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Increasing the Work Rates of Visually-Impaired, Mentally Retarded Adults through the Treatment and Prevention of Overselectivity (Overshadowing) and Masking

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INCREASING THE WORK RATES OF VISUALLY-IMPAIRED, MENTALLY RETARDED ADULTS THROUGH THE TREATMENT AND PREVENTION OF OVERSELECTIVITY (OVERSHADOWING) AND MASKING

by

John Schwade

A Thesis
Submitted to the
Faculty of The Graduate College
in partial fulfillment of the requirements for the Degree of Master of Arts
Department of Psychology

Western Michigan University
Kalamazoo, Michigan
December 1982
In Experiment 1, three legally-blind, mentally retarded adults were given 10 to 12 applications of discrimination training between pairs of sequential compound stimuli with immediate tactile and delayed (3-3.5 sec) visual elements. Sorting responses were brought under the control of these stimuli. In 29 of 33 applications, discrimination training resulted in reduced sorting rates concomitant to overselectivity (overshadowing), such that stimulus control was acquired by only delayed visual elements. Single-stimulus discrimination training (SSDT) between the previously-overshadowed immediate tactile elements produced expression of stimulus control by those elements of compound stimuli in 5 of 6 cases. SSDT with novel stimuli produced expression of stimulus control by immediate tactile elements of compound stimuli in 6 of 6 cases. In Experiment 2, three cases of masking, where stimulus control acquired by tactile elements in Experiment 1 was not expressed when tactile elements were presented in compound stimuli, were successfully treated by differential reinforcement of correct sorting responses occurring before the presentation of the delayed visual element.
ACKNOWLEDGEMENTS

I am indebted to Dr. Jack Michael, Dr. Howard Farris, and especially to Dr. Wayne Fuqua for their help in the preparation of this paper. I also wish to thank Stephen Schwade for his editing and Science Graphics for making a special effort in the preparation of the figures. Finally, I wish to acknowledge that both the conduct of this research project and the preparation of this manuscript would not have been possible without the constant aid and support of George Rhodes, M. D., and especially of Abigail S. Daniels, A. H.

John Schwade
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CHAPTER I

EXPERIMENT 1

Introduction

The work rates of mentally retarded adults employed in sheltered workshops and work activity centers are a primary determinant of their placement and advancement. Under certain conditions, a crucial determinant of work rate is the stimulus that controls work behavior. Specifically, when two (or more) stimuli have the same correlation with reinforcement for a particular response (so that each indicates to the worker the proper way to do a job), stimulus control of that response by one of these stimuli may produce a higher work rate than does stimulus control by the other stimulus. The effect of control by a particular stimulus upon work rate is especially evident when control by one stimulus necessitates the worker making an extra observing response whereas control by another stimulus does not. For example, when a worker can not assemble an object without continually interrupting his or her work to look at an assembled sample of that object, work will be slower than when each addition to the object indicates the next step in assembly.
In the terminology established by those conducting basic research in stimulus control (e.g., Johnson, 1970; Johnson & Cumming, 1968; Reynolds, 1961), each of two stimuli bearing the same relationship to reinforcement may be referred to as elements of a compound stimulus (CS). When the elements of a CS are not presented simultaneously, their presentation constitutes a sequential compound stimulus (Bellingham & Gillette, 1981; Thomas, Berman, Serednesky, & Lyons, 1968), as opposed to a simultaneous CS. Herein, the term "sequential compound stimulus" shall be extended to situations in which both elements of a CS are presented (or present) simultaneously, but the need for a worker to make an extra response to see one of those elements effectively makes that CS a sequential compound stimulus. Discrimination training involving one or more compound stimuli shall be referred to as compound-stimulus discrimination training, or CSDT, after established usage (e.g., Johnson, 1970; Johnson & Cumming, 1968; Reynolds, 1961).

The elements of a CS may be in different sensory modalities, as when a worker may both see and feel the differences between two objects, or both see and feel how to do a job. Work is sometimes most efficient when it is controlled exclusively by stimuli of a particular sensory modality. Typing, for instance, can be accomplished much faster when the typist does not have to
look at the keyboard, and typing is instead controlled by tactile stimuli, specifically the position of each key.

For visually-impaired workers, control of work behavior by visual stimuli often necessitates making an extra response to magnify the visual stimulus, either lifting an object closer to their eyes or lowering their eyes to the object. When tactile stimuli are available concurrently, as when a worker manipulates objects with distinctive tactile and visual elements, work controlled by visual elements will typically be slower than work controlled by tactile elements. The presentation of a sequential CS with an immediate tactile element and a visual element delayed by a magnifying response shall hereafter be referred to as a visual-lag compound stimulus, or V-lag CS.

Despite the greater efficiency and speed of work controlled by tactile elements under the stated conditions, stimulus control by tactile elements may never develop. When the development of stimulus control by one element of a CS prevents the development of stimulus control by another element, the problem is called stimulus overselectivity, or just overselectivity (Lovaas, Schreibman, Koegel, & Rehm, 1971, coined this term). This problem has been displayed by mentally retarded individuals (Bailey, 1981; Lovaas et al., 1971;
Wilhelm & Lovaas, 1976). Thus, overselectivity, wherein stimulus control is acquired by only the delayed, visual element of a sequential CS, may reduce work rates of mentally retarded, visually-impaired workers.

Overselectivity was first demonstrated by Lovaas et al. (1971). They administered discrimination training to one group each of autistic, retarded, and normal children. Responses were reinforced only in the presence of a simultaneous CS consisting of visual, auditory, and tactile elements (a red floodlight, white noise, and inflated blood-pressure cuff, respectively). In the absence of this CS responses were never reinforced. Following discrimination training, each element was presented separately and responding to each was measured. Lovaas et al. reported that, generally, autistic subjects responded to only one element of the CS, retarded subjects to two, and normal children to all three. Numerous demonstrations of overselectivity have since been published (Bailey, 1981; Koegel & Schreibman, 1977; Koegel, Schreibman, Britten, & Laitinen, 1979; Koegel & Wilhelm, 1973; Lovaas & Schreibman, 1971; Schover & Newsom, 1976; Schreibman, Koegel, & Craig, 1977; see reviews by Lovaas, Koegel, & Schreibman, 1979; Lovaas & Newsom, 1976).

A sufficient treatment for reduced work rates concomittant to overselectivity would seem to be the establishment of stimulus control by the previously-ignored
element. Although subjects who respond to each element of a CS presented separately do not necessarily respond to both elements when they are presented simultaneously (Honig & Urcuioli, 1981), they might respond to the previously-ignored element when it is presented as the immediate element in a sequential CS. There are two reasons to expect this result. First, the immediate element of a sequential CS is, of course, present in isolation prior to the presentation of the delayed visual element. Second, Randich, Klein, and LoLordo (1978, Exp. 3) showed with pigeon subjects that when stimulus control of a particular response was acquired separately by two stimuli, which were then presented in a sequential CS, subjects responded to the immediate element of the CS. Note, however, that the immediate element was not a previously-ignored element.

Three treatments for overselectivity, each establishing stimulus control by the previously-ignored element of a CS in isolation, have been reported. Schover and Newsom (1976) accomplished this with autistic children by using a combination of overtraining and partial reinforcement of correct responses to compound stimuli. Subjects received discrimination training between two compound stimuli. Initially, every correct response was reinforced. Subsequently, in the partial-reinforcement condition, an average of every third correct
response was reinforced. Throughout both conditions, all incorrect responses were punished. Prior to overtraining, the stimulus control acquired by each element was measured by presenting a separate element on every fifth trial. On these trials correct responses were not reinforced. Overtraining consisted of a repeat of the sequence of continual reinforcement and partial reinforcement conditions. Finally, the stimulus-control test was repeated.

The first stimulus-control test revealed overselectivity. In the second administration of the test, following overtraining, there was a statistically significant increase in responding to the previously-ignored element. Unfortunately, the authors did not publish data for individual subjects, which would have revealed whether overtraining produced consistent responding to the previously-ignored element in any given individual. Therefore the applicability of the procedure to working behavior, where consistent performance is vital, is difficult to evaluate.

