Stimulus Overselectivity: Empirical Basis and Diagnostic Methods

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Abstract

This paper presents the empirical basis for the phenomena known as stimulus overselectivity. Stimulus overselectivity involves responding on the basis of a restricted range of elements or features that are discriminative for reinforcement. The manner in which such a response pattern impedes the skill acquisition in children is identified. A classification system is presented for three different types of overselectivity: identical feature control, irrelevant feature control, and incomplete stimulus control.

Keywords

Stimulus Overselectivity, Stimulus Discrimination, Assessment, Autism, Error Pattern Diagnostic System

In the 1960s, a research program directed at treating the many deficit skills of children with autism was underway at the University of California at Los Angeles (UCLA). The use of operant shaping and reinforcement contingencies proved to be a significant factor in these children acquiring a variety of language, social and self-care skills. While substantial success was achieved, some of the children took an inordinate amount of training time to acquire targeted skills (Lovaas, Koegel, & Schreibman, 1979). Given that the program utilized consistent differential reinforcement and discrete trial training, such a result was puzzling.

Rather than attribute the delayed acquisition of skills to the child' diagnosed autism disorder, these researchers searched for environmental variables that might explain this phenomenon. Through basic research on compound stimulus presentations, they examined the basic "molecules" of discriminative stimuli (Lovaas, et al, 1979). The answer to the children's slower acquisition rates lie in the fine grain analysis of compound stimuli and whether each element exerts stimulus control (or not) over responding.

Responding on the basis of just one element or feature of a compound stimulus has been termed "stimulus overselectivity" (Lovaas et al, 1979). This phenomenon can be described as restricted stimulus control. The learner responds on the basis of one element or feature of the compound stimulus, to the exclusion of other elements. The desired behavior occurs given the presence of a select element or feature of the compound stimulus. Concurrently, the absence of that feature results in the lack of the desired behavior, and is similar to a phenomena in respondent conditioning called blocking. Therefore, consistent error patterns in simple and conditional discrimination tasks can be conceptualized as cases illustrating restricted stimulus control.

A compound stimulus involves multiple elements or features of the presenting stimulus context. The preschool language task depicted in Table 1 can be used to illustrate a compound stimulus presentation within a conditional discrimination task. Each column in Table 1 delineates a feature or element within the compound stimulus presentation. There are three different physical elements within each compound stimulus involving a single command: shape, size and color. Therefore, a child has to respond on the basis of all three features (i.e., what color, size, and shape is being manded). Let's say a child only responds on the basis of which color is presented in the command. Given this task, responding only to color will result in a failure to master this discrimination task. For example, when the command given is "*Touch the large blue triangle," this* child will respond correctly since there is only one of the three stimuli involving a blue color. But suppose the command issued is, *"Touch the large green circle?"* There are two index cards with a green color. If the child does not attend to another element beside color, he will never master this part of the task.

There are more elements to this type of discrimination task than just the three relevant elements of color, shape, and size. There are also elements of this discrimination task which are identical (i.e., the same) in all three stimulus presentations. All stimuli are presented on index cards that are of the same size and shape. Also, the presence of a voiced command from the instructor or therapist is involved in all stimulus presentations. Therefore, a human voice is an inherent feature in all three compound stimuli.

Instructional programs in educational settings often involve compound stimuli that are comprised of multiple relevant features, as well as other features not discriminative for reinforcement. An inability to respond on the basis of all of the relevant elements within a stimulus presentation would hinder acquisition of discrimination behavior. The behavioral effect of such a deficiency will be a persistent error pattern. Simply providing an additional 100, 200 or 2,000 trials may be insufficient if a child selects just the color feature as the basis for responding. If the ratio of reinforced trials is not sufficiently low (i.e., hovers around 50%), the transfer of stimulus control from the feature of color

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Table 1. Compound stimuli of a language task

Command	Color	Size	Geometric shape	Identical features
"Touch the large green circle."	green	large	circle	Index card that stimuli are on, voiced command
"Touch the large blue triangle."	blue	large	triangle	
"Touch the small green square."	green	small	square	

to other additional discriminative elements may not occur in a timely manner.

BASIC RESEARCH ON OVERSELECTIVITY

An analysis of the stimulus control characteristics of pervasive error patterns would be extremely useful for teaching children who display overselectivity. Researchers at UCLA conducted an experimental analysis of the phenomenon (Lovaas, Schreibman, Koegel, & Rehm, 1971). To determine the factors involved in overselectivity, the participant would acquire initial discriminated behavior in the presence or absence of a compound stimulus presentation, termed a simple discrimination task (i.e., the presentation of a compound discriminative stimulus, its absence defines the S – condition). Once this occurred, the analysis of overselectivity could be conducted. The stimulus control that each element exerts could be determined by isolated tests of each element.

