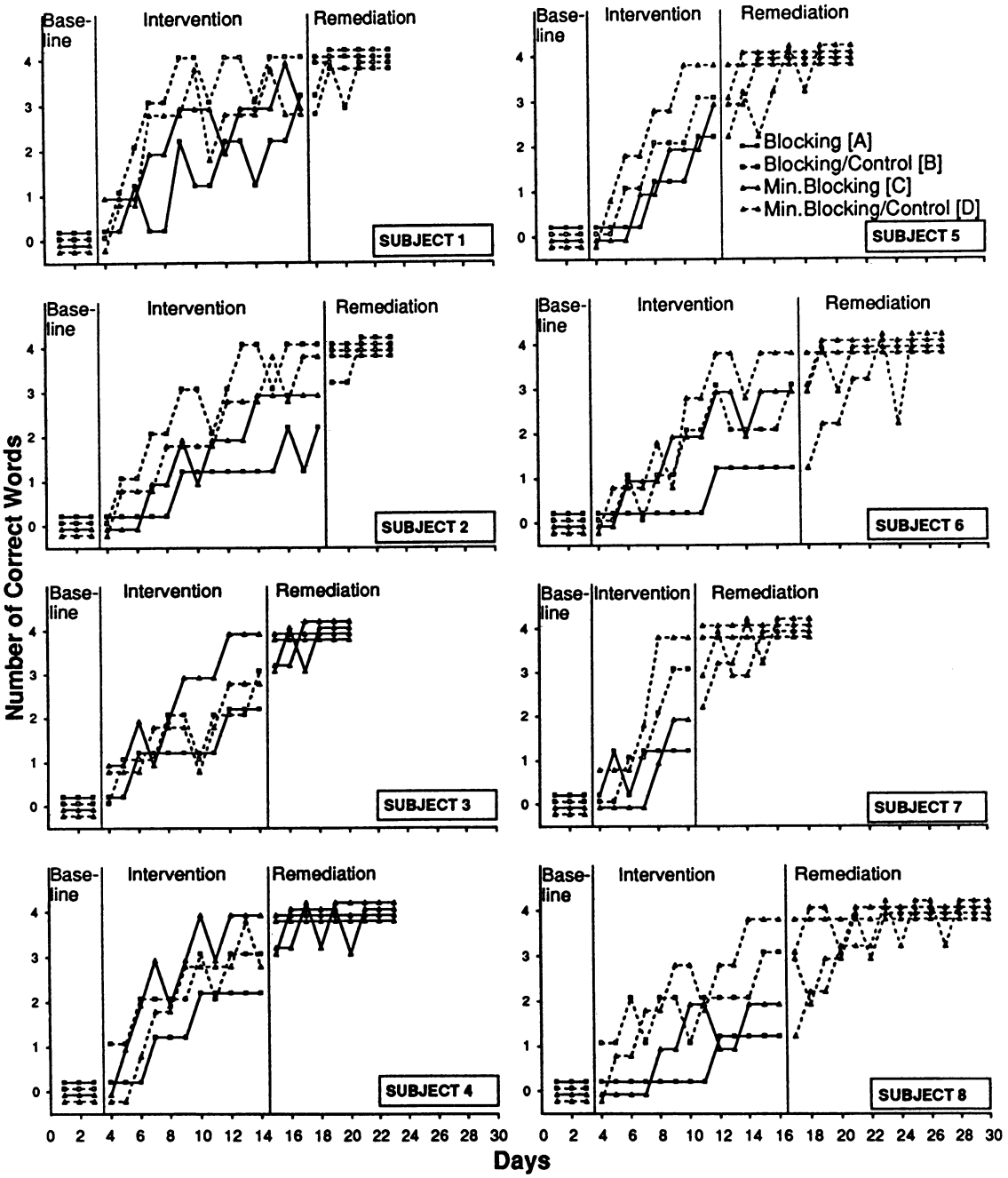

Figure 1. Number of words read correctly during baseline, intervention, and remediation. Posttest data are presented for the intervention and remediation phases. The condition that produced the most rapid learning was implemented in the final phase across all sessions.

compelling account for the picture-word phenomenon. In addition, the blocking hypothesis is broad enough to account for several related phenomena such as stimulus selection in paired associate learning with adults (Richardson & Stanton, 1972) and redundant relevant cue tasks with children (Trabasso & Bower, 1968).

There are two learning-theory explanations for

the blocking phenomenon: the reinforcement failure explanation of stimulus selection (Kamin, 1969; Rescorla & Wagner, 1972) and selective attention (Mackintosh, 1975; Pearce & Hall, 1980). The stimulus selection model posits that an unconditional stimulus (US) is able to support only a limited amount of conditioning and, once this limit is reached, the US can no longer initiate the processing that is necessary for associations to be formed. That is, the largest increment in association occurs in the very first trial, followed by successively smaller amounts in subsequent trials. Blocking occurs because of prior conditioning to Stimulus A; virtually all the conditioning that is available with the given US is acquired, leaving little that might accrue to the new stimulus added during compound (AB) training. According to this model, if the number of US presentations or US intensity is increased during compound training (i.e., permitting more conditioning), Stimulus B will acquire some associative strength and the effects of blocking will be attenuated.