Schreibman, Koegel, and Craig (1977) found that responding to the previously-ignored element of a CS increased as testing for the development of stimulus control by that element progressed. As in the Schover and Newsom (1976) experiment, stimulus-control test trials consisted of the separate presentation of an
element without reinforcement of correct responses. The results revealed an interaction among extended testing and two other factors, overtraining and schedule or reinforcement for correct responses. When testing was preceded by, in order, the schedule of partial reinforcement and continual punishment employed by Schover and Newsom (1976) and then 10 to 70 trials of overtraining, 8 of 8 subjects responded on 100% of the test trials. When overtraining was preceded by reinforcement of all correct responses, 3 of 4 subjects responded on 100% of the test trials. When this continual reinforcement of correct responses was not followed by overtraining, only 3 of 7 subjects responded on 100% of the test trials.

These results are the most impressive to date and, as such, the experiment of Schreibman et al. (1977) is an important contribution to the understanding of overselectivity. Nevertheless, the prolonged-testing procedure does not seem applicable to the present problem because there is no evidence that responding to the previously-ignored element will continue once the procedure is terminated, and continuation of the procedure is likely to result in a decrease in responding to the previously-ignored element. The stimulus-control testing that produced responding to the previously-ignored element was actually not extensive. In fact, each
subject received between 32 and 48 test trials, of which only one-half involved presentation of the previously-ignored element. Thus, the results might represent performance in a transition state (Sidman, 1960). The available evidence indicates that continued non-reinforcement of responses to the previously-ignored element would result in the extinction of such responses. In stimulus-generalization tests in which performance remains stable for long periods of time (e.g. Hanson, 1956), all of the stimuli or elements presented are correlated with the same schedule of reinforcement (or non-reinforcement). In the Schreibman et al. (1977) testing procedure, contrariwise, while responses to the separate elements were not reinforced, one-third of the responses to the CS were reinforced. This correlation of different reinforcement schedules with the stimuli presented during testing is sufficient to establish stimulus control such that, eventually, subjects respond only to the CS (Mackintosh, 1977; Schwartz, 1978).

Finally, Koegel, Schreibman, Britten, and Laitinen (1979) reported that during CSDT, a change from a continual reinforcement condition to the partial schedule of reinforcement utilized by Schreibman et al. (1977) increased responding to the previously-ignored element of a CS. Initially, each of two groups received CSDT, during which every correct response was reinforced and
every incorrect response was punished. For a partial reinforcement group, the schedule of reinforcement was changed so that one-third of correct responses were reinforced, while for a control group conditions remained unchanged. Testing for stimulus control by each element of the CS was conducted as in Schreibman et al. (1977), with each element presented separately and correlated with non-reinforcement of responding. In the partial-reinforcement group, 10 of 12 subjects responded correctly to the previously-ignored element at least 7 of the 8 times it was presented, and 5 of these 10 subjects responded correctly every time it was presented. In the control group, these figures were 6 and 2, respectively. But again, although the magnitude of this effect is substantial, it is not great enough to warrant the application of this procedure to working behavior.

With respect to the development of new, more effective treatments for overselectivity, Lovaas et al. (1979) stated, "Much may be learned by relating the studies on stimulus overselectivity more closely to similar work with animals" (p. 1250). This allows researchers to identify basic processes underlying overselectivity, and in turn to uncover potential treatments from among the procedures that have been used to modify those basic processes. Lovaas et al. (1979) and others (Koegel & Rincover, 1976; Koegel & Schreibman, 1974; Lovaas et al.,
1971) have facilitated this search for new treatments by pointing out the similarity between the overselectivity paradigm that has been employed with human subjects and the overshadowing paradigm that has been employed with animal subjects. As with overselectivity, overshadowing is said to have occurred when, following CSDT, responding occurs exclusively or predominantly to only one element when each element is presented separately (Honig & Urcuioli, 1981; Koegel & Schreibman, 1974; Mackintosh, 1977; Schwartz, 1978; Zeiler, 1978).

Reynolds (1961) was the first to demonstrate the phenomenon of overshadowing using the operant method of studying stimulus control. Initially, CSDT was administered to two pigeons. Key-pecking responses were reinforced in the presence of a CS consisting of a white triangle on a red background (S+) and extinguished in the presence of a CS consisting of a white circle on a green background (S­). When responding occurred almost exclusively in the presence of the S+ CS, responding to each element (red, green, triangle, circle) was measured separately. One pigeon responded almost exclusively to a single element of the S+ CS, the red key, while the second pigeon responded almost exclusively to the other element of the S+ CS, the triangle. The overshadowing effect has since been reproduced many times in the laboratory (see reviews by Honig & Urcuioli, 1981;
Mackintosh, 1977).

Johnson and Cumming (1968) have demonstrated a procedure that modifies overshadowing and is therefore a potential treatment for overselectivity. The procedure, single-stimulus discrimination training (SSDT), was applied after CSDT to train a discrimination between previously-ignored, or previously-overshadowed, elements of two compound stimuli. (Because two elements differing along one dimension were presented in discrimination training, perhaps "single-stimulus" is a misnomer; "single-dimension discrimination training" would be more descriptive.)

In Johnson and Cumming's (1968) Experiment 1, two pigeons were given CSDT between an S+ CS, a vertical line on a green background, and an S- CS, a horizontal line on a red background. Subsequently, each element (vertical and horizontal lines, green and red keys) was presented separately and responding to each was measured over two sessions. By the second of these separate-element test sessions, nearly 100% of the subjects' responses were made to the green element of the S+ compound stimulus. In fact, one pigeon did not respond at all to the vertical line element of the S+ compound. The results of Experiment 1 essentially served as a baseline for Experiment 2, determining the extent of stimulus control likely to be acquired by each element of the compound stimulus.

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stimuli during CSDT. In Experiment 2, two naive pigeons were given the same CSDT as the subjects in Experiment 1, followed by SSDT between the previously-overshadowed elements, the vertical (S+) and horizontal (S-) lines. The results of separate-element tests administered after SSDT revealed the establishment of a high degree of stimulus control (commensurate with that established by discrimination training when overshadowing does not initially interfere with learning) by the previously-overshadowed elements. The two subjects made 70% and 90% of their total responses to the vertical line element of the S+ CS. In fact, the subjects' responding to the line elements was selective; they made only 20% and 10%, respectively, of their total responses to the green element of the S+ CS, which had overshadowed the vertical line element in Experiment 1.2

SSDT might also be used to prevent, as well as treat, overselectivity. When it is possible to predict which elements of compound stimuli will be overshadowed during CSDT, those elements can be presented in SSDT prior to CSDT. Both this paradigm, SSDT prior to CSDT, and the resulting phenomenon, selective responding during CSDT to the elements that had been presented in SSDT, are called blocking (Kamin, 1968, coined this term; see reviews by Honig & Urcuioli, 1981; Mackintosh, 1977). Johnson (1970) provided one of the first
demonstrations of blocking in stimulus control of operant behavior. One group of pigeons was initially given SSDT, wherein responses to a vertical line (S+) were reinforced and responses to a horizontal line (S-) were extinguished. Thereafter, the vertical and horizontal lines were superimposed upon blue and yellow backgrounds, respectively, forming compound stimuli with line elements (vertical and horizontal) and color elements (blue and yellow). CSDT ensued, during which the reinforcement schedules correlated with the S+ and S- line elements remained unchanged. A subsequent generalization test consisted of the separate presentations of five line tilts and five color wavelengths. A control group received CSDT followed by the generalization test.

For subjects exposed to SSDT prior to CSDT, the generalization gradients obtained with the various line angles were steeper than those obtained with the various colors, indicating a greater degree of stimulus control by the wavelength dimension. In comparison with the control subjects, they exhibited a substantially greater degree of stimulus control by the line-tilt elements and a lesser degree of stimulus control by the color elements, which indicates that this selective responding to the line-tilt elements was not the result of overshadowing (i.e., selective responding would not have occurred if CSDT had not been preceded by SSDT). The blocking
phenomenon has been reproduced often (Chase, 1968; Chase & Heinemann, 1972; Fields, 1978; Mackintosh & Honig, 1970; Miles, 1970; vom Saal & Jenkins, 1970; see reviews by Honig & Urcuioli, 1981; Mackintosh, 1977).