The design of the initial study on this phenomenon was comprised of two phases (Lovaas, et.al., 1971). In the first phase, all participants received training on a discrimination task comprised of a compound stimulus consisting of visual, auditory, and tactile elements. All three elements were presented simultaneously and then terminated. The stimulus presentation had the following three elements occurring simultaneously: (a) a moderately bright visual stimulus involving a 160 watt red floodlight, (b) an auditory stimulus consisting of a 65 decibel level white noise, (c) a tactile stimulus whereby a pressure cuff on the child's leg was inflated. During the presentation of the compound stimulus, a bar press by the child was reinforced. Absence of these three elements resulted in no food for bar presses. In summary, bar presses produced food only when the compound stimulus was presented. Bar presses that occurred outside of the compound stimulus presentation were counted as errors. All children acquired this initial discrimination, bar pressing only when the compound stimulus was presented.

In the second phase of the experiment, the single-cue test condition was conducted. In this phase, the participants were exposed to a stimulus presentation involving only one of the elements of the compound stimulus delineated above. For example, the child was subjected to the red floodlight only. If the child pressed the bar, food was delivered and the occurrence of the bar press behavior was noted for this element. Similarly, the other two elements were also presented in isolation, and the occurrence of bar pressing under each element was recorded. Again, bar presses in the absence of any element being presented went unreinforced and constituted errors. Each single element was presented 70 times over 10 test sessions. Therefore the number of bar presses to each single element was noted over the 70 trials.

The dependent variable was the number of bar presses occurring to each single element in the second phase. The research participants involved three groups of students. There were six participants who were classified as having mental retardation, six participants who were diagnosed with autism, and six participants who were not disabled. During the single-cue test, the children who were not disabled responded equally to all three of the single elements presented. Whether the red floodlight was presented, or pressure was applied to the leg or, the white noise was presented, these participants bar pressed.

In contrast, children diagnosed with autism primarily responded when only one of the elements was presented. Three of these children bar pressed primarily to the white noise whereas two of the children bar pressed primarily when the red floodlight was presented. None of the children with autism responded to the tactile stimulus. For the children who responded only to the white noise, presentation of the red floodlight or pressure cuff on the leg resulted in lack of bar pressing. Similarly, for the children with autism who were under control of the red floodlight, presentation of the other two elements produced little or no bar pressing.

The following comment is illustrative of the observed phenomenon:

> *"it was striking to observe the autistic children attentively respond to one of the component elements, only to remain motionless in the presence of the other, even though that element had been previously trained (in the compound stimulus) as discriminative for reinforcement" (Lovaas, et.al.,1979, pg 1238)."*

A plausible hypothesis given this data could be that these children with autism have an auditory, visual, or tactile processing problem. Was it possible that these children with autism simply have a deficiency with respect to certain stimuli? The possibility of a modality weakness for certain stimuli was tested in a subsequent study. The researchers selected two of the children with autism from the original study to determine if a sensory deficit could explain the results (Lovaas et al, 1971). Each child was provided additional training to respond to the single element that resulted in the least bar presses for them in the first part of the experiment. If the children had sensory deficits in that particular modality, obtaining bar pressing to its presentation would have been difficult. Both children acquired bar pressing to the single element presentation.

Therefore, the results could not be explained as an outcome of a sensory deficiency or preferred sensory modality. Rather, the more viable explanation of the results pointed to overselectivity to a compound stimulus presentation involving several elements. Other research studies have also verified that children with autism demonstrated difficulty with compound stimuli, even if the multiple elements involve the same sensory modality (Cowan, Hoddinott, & Wright, 1965; Koegel & Wilhelm, 1973;

Reynolds, Newsom, & Lovaas, 1974). Recent research has demonstrated that overselectivity can occur with tactile elements as well (Ploog & Kim, 2007).

In this study, the compound stimulus was comprised of tactile features involving texture and shape. To provide such a compound stimulus void of visual stimuli, each participant felt a different texture on a particular shape (as the S+), which was shielded from his or her view. The results were in line with prior research findings on compound stimuli and subsequent tests of stimulus control. Children with autism and non-disabled children demonstrated restricted stimulus control when the compound stimulus elements were isolated and tested individually.