In terms of the picture-word problem, if enough picture–spoken word (A-US) pairings occur, the associative strength of the picture (A) will approximate the value of the associative strength of the spoken word (US). Thus, from the first picture/written word–spoken word (AB-US) pairing, a written word–spoken word (B-US) association will be prevented from forming because the picture–spoken word (A-US) pairings have already used up most of the associative strength of the spoken word (US). Given that most young children bring to the learning situation a vast repertoire of verbal behavior that includes correct verbal responses to pictures, it is likely that the associative strength of common pictures will indeed approximate the value of the associative strength of their verbal responses to the pictures. When subsequently provided with a new picture/written word–spoken word pairing, young children may not attend to the written word because of the prior picture–spoken word pairing.

The selective attention model posits that if enough picture–spoken word (A-US) pairings occur, the presentation of the picture (A) eventually will predict the correct response (i.e., the spoken word/US). On the first picture–written word (AB-US) pairing, both the picture (A) and the written word (B) are attended to and a written word–spoken word (B-US) association begins to be formed. However, subsequent presentations of the picture–written word (AB-US) compound stimulus show that the written word (B) is redundant because it does not signify a change in the correct response (i.e., spoken word/US). Thus, the written word (B) receives no more attention and, hence, the written word–spoken word association does not develop any further.

Both models predict that presenting the written word alone (i.e., without pictures) will be more efficient in terms of learning to read new words. One promising area of research would be to assess the predictions of the two models in terms of blocking with a single compound trial. That is, what do students attend to when a picture-word compound stimulus is presented? The stimulus selection model predicts blocking with one trial because conditioning accruing to the written word would be negligible if conditioning to the picture is asymptotic. However, the selective attention model predicts the failure of blocking with a single compound trial because one trial with the picture–written word compound stimulus is needed to establish the redundancy of the added written word. At present, there is divided support from the literature on research with nonhuman subjects for both models (Azorlosa & Cicala, 1986; Balaz, Kasprow, & Miller, 1982), but no data from applied studies are available. In future research on this problem, it may be useful to use psychophysical equipment to track the orientation of the learner's eye to determine, for example, if the learner even orients toward the word following picture-only training.

One potential limitation of the present study concerns the provision of the verbal label for the picture during Condition A (blocking) and the word during Condition C (blocking reduction) but not during the control conditions (B and D). As a result, the compound stimui presented during Conditions A and C actually consisted of the picture, the word, and the verbal label provided with the picture or word during the initial presentation. When asked

what the compound stimulus represents, the students may have been responding to the verbal label provided moments earlier rather than to the written word provided within the compound stimulus. However, the use of posttest rather than acquisition data appears to preempt a verbal mediation explanation of the findings. Furthermore, a verbal mediation explanation would predict similar acquisition rates under the two blocking conditions (A and C), a prediction contrary to the present findings.

Another factor that deserves consideration is whether the actual phenomenon causing the inhibition in learning is a result of blocking, overshadowing, or a combination of the two operations. As typically presented in the basic research literature (e.g., Rescorla, 1988), blocking effects occur when a student's learning history is to respond at criterion to a specific stimulus (e.g., a tone). After a training criterion has been met for responding to the tone, a second set of training occurs in which the tone is paired with a second stimulus (e.g., a light) until a training criterion again has been met. In overshadowing, however, both stimuli are always present during training, but the saliency of one of the stimuli (e.g., the volume of the tone) is exaggerated relative to the other stimulus. The outcome for the students is usually the same (i.e., they come under stimulus control of only the tone), although the operations by which this occurs are different. Although blocking appears to be the basic operation involved in the present study (because the students responded to criterion on the pictures in the pretest prior to picture-word conditioning), overshadowing may have occurred also because the salience of the picture (Condition A) and the word (Condition C) was enhanced.

The findings reported in this paper are important for applications in educational practice. Beyond confirming what perhaps is already known about learning by individuals with mental retardation, the findings are of major importance to teachers of beginning readers in general. Virtually all beginning reading texts used to teach initial words to young children contain pictures *and* words. Our findings suggest that acquisition of basic written words can be more rapid if texts with only words are used. Of course, these results do not provide the basis for teaching reading to children who have already acquired basic words because, for them, the presence of pictures may provide the context for increased comprehension (Singh & Singh, 1984).

Of primary importance is that the present study integrates basic and applied research within a stimulus control paradigm. The vast amount of basic research on stimulus control is useful not only in developing effective and efficient instructional programs (e.g., Repp, Karsh, & Lenz, 1990) but also, as in the present study, in analyzing the operations that explain the occurrence of educationally significant behavior in children, thereby enhancing the social validity of basic research. More research that directly applies principles derived from basic research to educational practice is needed.

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