Thus, a single procedure, SSDT, might be applied after CSDT to treat overselectivity when it develops, or prior to CSDT to prevent the problem from developing. To distinguish between these two SSDT paradigms, the former application will be called overshadowed-stimulus discrimination training (OSDT), whereas the latter application will be called blocking (BLKG).

Experiment 1 is a systematic replication of both OSDT and blocking with human subjects, specifically visually-impaired, mentally retarded workers. Subjects performed simulated quality-control inspections requiring sorting of two types of objects. Objects were first handed to workers under a shield that prevented them from seeing the objects. After the imposition of a delay approximating the time it usually took a subject to make a magnifying response, an identical object was shown to the subject. Workers received reinforcement each time they sorted an object to the correct side, whether the sorting response occurred before or after the object was shown to the worker. Thus, on each trial, workers were presented with a sequential CS consisting of an immediate tactile element, which they could feel,
and a delayed visual element, which they could see, and CSDT was used to teach workers to sort objects to the correct side. When CSDT resulted in reduced work rates concommitant to overselectivity, the effectualness of OSDT as a treatment was experimentally analyzed. The effect of blocking as a preventative for this problem was also analyzed experimentally. It was expected that SSDT would produce higher work rates by enabling workers to respond to immediate tactile elements of V-lag compound stimuli, and further, that once they were able to do this, subjects would not wait for the presentation of the visual element before sorting an object.

Method

Subjects

Three visually-impaired, mentally retarded adults participated. All had been diagnosed as legally blind and borderline retarded. Physician's reports of functional vision for each subject indicated that Subject 1 was able to read 18-point type at a distance of one inch, Subject 2 could count fingers at a distance of five feet, and Subject 3 could read 18-point type at a distance of one foot. Subjects were selected on the basis of the observation that they made visual magnifying responses as they manipulated objects, even when those objects had distinctive tactile features.
The ages of Subjects 1, 2, and 3 were 33, 41, and 49 years, respectively. The subjects were employed in a work activity center. Subject 1 had worked there for 7 years, Subject 2 for 10 years, and Subject 3 for 5 years. All had experience working on simulated jobs. Generally, good performance in simulated work had increased their chances of being awarded the opportunity to work for pay. Subjects agreed to participate in the experiment with the understanding that good performance on the experimental job simulation would likewise be rewarded with greater opportunities to do paid jobs. Each subject had been employed outside of vocational training and rehabilitation facilities. Subject 1 had packaged bottles for a major pharmaceutical firm for one year, Subject 2 had washed dishes in a university cafeteria for eight years, and Subject 3 had worked in an auto-body shop for a length of time he could not specify. A layoff and family relocation were documented to have caused the termination of this employment for Subjects 1 and 2, respectively. Subject 3 claimed that failing eyesight was the cause of his termination. Each subject expressed a desire to return to outside employment.

Subject 1, who had received training in braille reading at least 10 years prior to participating in the experiment, was the only subject with any experience relevant to tactile discriminations. In a test
administered by the experimenter, this subject was able
to name every braille letter. The test consisted of two
presentations of each braille letter beneath a shield.
Letters were presented in random order.

Setting

Sessions were conducted with subjects seated at a
table in a factory building that was well lighted by
overhead flourescent lamps. Although background noise
could not be controlled, it was not excessive, being only
that inherent in manual assembly. Subjects were habitu­
ated to it and did not appear to be distracted. Room
temperature, likewise, could not be controlled, and
varied from 12° C to 26° C. Because cooling of the skin
surface has been shown to decrease sensitivity to such
tactile stimulus dimensions as pressure of a point
(Stevens, Green, & Krimsky, 1977), roughness (Green,
Lederman, & Stevens, 1979), and width (presence of) a
gap (Mackworth, 1953; Mills, 1956; Provins & Morton, 1960),
if a subject complained of feeling cold the session was
terminated.

Apparatus and Materials

While seated at a table, a subject's view of objects
on the tabletop was shielded by a white, opaque, 50 cm by
40 cm piece of plastic extending below the chin. Also
concealed by the shield were plastic trays, 13.5 cm by 8.5 cm, and 6.5 cm deep, one on the left and one on the right side, into which objects were sorted. The shield was affixed 30 cm above the tabletop, so that subjects had sufficient room to manipulate objects below it. Objects placed atop the shield for subjects to see were 15-20 cm from their eyes. The experimenter was seated at the table, across from the subject, and was able to view objects placed beneath the screen.

Discriminations between pairs of objects with distinctive visual and tactile features were trained. Pairs of braille characters were the first objects used with each subject. Because Subject 1 was able to read braille, braille-like characters that did not correspond to any letters of the alphabet were also used. Braille stimuli were on cards, 5 cm by 8 cm. The upraised dots were blackened to provide distinctive visual features. Braille characters consist of from one to five upraised dots (pictured in Loomis, 1982). The braille dots comprising a character may be in any combination of six positions, formed by two columns of three positions. The position of braille dots comprising a character may be described by any combination of the numbers one to six. The positions in the first column are denoted by, from top to bottom, the numerals 1, 2, and 3; from top to bottom, the positions of the second column are denoted by
the numerals 4, 5, and 6.

The following are the pairs of braille and braille-like characters used, along with a numerical description of each: Braille I, 1, 2, 6 vs. 1, 2, 5, 6; Braille II, 3, 4 vs. 1, 6; Braille III, wherein each stimulus consisted of two contiguous braille-like characters, 1, 2, 3, 4, 5, 6 and 4, 5, 6 vs. 1, 2, 3, 4, 5, 6 and 1, 1, 3; Braille IV, 1, 2, 3, 4, 5, 6 vs. 1, 2, 3, 4, 6; Braille V, 1, 3, 5, 6 (z) vs. 1, 3, 5 (o); Braille VI, 2, 3, 4, 5 (t) vs. 2, 3, 4 (s); Braille VII, 2, 4, 5 (j) vs. 2, 4 (i); Braille VIII, 1, 2 (b) vs. 1, 2, 3 (l). All braille stimuli were considered to differ along a single tactile dimension, pattern (of dots).

What follows are the other pairs of objects presented to subjects. Listed are the tactile dimension along which the members of a pair differ, the type of object, and the distinctive tactile and visual features of each member of the pair.

**Texture.** Fabric: leather, black vs. suede, brown. Cotton swabs: plastic stem, blue vs. paper stem, white. Pieces of fabric were mounted on pieces of cardboard, 5 cm by 8 cm.

**Shape.** Shapes I: rectangle, blue vs. parallelogram, green. Shapes II: circle, red vs. ellipse, yellow. Shapes consisted of colored construction paper mounted on cardboard. The sides of both the rectangle and the
The interior angles of the parallelogram were $80^\circ$ and $100^\circ$. The diameter of the circle and the long axis of the ellipse were both 5 cm.

**Roughness.** Sandpaper: 60 grit (coarser), brown vs. 220 grit, black. Cigar tubes: coarse plastic, brown vs. smooth plastic, blue. Pieces of sandpaper were mounted on cards 5 cm by 8 cm. Cigar tubes are simply the containers in which cigars are packaged for sale.

**Sharpness (vs. roundness).** Pencils: hexagonal, yellow vs. round, white. Lip balm tubes: sharp edge, green vs. rounded edge, black.

**Presence of grooves.** Pens: grooved barrel, white vs. smooth barrel, red. Bottlecaps: grooved edge, white vs. smooth edge, transparent.

Pairs of bolts, some with slot heads and some with flat heads, were also used.

**Procedure**

**CSDT.** Subjects 1, 2, and 3 received CSDT for, in order 10, 11, and 12 discriminations. Trials were initiated when an object was handed under the shield to the subject. After a delay of 3-3.5 sec, an identical object was placed atop the shield. Handing the object to the subject constituted the presentation of the immediate tactile element of a sequential CS, and showing the object to the subject constituted the presentation of the delayed visual element.
Objects were presented in a random order with two restrictions to prevent position biases in sorting: an object was not presented on more than two consecutive trials, and each object was presented an equal number of times within each session.