Perhaps the results of the previous studies point to children who are "super-efficient" learners (Koegel & Schreibman, 1977). The child's attending to just one element when presented with a compound stimulus was sufficient (and therefore efficient) to maximize reinforcement. Koegel and Schreibman (1977) utilized an ingenious methodology to address this potential hypothesis. The participants were first trained to respond to single elements in the discrimination task. For example, the participant was exposed to the auditory stimulus and trained to press the bar. Subsequent to this response being established, the participant was then trained to respond to the visual stimulus in isolation. At the completion of this first phase, the participant was responding to either single element when presented in isolation. Subsequently, one of three test trials was alternately presented. One third of the trials involve the visual stimulus only, one third involving auditory only, and one third presented the visual and auditory stimuli simultaneously (i.e., compound stimulus). However, in this phase of the research, bar pressing was only reinforced in the presence of the compound stimulus. Bar pressing to either the visual stimulus only or the auditory stimulus presented in isolation was not reinforced. Would a shift in reinforcement contingencies, whereby food reinforcement is switched, result in immediate change in responding to maximize reinforcement? A super-efficient hypothesis would predict that the child would maximize reinforcement.

The children with autism continued to respond to the presentation of a single element for hundreds of trials in this second phase of the study. The authors noted that responding in the absence of reinforcement would not appear to be a super-efficient learning strategy. In contrast, children who were not disabled quickly switched their responding to only the presentation of the compound stimulus during the test phase of the experiment. Their behavior in the single cue presentation fell under control of the extinction contingency in effect, and they did not respond when bar pressing resulted in lack of reinforcement...

Lovaas and Schreibman (1971) conducted another study that involved a stimulus complex consisting of just two elements. The two elements presented simultaneously were the red floodlight and white noise (as in the Lovaas et al., 1971 study). The training phase on the compound stimulus presentation (both elements presented simultaneously) was followed by single-cue testing. The children who were not disabled showed bar pressing to either of the single elements when presented. For the children with autism, two outcomes were now observed given the reduction to only two elements contained in the compound stimulus. Restricted stimulus control was not evidenced for two of the children with autism. In contrast, four of the other children with autism did not respond equally to both elements, clearly depicting restricted stimulus control from only one element. Perhaps the most interesting finding was that of John T. and Janet. During the initial set of test trials, they responded to only one feature. However, as single-cue testing progressed, both of these participants acquired responding to the other (previously) nonfunctional element. In summary, reducing the complexity of the stimulus presentation from three to two elements certainly proved to be beneficial to some of the children.

Overselectivity has also been demonstrated with other types of disabling conditions (see Ploog, 2010 for a complete review). A research study that was conducted by Bailey (1981) found children with learning disabilities exhibiting overselectivity in a task involving three critical elements as the compound stimulus. The participants of the study were from three groups. One group was comprised of 16 young students diagnosed with mild mental retardation. Another group was comprised of 16 students with learning disabilities and the last group involved 15 non-handicapped first and second graders. A fourth group involved students with mental retardation who were older than 16.

All students were shown three pictures on the same sheet of paper as the S+; a sun, a bird and a foot. Responding (touching paper) was reinforced when the child was presented with this sheet of paper depicting these set pictures. On another sheet of paper, the non S+ (called the S-) consisted of the following three pictures: book, girl, and cat. Touching this paper did not result in reinforcement. All children acquired this visual discrimination.

Single-cue testing was then initiated to determine if restricted stimulus control had occurred. One picture from the S+ compound stimulus was presented along with one picture from the S – compound stimulus, on two separate sheets of paper. None of the non-handicapped children showed overselectivity. However, nine of the children with mild mental retardation and eight of the children with learning disabilities showed overselectivity. The majority of the children with mental retardation responded correctly to just one of the pictures from the S+ compound stimulus. Concurrently their rate of correct response to the other pairs was not adequate. Children with learning disabilities responded correctly to two of the three pictures that were on the S+ page, as did the children who were older than 16 diagnosed with mild mental retardation. However, one of the S+ pictures did not produce a high rate of correct responses.

More recent research has investigated the phenomena of restricted stimulus control with delayed match to sample (DMTS) procedures. For example, three individuals with mental retardation served as participants in a study determining if a differential observing response (DOR) could overcome the restricted stimulus control they demonstrated in the baseline DMTS (Dube & McIlvane, 1999). A DOR involves a behavior that belies the unobservable entity called "attention." For example, when a student is looking at a therapist during lecture, we would like to infer that they are paying attention, but such an assumption may be inaccurate. However, measuring correct responses to questions that are drawn from such a lecture would be a behavioral measure of attention.