A delayed-prompt type of transfer-of-stimulus-control procedure (Striefel, Bryan, & Aikens, 1974; Touchette, 1971) was used to teach subjects to sort objects to the proper side. The prompt, which consisted of the experimenter saying simply "left" or "right," was presented after the sequential CS. (Note that although the presentation of the prompt followed most closely the presentation of the delayed visual element, both elements of the CS were present when the prompt was given.) The delay from the sequential CS to the prompt was increased by 1 sec after every five consecutive correct sorting responses, whether they occurred before or after the presentation of the prompt. After each error the delay was decreased by 1 sec.

Both social and monetary consequences were used. Every correct sorting response, whether prompted or unprompted, was followed by praise, either "good" or "o. k." Incorrect sorting responses were followed by the experimenter saying "wrong" or "no." This was accompanied by a mild admonishment to "Concentrate on your work" if an error occurred after ten or more consecutive correct,
unprompted responses. Money was dispensed according to a differential-reinforcement-of-unprompted-responses format (Howard, Note 1; Olenick & Pear, 1980). One cent was dropped into a glass jar beside the subject after each correct unprompted response, but after only every fifth correct prompted response. One cent was removed from the jar after each incorrect sorting response. These contingencies of reinforcement and punishment were explained to subjects at the beginning of the experiment.

Trials were terminated immediately upon the occurrence of a sorting response. Thus, when a response preceded a prompt, the prompt was not presented on that trial, and likewise when a response preceded the presentation of the visual element. A 10-12 sec inter-trial interval, allowing for the recording of responses, was interspersed before the initiation of the next trial.

Subjects were given the following instructions prior to each CSDT session: "We're going to practice quality-control inspecting (again). I'll hand you an object under the shield and then I'll show it to you. Sort it to the side where it belongs. (Remember to) Work as fast as you can."

Sessions were conducted once daily, every weekday. Each session consisted of 50 to 70 trials. A session was extended beyond 50 trials when it was possible within that session for a subject to meet a performance criterion,
prior to the 70th trial, of 49 correct, unprompted sorting responses within a block of 50 trials. This relatively stringent criterion was imposed to ensure that subsequent measures of stimulus control would reflect steady-state performance (Sidman, 1960). Note that sessions were not terminated after the passage of a particular length of time. Consequently, the number of reinforcements subjects received in a session was not determined by whether they responded prior to the presentation of the visual element or the presentation of the prompt.

Post-CSDT tests. The primary measure was the percentage of responses that occurred prior to the presentation of the delayed visual element of the sequential CS, as this was the determinant of work rate targeted for change in the present experiment. Given such a measure, however, to determine what phenomenon it represents (e.g., whether overshadowing has occurred) it is necessary to present each element of the CS in a manner other than the way it is presented in the V-lag CS. Thus, three tests were administered in the session following the achievement of criterion performance for a particular discrimination in CSDT.

The first test administered was a conflict-compound (CC) test (Hugenin & Touchette, 1980; Ray, 1969). This was identical to CSDT, except that on 20 of 60 trials in the test session, subjects were handed an object that
they had been trained to sort to one side and shown the object that they had been trained to sort to the opposite side. On these CC trials, all responses were reinforced. The side to which an object was sorted revealed the predominant or sole source of stimulus control. Note that the CC test was unobtrusive; from the subject's point of view, it involved no change from the CSDT condition of the previous session.

Each CC test was followed by two separate-element tests, in order, a tactile-element test (TE test) and a visual-element test (VE test). Each separate-element test was 10 trials long and was administered under conditions of nondifferential reinforcement of all sorting responses. Prior to each TE test, subjects were given this instruction: "I'm going to hand you an object but I'm not going to show it to you. I want you to try to sort it anyway. I'll give you a penny for each try, whether you're right or wrong." The VE test procedure is described in the instructions given to subjects, presented here: "I'm going to hand you a marble and then show you an object. I want you to sort the marble to the side where that object should go. I'll give you a penny for each try, whether you're right or wrong." Marbles were used here because presenting the visual element of an object separately obviously necessitated that the subject be prevented from holding that particular object.
SSDT. SSDT with tactile elements was identical to CSDT in all but three ways. First, of course, the visual element was not presented after the tactile element. Subjects were instructed, "I'll hand you an object but I won't show it to you. I want you to learn to sort the object without looking at it." Second, it was necessary to instruct subjects in how to feel the differences between pairs of objects. For example, they were instructed to roll pencils between their thumb and forefinger. Finally, a latency requirement was added to the criterion for termination of discrimination training with a pair of objects. The last 20 responses made in meeting the previously stated criterion must have been made within 3 sec of the presentation of an object.

Post-SSDT tests. In the session following the completion of SSDT with a pair of objects, CSDT conditions were established (after blocking) or re-established (after OSDT) with that pair of objects. This was called a compound-stimulus test (CS test) because its purpose was to test whether the establishment of responding to tactile elements in isolation would produce responding to those elements when presented in a V-lag CS, rather than to train a discrimination. When responses occurred prior to the presentation of the visual element (pre-VE responding) on any trials in the CS test, CSDT conditions were established (following blocking) or re-established (following OSDT).
in a subsequent test session with a pair of objects differing along the same tactile dimension as the objects used in the CS test. This was called a same-dimension probe test (SDP test). If pre-VE responding occurred in SDP tests, CSDT was subsequently administered with a novel pair of objects differing along the same tactile dimension as the objects presented in the SDP tests. This was followed by an extra-dimension probe test (EDP test), in which CSDT conditions were re-established with a pair of objects differing along a tactile dimension different from the dimension along which the items presented in the previous SSDT and SDP tests differed. The purpose of these last three measures was to establish the generality of the effect of SSDT with a particular pair of objects. (These are not measures of "generalization"; see Johnston, 1979.)

Experimental Design

Table 1 presents the order in which discriminations between pairs of objects were taught and the order in which tests were administered. The pairs of objects used in training and testing are listed in order of introduction in the left-hand column. Each successive introduction of a pair of objects for training or testing purposes is indicated by an indentation. Within rows, each data entry indicates the particular type of training or test that was administered, and reading left to right, the order in
Table 1
Sequence of Conditions and Results

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Sequence of Conditions and Results

Subject 1 (continued)

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## Sequence of Conditions and Results

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Sequence of Conditions and Results

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Sequence of Conditions and Results

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which each training or testing condition was presented.

Subjects initially received CSDT for six to eight pairs of objects to assess the prevalence of the overselectivity problem. OSDT was administered for one of these pairs of objects. SSDT was administered with a novel pair of objects in a blocking paradigm. After CSDT with two more pairs of objects, OSDT and blocking were replicated within subjects. The OSDT-blocking order was counter balanced between subjects.

To demonstrate a blocking effect, it is necessary to control for overshadowing. That is, the experimenter must provide evidence that the selective responding to tactile elements that follows the application of blocking is not attributable to the overshadowing of visual elements. Therefore, for each pair of objects used in blocking with a particular subject, overshadowing of tactile elements was demonstrated with another subject. Within-subject control procedures were also used to decrease the probability of erroneously concluding that a blocking effect was present. Prior to using the blocking paradigm with a particular pair of objects, overshadowing of tactile elements was demonstrated with a pair of objects differing along the same tactile dimension as the pair of objects used in the blocking paradigm.

To demonstrate the effect of OSDT with a particular pair of objects, it is necessary to provide evidence that
attenuation of overshadowing (Bellingham & Gilette, 1981; Thomas, Berman, Serednesky, & Lyons, 1968) did not occur as a result of SSDT with another pair of objects. Thus, whenever SSDT with another pair of objects was interspersed between CSDT and OSDT with a particular pair of objects, attenuation of overshadowing was discounted by presenting that particular pair of objects in an EDP test prior to using it in OSDT.

**Accuracy of Recording**

Accurate recording was facilitated by using the sorting response, which produced a permanent product (the sorted object). The experimenter recorded each response immediately, and checked the accuracy of recording by counting the number of each type of object in the trays when they were emptied and comparing this to the record. Thus, the accuracy of recording was ensured by essentially repeating the observations under conditions more favorable to accurate recording than those in effect as the data were originally recorded (Johnston & Pennypacker, 1980). In addition, a measure of inter-observer agreement was obtained. A second observer recorded data for one session per subject each week. Inter-observer agreement on both the sorting of objects and the timing of sorting responses (pre- or post-VE) was 100% throughout the experiment.
Results

CSDT Performance

Table 1 displays both the trials to criterion and percentage of trials on which pre-VE responses occurred for each discrimination trained in CSDT. The two failures of Subject 2 to learn braille discriminations are the only cases in which the criterion was not met. Generally, the number of trials to criterion was far greater for braille discriminations than for any other pair of objects. With one exception, all responses during CSDT were made after the presentation of the visual elements. The exception was the performance of Subject 1 during CSDT with Braille IV. After waiting for the presentation of a prompt on the first four trials, the subject made correct pre-VE responses on all subsequent trials. Note that Subject 1 had received CSDT with Braille IV after having received, in order, CSDT with Braille I and Braille II and SSDT in the blocking paradigm with Braille III. Thus pre-VE responding during CSDT with braille stimuli occurred only after SSDT with braille stimuli.

Post-CSDT Tests

CC test. With the exception of Subject 1's performance after CSDT with Braille IV, on CC trials subjects always waited for the presentation of the visual
element and then sorted in accordance with that element. In the CC test following CSDT with Braille IV, Subject 1 responded prior to the presentation of the visual element and sorted in accordance with the tactile element on every CC trial. No subject detected the discrepancy between the tactile element and the visual element on CC trials.

**TE test.** The results, in terms of percentage of correct sorting responses, are presented in Table 1. In interpreting these results, realize that for percentage values below 100%, the same percentage in two different cases does not necessarily represent the same degree of stimulus control (Sidman, 1980). For example, in the TE test with balm sticks Subject 3 simply sorted objects to alternate sides on successive trials and obtained a score of 60%, whereas in the TE test with fabric this subject simply sorted objects to the left side on the first five trials and to the right side on the second five trials, and obtained a score of 50% correct. In this instance, it would be fallacious to interpret the 60% score as representing a greater degree of stimulus control by the tactile elements than the 50% score. The only unequivocal indication of the acquisition of stimulus control by tactile (or visual) elements is a score of 100% correct sorting responses.

A score of 100% correct was achieved in only 4 of 33 cases. Thus, overshadowing of tactile elements was prevalent. In three cases (Subject 1, with bolts; Subject 2,
with sandpaper and cigar tubes) the expression of stimulus control by tactile elements was unexpected because on the corresponding CC tests subjects made neither pre-VE responses nor sorting responses in accordance with the tactile elements.

**VE test.** As Table 1 reveals, in every case in which the criterion was reached in CSDT, subjects obtained scores of 100% correct on the VE test.

**SSDT Performance**

Trials to criterion for each discrimination are shown in Table 1. For Subject 3, training of the Braille 8 discrimination was terminated because, after failing to meet criterion in 660 trials, the subject became disgruntled. The failure to meet criterion in this case was unexpected because at one point the subject made 17 consecutive correct, unprompted responses. But after this performance, which exceeds the common criterion of 10 consecutive correct, unprompted responses, the subject sometimes seemed unable to even detect the position of the braille character on the card. This evinces the importance of stringent criteria.

**Post-SSDT Tests**

**CS test.** For each pair of objects presented in CS tests, the percentage of trials on which a subject
responded prior to the presentation of the visual element is shown in Table 1 and displayed graphically in Figure 1. OSDT produced stable pre-VE responding within 50 trials in 4 of 6 cases. These successes occurred in the first application with Subject 1, the second application with Subject 2, and both applications with Subject 3. The percentage of trials on which pre-VE responses occurred in these cases were, in order, 64%, 92%, 80%, and 86%. Although at the beginning of each of these test sessions subjects made post-VE responses, they concluded the sessions by making pre-VE responses on 15 of 16, 46 consecutive, 17 of 18, and 39 consecutive trials, respectively.

OSDT was unsuccessful in its second application with Subject 1, who failed to make a single pre-VE response in the CS test. In the first application of OSDT with Subject 2, CS test performance initially resembled that in more successful cases; the session began with post-VE responding, but by the 37th trial the subject had made 13 consecutive pre-VE responses. After making an incorrect pre-VE response on the 38th trial, however, the subject made only 10 pre-VE responses in the next 30 trials. To avoid an equivocal result, the test session was extended for another 75 trials. Eventually pre-VE responding recovered; the subject made such responses on 21 of the last 22 trials.

Blocking was successful in producing pre-VE
Figure 1. Pre-VE responding during CSDT and CS tests.
responding in 6 of 6 applications. Furthermore, there was little or no delay to pre-VE responding. Indeed, in the second application of blocking with each subject, it produced pre-VE responses on the first and all subsequent test trials. In the first application, stable pre-VE responding was seen in Subjects 1, 2, and 3 by, in order, trials 2, 11, and 14; the subsequent percentages of pre-VE responses were 97%, 100%, and 97%, respectively.

One noteworthy finding was that during CS tests, when sorting responses were made after the presentation of the visual element, no errors were made. Some pre-VE sorting responses, however, were incorrect. In CS tests following the first application of OSDT for Subjects 1, 2, and 3, errors occurred on 1 of 32, 2 of 81, and 3 of 40 pre-VE responses, respectively. Subject 2 also made errors on 1 of 43 pre-VE responses following the second application of OSDT, and 4 of 46 following the first application of blocking.

**SDP and EDP tests.** In only one application of SSDT was its effect, pre-VE responding, not limited to the CS test with the pair of objects used in training. For Subject 1, blocking with Braille III was followed by performance on SDP tests with Braille I and Braille II that was typical of CS test performance. During the first half of the test sessions no pre-VE responses occurred, but during the second half the subject made pre-VE responses on 92%
and 88% of the trials, respectively.

**TE test.** For a particular pair of objects, subjects' scores on the TE test generally corresponded to their performance on the CS test. With one exception, when any pre-VE responses occurred on the CS test, the subject scored 100% on the corresponding TE test. The exception was in the performance of Subject 1 after the second application of OSDT. After failing to make a single pre-VE response in the CS test, Subject 1 scored 100% correct on the TE test (see Table 1).

**VE test.** Performance on VE tests remained at 100% correct in all cases in which this performance had originally been established in CSDT. The VE tests of greatest interest were those administered after the post-blocking CS tests in which the visual element was presented. Only these particular tests could reveal whether the blocking paradigm prevented, or blocked, the acquisition of stimulus control by visual elements. Blocking was indicated in one of three such cases. Subject 1 scored only 50% correct (chance-level performance) on the VE test following application of the blocking paradigm with Braille III and administration of a corresponding CS test in which the visual elements were presented twice. In two other such cases, following applications of the blocking paradigm with balm for Subject 2 and pens for Subject 3, VE test scores were 100% correct, indicating that SSDT in the blocking
paradigm did not block the acquisition of stimulus control by visual elements.

**Discussion**

Overselectivity and concomitant reduced work rates were a prevalent problem. Post-CSDT TE tests revealed that in 29 of 33 discriminations between sequential compound stimuli, the acquisition of stimulus control by immediate tactile elements was overshadowed by the acquisition of stimulus control by delayed visual elements. Furthermore, during post-CSDT CC tests, pre-VE responding occurred in only one case, and did not occur in the three cases where stimulus control had been acquired by the immediate tactile elements of compound stimuli (as revealed by scores of 100% correct on corresponding TE tests).

It is noteworthy and perhaps surprising the the tactile elements of certain compound stimuli did not acquire stimulus control during CSDT even when it was very difficult for a subject to learn to discriminate between the visual elements of those compound stimuli. For Subjects 1 and 3 the trials needed to reach criterion for braille discriminations during CSDT were far greater than for any other discriminations, yet the tactile elements of braille compound stimuli were overshadowed. For Subject 2, tactile elements of braille cards did not acquire stimulus control, even though this subject was unable to learn braille
discriminations with visual elements available concurrently.