Previous research demonstrated that having the individual label (tact) the presented stimulus (Gutkowski, Geren, Stromer, & MacKay, 1997, as cited in Dube & McIlvane, 1999) reduced stimulus overselectivity. The tact served as the DOR in this case. However, such a method would be impractical for persons who are unable to respond vocally, which was the case with the participants in the current study. The DOR procedure involved having the participant touch the presenting compound stimulus before being presented with choice stimuli requiring a correct response. Such touching responses were prompted to develop this behavior during the experimental condition. All correct responses were reinforced with tokens that were exchanged for preferred foods.

The results demonstrated that when observing responses occurred through prompting, the individuals performed better on the DMTS and both elements exerted stimulus control. Subsequently, removal of the prompting of the observing response produced a reduction in correct responses. These results indicate that stimulus overselectivity may involve the individual's lack of attention to the compound stimulus; hence a procedure that requires a behavior that belies attention, such as touching the compound stimulus remediates the deficit.

The utility of a DOR intervention was extended in a single participant study that demonstrated increased skill at match-to-sample tasks with printed words having two letters in common (Walpole, Roscoe, & Dube, 2007). In the baseline, the individual with autism was able to match words with no common letters or identical features (e.g., sample stimuli comprised of *car* vs. *doll*), but not words that have two letters in common (e.g., sample stimuli comprised of *car* vs. *can*). The DOR procedure required the participant with autism to match the letters that were discriminative for differential response (e.g., the letters *r* and *n* in *car* and *can* as sample stimuli to be matched to corresponding letters). Such an orienting response was successful in improving accuracy with match-to sample tasks involving two identical features in post DOR training. Other research has also found that an observing response, particularly one that is repeated before the test trial, lessens restricted stimulus control (Doughty & Hopkins, 2011).

Overselectivity has also been demonstrated in nonclinical populations, by inducing conditions beyond compound stimulus presentations (McHugh & Reed, 2007). The methodology to study the phenomena of stimulus overselectivity in McHugh and Reed (2007) was similar to the early research on stimulus overselectivity (Lovaas, et al, 1979) in that the training phase involved discriminations of two sets of compound stimuli. Each compound stimulus used in the study consisted of two font types from Microsoft Word 2000. For example the S+ compound stimulus might be a special font (wingding) of the letters AB. The S – might be the letters LM. Following the training phase, participants were then provided probe tests to determine if both elements of the compound stimulus were equally capable of producing the correct response to the S+. Again, this phase was the same as previous test phases in overselectivity research (Lovaas, et al, 1979). Each element was tested in isolation to determine its control over the response.

These researchers were also interested in determining if chronological age has an effect on stimulus overselectivity. There were three age groups involved in the study, 16 participants in each group. To determine if stimulus overselectivity could be produced in individuals from nonclinical populations, McHugh and Reed (2007) used a distracter task before the training and probe test phases. The distracter task involved a grid, with several geometric shapes drawn within some of the boxes on the grid. All participants were exposed to the grid and told to memorize it. To produce the distraction, half the participants in each group were told they would have to replicate by drawing the shapes within the grid at the end of the experiment. They were informed that this part of the experiment did not relate to the next part of the experiment. The other half of the participants in each group were told to memorize the grid but not given the instruction that they would be required to replicate the exact form of the grid at a later time. Therefore the grid task would be more burdensome to the individual's were told they would be assessed on their memory of the later point in time.

The results demonstrated that the assumed distraction produced by the instruction for half of the participants increased the number of trials needed to criterion in the probe tests. With respect to the age variable, young adults reached the criterion performance the fastest. Elderly adults were the slowest to achieve criterion performance. Main effects were achieved for both the distraction variable as well as the age variable. Elderly adults were significantly different in their trials to criterion then the other two groups.

Probably the most significant impediment to skill acquisition from restricted stimulus control would be in environments that rely heavily on observational learning methods. Children learn how to perform certain chains of behaviors, and when to perform such, by watching others. Young non-disabled toddler and pre-school children acquire simple to more sophisticated social skills and language via observational learning. To acquire a skill via observation, one must be able to view the sequence of behaviors performed and then be able to replicate the sequence under given conditions. Attending to only a select portion of the modeled chain of behaviors would be evidence of overselectivity.