During CSDT with braille cards, Subject 2 attended to the behavior of the experimenter, which certainly interfered with the acquisition of stimulus control by either the tactile or visual elements of these compound stimuli. After the visual presentation of a braille card, Subject 2 would hold the other braille card over one of the containers while looking at, and apparently listening to, the experimenter. If the experimenter made any discernable gestures, whether moving his head, shifting in his seat, or even breathing deeply, the subject would move the card to a position over the other container. Only when no further gestures were forthcoming would the subject drop the card into a container. Because the subject was likely to make a correct sorting response on 50% of such trials, many such operants (sorting responses controlled by the experimenter's gestures) were undoubtedly reinforced before the experimenter detected the problem.

This problem was subsequently observed outside the experimental situation, while the subject was being trained to stack boxes in a pattern, which involved relatively difficult visual discriminations. That the responses of Subject 2 were controlled primarily by the trainer's reaction was most evident when errors were committed. After each error, the trainer would repeat a full or partial explanation of the proper place to
stack the box the subject was holding. But instead of following these instructions, Subject 2 would simply spin and turn the box until the trainer ceased to reiterate the explanation, whereupon the subject would place the box in its proper position. The trainer praised the subject after each correct placement of the box, irrespective of whether the subject had followed instructions or responded to the trainer's own reactions.

The problem with this type of training is that responses made without the aid of the trainer's reaction, which was the effective prompt, were not differentially reinforced. Because stacking the box in the proper position was reinforced equally whether or not it was controlled by the prompt, the trainer's reaction blocked the acquisition of stimulus control by the pattern of boxes already stacked, as evidenced by the subject's inability to stack boxes properly in the absence of the trainer (Fields, 1978). To the extent that this erroneous training procedure influence the CSDT performance of Subject 2, the subject's inability to learn braille discriminations might be said to represent a "learned learning disability."

In 6 of 7 applications of SSDT in the OSDT paradigm, subjects achieved criterion performance. In 5 of the 6 cases in which stimulus control was acquired by tactile elements in isolation, pre-VE responding emerged in
corresponding CS tests, and thus overselectivity and con-
committant reduced work rates were successfully treated.

Stimulus control by tactile elements in isolation
was established in all 6 applications of SSDT in the
blocking paradigm. In corresponding CS tests, pre-VE
responding emerged immediately or almost immediately in
all 6 cases. This effect was not dependent upon blocking
of the development of stimulus control by visual elements
in the CS test. Therefore, the blocking paradigm was
found to be an effective preventative for overselectivity.

For Subject 1, the application of SSDT in the blocking
paradigm with Braille III was followed by pre-VE responding
in SDP tests with other pairs of braille cards (Braille
I and Braille II). It is not clear why this effect of
SSDT was limited to a single application. Perhaps the sub-
ject's pre-experimental training in tactile braille reading
was a factor. Another possibility is that the effect was
present after other applications of SSDT but it was not
discovered because the experimenter did not properly spec-
ify the tactile dimensions along which two pairs of objects
differed. Santiago and Wright (1980) have shown that the
physical dimensions of stimuli specified by an experimenter
are not necessarily the dimensions that acquire stimulus
control over responding. Future research will, it is hoped,
map the tactile dimensions of objects that are most likely
to acquire stimulus control of responding, and include
measures of responding to stimuli differing along those dimensions.

In discussions of this effect of SSDT, pre-VE responding on SDP tests, the author has found it common for others to refer to the phenomenon as "stimulus generalization" or "generalization." Nevertheless, this result does not represent either "stimulus generalization" in the traditional, restricted sense (c.f. Honig & Urcuioli, 1981), or "generalization" in the broad sense (c.f. Stokes & Baer, 1977). "Stimulus generalization" describes responding (in a generalization test) to stimuli that were not present during discrimination training (but which are similar to the S+ present in discrimination training). What is crucial is that "stimulus generalization," being the reciprocal of "discrimination" (Whaley & Malott, 1971), decreases with further discrimination training. Conversely, the result of interest in the present experiment is an increase in the number of stimuli to which a subject responds as a result of discrimination training. Therefore, this result can not represent "stimulus generalization." "Generalization" is defined by Stokes and Baer (1977) as "a change that occurs without specific training." In the SDP tests, all responses to the tactile elements were reinforced. Presumably training can not be more specific than this. Thus, the phenomenon does not represent "generalization."
An important aspect of SSDT seemed to be the instruction of proper ways to feel the tactile features of objects. The failure of subjects to feel for the distinctive tactile features of objects prior to instructions was striking. For example, initially Subject 2 and 3 did not rub their fingers across the pieces of fabric. This finding contradicts a popular assumption, that persons with impairments of one sensory system naturally compensate through the development of greater sensitivity and ability of other senses. This and other considerations in the application of SSDT shall be elaborated upon the the General Discussion section.

Experiment 1 demonstrated that overselectivity is not the only problem of what has been called "selective attention" (see Wilkie & Masson, 1976, for a critique of this term) that may reduce work rate, and that overshadowing is not necessarily the only basic process implicated in instances of selective responding to a single element of a CS. There were three cases in which pre-VE responding did not occur during CSDT or corresponding CC tests despite the acquisition of stimulus control by immediate tactile elements, and one case in which pre-VE responding did not occur on the CS test following OSDT. The practical implication of this finding is that, in treating the problem of overselectivity, practitioners can not depend upon procedures that produce stimulus control by the
previously-overshadowed element of a CS in isolation because such procedures do not always produce responding to that element when it is presented as part of a CS.

The theoretical significance of this finding is that it evinces the value of the distinction that Mackintosh (1977) has made between the acquisition of stimulus control and the expression of stimulus control. In the four cases under consideration, the acquisition of stimulus control by tactile elements was indicated by a score of 100% correct on the corresponding TE test. The CC and CS tests, however, indicated that the stimulus control acquired by tactile elements was not always expressed in the presence of visual elements that had acquired stimulus control over the same (in the CS test) or different (in the CC test) response. Some of the terms that have been used to discuss such results, for example "selective attention," obscure the distinction between the acquisition and expression of stimulus control. As such, these terms should be either redefined or dropped from the vocabulary of behavior analysis.

When stimulus control is acquired by each element of a CS separately, but expressed by only one element when the elements are compounded, the phenomenon is called masking (see reviews by Honig & Urcuioli, 1981; Mackintosh, 1977). The definition of masking applied to the four cases in which subjects failed to respond to the
immediate tactile elements of sequential compound stimuli despite the acquisition of stimulus control by those elements. In these cases the presence of delayed visual elements of sequential compound stimuli can be said to have masked the expression of stimulus control by the immediate tactile elements.

Masking has been studied in the laboratory by, first, employing SSDT with pairs of stimuli differing along two dimensions and then presenting one stimulus from each dimension during the administration of generalization tests. In a representative experiment, Honig and Gerry (Note 2) first trained pigeons to discriminate between two tones by reinforcing pecks on a blue keylight during the S+ tone and extinguishing pecks during the S- tone. They then trained the pigeons to discriminate between the presence and absence of a key containing three vertical lines on a white background by reinforcing key pecks in the presence of the lines (S+) and extinguishing key pecks in the absence of the lines (S-). In a subsequent generalization test, they presented the lines tilted at one of four angles, either in isolation or in combination with the S+ tone or the S- tone. Compared with the generalization gradient obtained when the tilted lines alone were presented, the gradient obtained when the S- tone was also presented was not as steep, and the gradient obtained in the presence of the lines plus the S+ tone.
was flatter still. This indicates a decrement in the expression of stimulus control by the visual stimuli when auditory stimuli were present.

Masking has also been studied with humans, using a test for the expression of stimulus control that was very similar to the conflict-compound test used in Experiment 1. Colavita (1974, Exp. 1) used this method in studying the phenomenon of visual dominance relative to auditory stimuli (see review by Posner, Nissen, & Klein, 1976) in a reaction-time paradigm. Subjects were trained to press one of two keys when they heard a tone (tone key) and to press the other key when they saw a light flash (light key). The light and tone were presented in random order during training. Testing for each of ten subjects consisted of the presentation of five conflict-compound (CC) trials on which both the tone and the light were presented. On 49 of the 50 CC trials, subjects pressed the light key. On the one trial on which a subject responded to the tone key, the subject reported that he believed that he had made an error. In fact, after 16 of the CC trials, subjects reported that they did not hear the tone.

In subsequent systematic replications of this experiment, subjects pressed the light key on 88% of CC trials when the intensity of the tone was increased (Colavita, 1974, Exp. 2), and on 94% of the CC trials when ambient illumination was increased, thereby making the light less
salient (Colavita, 1974, Exp. 3). Thus, in these experiments the expression of stimulus control by an auditory element of a conflict-compound stimulus was masked by the expression of stimulus control by a visual element (Randich, Klein, & LoLordo, 1978, identified these particular results as masking; Colavita, 1974, did not relate these results to any of the processes discussed in this paper).

Visual dominance relative to auditory stimuli has since been replicated when subjects were required to look at the source of the tone rather than the source of the light (Colavita, Tomko, & Weisberg, 1976), to react to stimulus offset rather than stimulus onset (Colavita & Weisberg, 1979), and when auditory stimuli were delivered through earphones (Colavita, 1982). Also, Randich et al. (1978, Exp. 1 & 2) have reproduced the effect with pigeons, using the Colavita (1974, Exp 1) procedure, and Meltzer and Masaki (1973) have reproduced visual dominance using a free-operant procedure rather than a discrete-trials procedure.

Although there have been no published reports of the masking of tactile stimuli by visual stimuli, Rock and Victor (1964) conducted a relevant experiment. They had human subjects both feel a sample object that was concealed from their sight, and view the same object through a lens that distorted its apparent size. In a version of the CC
test, each subject was asked to choose, from an array of like objects differing in size, the one that was the same size as the sample. In almost every instance, subjects chose an object that matched the apparent size of the object they had viewed. It is not certain, however, that this result represents masking of tactile elements by visual elements. What is lacking is evidence that subjects were able to choose objects matching the felt size of a sample, that is, evidence of the acquisition of stimulus control of the matching response by tactile elements.

In Experiment 1, the blocking paradigm prevented the masking immediate tactile elements by delayed visual elements. The treatment of masking has been attempted only once to date. Randich et al. (1978, Exp. 3) reversed the masking of an auditory element of a simultaneous CS by a visual element when they presented the auditory element as the immediate element of a V-lag CS. Considering that in Experiment 1 the immediate tactile element of a sequential CS was masked by the delayed visual element, the Randich et al. procedure does not seem applicable to the present problem. Furthermore, even if a greater increase in the delay from the tactile to the visual element were effective, it should not be done in the present situation because the delay value was chosen to model the delay caused by a magnifying response.

A feasible way to treat masking of immediate tactile
elements by delayed visual elements is to reinforce correct, pre-VE responses and extinguish post-VE responses. In effect, this constitutes differential reinforcement of short-latency responses to the immediate tactile element of a V-lag CS. There have been no published reports of the application of differential reinforcement of short-latency responses in an operant discrimination involving two or more stimuli. The procedure has, however, been used in decreasing reaction times to the onset or offset of a solitary stimulus. Saslow (1972) decreased the reaction times of two monkeys to the offset of a light by reinforcing only responses that preceded the expiration of an interval, which became shorter as training progressed. Likewise, Snodgrass, Luce, and Galanter (1967) lowered the reaction times of humans to a loud tone by informing subjects, after every trial, whether their reaction was fast enough to meet a gradually decreasing criterion. Both Saslow (1972) and Snodgrass et al. (1967) discovered a limit to the effectiveness of the differential-reinforcement-of-fast-reaction-times procedure. When the criterion for reinforcement became too stringent, below 180 msec and 105 msec in the Saslow (1972) and Snodgrass et al. (1967) experiments, respectively, the variability of reaction times increased so greatly that subjects met the criterion on fewer trials.

The purpose of Experiment 2 was to develop a novel
treatment for reduced work rates concommittant to the masking of immediate tactile elements of V-lag compound stimuli by delayed visual elements. The procedures of Saslow (1972) and Snodgrass et al. (1967) were adapted such that pre-VE responses were differentially reinforced.
CHAPTER II

EXPERIMENT 2

Method

Subjects and Materials

Subjects 1 and 2, who exhibited masking in Experiment 1, participated. The differential-reinforcement procedure was applied in three cases: with pencils for Subject 1, and with sandpaper and cigar tubes for Subject 2. Recall that for Subject 1 masking of tactile elements had been observed after OSDT, while for Subject 2 it had been observed after CSDT.

Procedure

Each application of the procedure was performed within a single session. Sessions began with a baseline condition identical to the CS test condition in Experiment 1. The treatment condition differed from baseline only in that the programmed consequences of correct and incorrect sorting responses were delivered only for pre-VE responses. Neither reinforcement of correct responses nor punishment of incorrect responses followed post-VE responses.
Experimental Design

The experiment included three experimental designs: a multiple-baseline design across subjects, and for Subject 2, across discriminations; and a reversal design, in cases where the effects of treatment were not irreversible. Condition changes were not accompanied by a description of the new conditions.

Results

As seen in Figure 2, differential reinforcement of pre-VE responses produced stable pre-VE responding in all three applications. In the initial implementation of differential reinforcement conditions within each session, the first pre-VE response occurred on trials 21, 3, and 14 for, in order, Subject 1, and the first and second applications for Subject 2. In these three cases a criterion of 20 consecutive correct (unprompted) pre-VE responses was met on trials 63, 61, and 102, respectively. For Subject 1, the reversal to CS test conditions resulted in a reduction of pre-VE responses, such that they occurred on only 70% of the last 20 trials in that condition. Reinstatement of differential reinforcement produced criterion performance again within 74 trials. For Subject 2, the reversal to CS test conditions did not result in a reduction of pre-VE responding; not a single post-VE
Figure 2. Pre-VE responding during CS test and differential reinforcement conditions.
response occurred in either case. The consistency of pre-VE responding prevented the presentation of the visual element, and thereby the reinforcement of post-VE responses.

It is interesting that in the second application of differential reinforcement with Subject 2, pre-VE responding persisted despite the commission of three errors, which had disrupted the subject's pre-VE responding in Experiment 1.

Discussion

Differential reinforcement of pre-VE responses proved to be an effective and efficient treatment for reduced work rates concommitant to masking of immediate tactile elements of V-lag compound stimuli. The treatment produced the desired effect in all three applications, and in two cases the effect was irreversible.

The determinants of this irreversibility are not certain at present. It might be attributable to the experiences of subjects with the particular pairs of objects used in the differential reinforcement procedure. Recall that for Subject 1, masking of the tactile elements of the objects used in the differential reinforcement procedure was preceded by the overshadowing of those elements in CSDT, while for Subject 2 the tactile elements of the objects used in the differential reinforcement procedure had acquired stimulus control during CSDT. It
is also possible that reversibility and irreversibility were attributable to the respective objects per se.

It is interesting that the differential reinforcement procedure, which included the extinction of correct, post-VE sorting responses, resulted in correct pre-VE responding rather than in the disruption of post-VE responding, for example, sorting objects to the wrong side. Perhaps the experiences of subjects in Experiment 1 were a precondition for the successful application of differential reinforcement of pre-VE responses in Experiment 2. The tactile elements of the objects used in Experiment 2 had already acquired stimulus control, which enabled subjects to make correct pre-VE responses. Also, each subject had experienced four applications of SSDT during Experiment 1, which might have indicated to subjects that responses to tactile elements would be reinforced in Experiment 2. Practitioners should be aware that in the absence of these or unspecified preconditions the differential reinforcement procedure might result in the disruption of established responding to the delayed element of a sequential CS.

**General Discussion**

Experiment 1 demonstrated that overselectivity and the concomittant reduced work rates were a prevalent problem. CSDT resulted in the overshadowing of
immediate tactile elements by delayed visual elements in 29 of 33 cases. SSDT in the OSDT paradigm was found to be a useful treatment for this problem. OSDT resulted in responding to the previously-overshadowed tactile elements of V-lag compound stimuli in 5 of 6 cases in which it established stimulus control by those elements in isolation. An unexpected finding, however, was that the establishment of stimulus control by immediate tactile elements in isolation, whether in OSDT or CSDT, did not necessarily result in the expression of stimulus control by those elements when presented as the immediate elements of V-lag compound stimuli. SSDT in a blocking paradigm was found in all cases to be an effective preventative of these problems, producing immediate and stable responding to the immediate tactile elements of sequential compound stimuli.

The results of Experiment 1 indicate clearly that when the expression of stimulus control by a single element of a CS is desirable, SSDT within the blocking paradigm should be applied when possible. In particular, the use of blocking to produce responding to the tactile elements of compound stimuli that also include visual elements should prove advantageous relative to other procedures, and practicable too. For example, as braille reading is typically taught, students are allowed to both feel and see the braille letters. With sighted students,
including visually-impaired students, this sometimes results in the overshadowing of tactile elements, so that students are unable to read braille without looking at the braille letters (Kaarlela, Note 3). Application of blocking would entail teaching students to read braille letters and test presented under a shield prior to allowing them to see the braille.

The blocking paradigm might also be used to improve driving safety. It is safer for drivers to operate the controls and accessories of automobiles tactilely rather than visually because the latter requires them to look away from the road. Nevertheless, many drivers look at their controls and accessories during operation because the tactile elements (the position and feel of the knobs, dials, etc) have been overshadowed or are masked. The results of Experiment 1 support the recommendation that, before ever driving a particular vehicle, a driver should learn to operate the controls and accessories of that vehicle while his or her eyes are closed. Automobile manufacturers could, of course, facilitate the tactile operation of automobile controls and accessories by including distinctive tactile features in their designs.

The elimination of visual elements in initial training might also be used to produce the expression of stimulus control by tactile elements in teaching such diverse skills as dribbling a basketball while watching
an opponent (instead of watching the ball) and playing a musical instrument while reading a musical score or watching a conductor (instead of looking at the instrument).

Applications of SSDT, whether in the blocking or the OSDT paradigm, should not consist simply of the elimination of visual elements. This might prove to be ineffective, inefficient, or unpleasant for the student. The elimination of visual elements should be accompanied by all of the techniques of an effective instructional technology, including effective consequences, helpful instructions, and a transfer-of-stimulus-control procedure. All of these techniques were used in the SSDT with tactile elements employed in Experiment 1. Also, in consideration of students' comfort, teachers should eliminate as few visual stimuli as possible. Having one's vision restricted, and especially being blindfolded, is uncomfortable for some individuals. There is no reason to blindfold a student when relevant tactile stimuli can be presented under a shield. If blindfolding is necessary, it should be for short intervals.

Despite the advantages of using SSDT within the blocking paradigm to prevent overshadowing and masking, it is not always possible to do so. When overshadowing has already occurred, SSDT may be used in the OSDT paradigm to establish stimulus control by the previously

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overshadowed elements. If this is not sufficient to produce the expression of stimulus control by those elements when presented in sequential compound stimuli, the differential reinforcement procedure demonstrated in Experiment 2 may be applied. Note that the applicability of this differential reinforcement procedure is, unlike SSDT, limited to producing responding to an element of a sequential CS. It is not possible to differentially reinforce responses to a single element presented as part of a simultaneous CS.

The practical application of the differential reinforcement procedure is likely to be more complicated than the application of SSDT. The principle complication is the need to determine whether the visual element of an object has effectively been presented, that is, whether a magnifying response has occurred. This determination will sometimes be difficult. For example, when a worker is performing a quality-control inspection, it will not always be obvious when the worker has moved his or her eyes close enough to a product to see defects.

Piece-rate pay is another complication. Workers in sheltered workshops and work activity centers are most often paid on this basis, and U. S. Department of Labor regulations require that workers paid on this basis receive payment for each piece they produce. Therefore, the differential-reinforcement-of-pre-VE-responses
procedure can not involve the withholding of pay for pieces manufactured with the aid of a magnifying response. Fortunately, the procedure can be adapted so that the worker's pay, usually the most effective reinforcer that may be manipulated, is dependent upon the worker responding without the aid of magnifying responses. For example, workers could be required to work at a rate commensurate with that achieved when magnifying responses do not interrupt their work, or face temporary removal from the job (and thereby, loss of the opportunity to earn money). Or, removal from a job could be made dependent upon the occurrence of a magnifying response. Of course, both recommendations presuppose that money is an effective reinforcer for a particular worker doing a particular job.

Masking has not previously been reported in the literature of applied behavior analysis. Nevertheless, it seems to be prevalent. Consider, for example, the response of accelerating an automobile when a red traffic signal turns green. Stimulus control by the traffic signal is often masked by another stimulus presented to the driver, the acceleration of oncoming traffic. This masking is dangerous when the oncoming traffic has been given a green left-turn signal. Yet the problem is so common that at many intersections "Wait for green" signs have been hung. Other examples that may represent
masking include a worker relying upon others for instructions in how to do a job, even though the worker has been sufficiently trained to do the job independently and has exhibited this ability; and in baseball, an advancing baserunner watching the baseball and fielders instead of looking at the signals of the first- and third-base coaches.

Training programs should include measures, preventatives, and treatments of masking. At this point, however, not enough is known about masking to allow its prevention and treatment in all cases. What is more clear is how masking may be detected and measured. A simple guideline is to make testing realistic. Tests for stimulus control of a particular response by a particular stimulus must be conducted in the presence of potential masking stimuli.

The need for such testing is evident in the case of a driver entering an intersection only when a red traffic signal turns green. In some state driver's license exams, stimulus control of the accelerating response is tested in isolation, that is, on a course devoid of other drivers. It is suggested that licensing exams should be administered in the presence of potential masking stimuli, whether by simulating actual driving conditions on the test course or by having the examiner accompany the licence candidate on a drive through actual traffic.

The present experiments demonstrate that basic research such as that published in the Journal of the Experimental
Analysis of Behavior (JEAB) remains relevant to important human problems, despite the drastic reduction of JEAB citations in the Journal of Applied Behavior Analysis (Hayes, Solnick, & Rincover, 1980). Also demonstrated is the value of relating human problems, treatments, and preventative to the processes and principles explicated in basic research publications such as JEAB, another practice that is declining (Birnbrauer, 1979; Deitz, 1978; Hayes, 1978; Hayes et al., 1980; Michael, 1980; Schwade, Note 4), despite its benefits for the field of applied behavior analysis (Birnbrauer, 1979; Deitz, 1978; Hayes, 1978; Hayes et al., 1980; Johnston, 1979; Michael, 1980; Pierce & Epling, 1980; Schwade, Note 4; Woods, 1980).

The prior identification of the similarities between the human problem of overselectivity and a process studied in the laboratory, overshadowing, facilitated the discovery in the literature of the OSDT procedure, which proved to be a useful treatment. A review of the basic research on stimulus control provided an effective preventative, the blocking paradigm.

Even when relation of a human problem to basic processes and principles does not immediately provide an effective procedure, as in the case of masking, it is ultimately beneficial to the field of applied behavior analysis because, should a procedure that modifies basic processes be discovered, its relevance to human problems
will become apparent immediately. Also, relating human problems, treatments, and preventatives to basic research is beneficial to the field of the experimental analysis of behavior because it extends and established the generality of the processes and procedures that are studied by researchers in this field (Baer, 1978; Michael, 1980).

Many laboratory studies that are relevant to human problems and behavior remain to be applied, particularly in the area of stimulus control (Michael, 1980). It is hoped that the present experiments will serve as a model for the application of that research.
For the sake of convenience, "ignored" is used herein to refer to an element that has not acquired stimulus control of the response under study, as Hugenin and Touchette (1980) and Ray (1969) have used it. It implies neither an action on the part of the subject nor an inability or failure to detect the presence of an element.

Santiago and Wright (1980) qualified these results subsequent to performing a replication of Johnson and Cumming's (1968) Experiment 1, utilizing measures of the stimulus control acquired by additional features of the lines. While the angle of the lines was again found to be overshadowed, the brightness contrast between the lines and their backgrounds acquired stimulus control. Nevertheless, this qualification does not diminish the potential of SSDT as a treatment for overselectivity, as SSDT did establish stimulus control by the previously-overshadowed dimension of line angle.
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