Varni, Lovaas, Koegel and Everett (1979) conducted a study that demonstrated the lack of capability that children with autism have in acquiring skills through observation. In simulating an observational learning paradigm, the children who participated in this research observed a model perform a chain of behaviors for 20 observation trials. This was followed by a test trial where the child participant was tested to determine if she or he could perform the chain of behaviors that had just been demonstrated for 20 trials (modeled). For example, in one observational learning sequence, the model was given a verbal command by the therapist, "phone" and then required to pick up the handset of the phone nearby. Performance of this chain by the model resulted in reinforcement by the therapist. This was conducted 20 times in a row by the model. The test trial involved the therapist presenting the same command, "phone" to the child. If the child did not perform that correct sequence of behaviors, another 20 trials of modeling were provided. The observation trials continued until the child responded correctly on a test trial or a ceiling of 1000 observation trials had occurred. If the child acquired this task, another observational learning task was presented in the same fashion.

The results of the study showed that children with autism usually learned only a part of the behavior they observed. For example, a child might touch, rather than pick up, the phone. Thus, only a restricted portion of the modeled behavior that they observed was acquired. This finding has significant implications for teaching practice when working with children with autism. It is unfortunate that many classrooms for children with autism heavily rely on observational learning paradigms, via the group lesson approach.

This phenomenon has important implications when considering a child's ability to profit from everyday learning opportunities. Whether it is older brothers and sisters, or the neighborhood children with whom they play, young children acquire many behavioral chains by observation. In contrast, children who are unable to attend and subsequently imitate observed behavioral chains do not acquire age-appropriate social and play skills. In the long run, such contexts *lose their value* to these children and they may find comfort in isolation from others. If children with disabilities cannot learn by watching a sequence of behaviors, such a deficit would definitely hinder their social, play, and academic development.

IMPLICATIONS OF RESTRICTED STIMULUS CONTROL

It is evident that in everyday life, behaviors occur to stimulus presentations that involve many elements, i.e., we respond to compound stimuli. A child's inability to attend to multiple elements within compound stimuli can hinder generalization across multiple exemplars within a stimulus class. Further, a behavior that is under stimulus control of an irrelevant feature of a stimulus compound will "disappear" when that feature disappears with other stimulus presentations from the same stimulus class. A study by Koegel and Rincover (1976) demonstrated how an irrelevant feature might be responsible for the lack of generalization. A therapist taught ten children with autism to perform a very simple behavior to the command "Touch your nose." All children acquired this behavior of touching their nose when issued that command. The generalization test was to have a second therapist issue that command, but in a different context (outside instead of in the therapy room). Four of the ten children did not perform the behavior in the generalization test. It is easy to just dismiss these children's failure as a case of failing to generalize because of different therapists or context. But the reason for generalization was more complex than changes in personnel. Extensive testing of each of these four participants revealed that the stimulus control obtained in the original discrimination task was the result of an irrelevant feature that was correlated with the command. In one case, the therapist's incidental hand movement while presenting the verbal command, "touch your nose," controlled the response of touching the nose in the therapy sessions. The therapist in the generalization setting, unaware of such a "prompt," did not perform the same gesture and the child's response of touching his nose "disappeared." For this particular child, touching his nose probably could be evoked for any other command, if it was presented simultaneous with the particular incidental hand movement. Unfortunately the hand movement (with the original therapist) became the discriminative stimulus for touching his nose. The absence of this hand movement resulted in absence of the requested behavior under the relevant command. A more recent study also demonstrated that the presence of the therapist could exert inadvertent stimulus control (in this case, refraining from pica), and that their absence resulted in the re-emergence of pica (Falcomata, Roane, & Pabicio, 2007).

In the 1990s, many preferred elementary reading programs emphasized natural literature and books as reading programs. The basal texts were often discarded. Teachers were told to select reading material for their kindergarten and early elementary classes that would capture the interest of the children. The assumption of the "reading experts" at that time was that the development of reading was simply a motivational issue. Hence, if motivation is maximized by materials that present interesting stories, then voila, children will learn how to read (phonics and letter sound relationships need not apply). Many beginning reading materials feature colorful pictures with text (the high interest aspect). Often, one sentence on a page is accompanied with a large detailed picture. The teacher would read the story to the class, point to the pictures and text and then have the children "read" the same story. Further, the language arts program featured the children drawing their own pictures to this story. For example, the page might have the following written words printed, "The boy went swimming." The children would then draw their own illustration of that sentence and then would do the same for subsequent pages. In other words, the children illustrated their own book, but each child had the same text. It appeared that many young children became *instant readers* during the literacy-based approach to reading in the 1990s.

If the child memorized the words to say on each page, it appeared that the child was reading when in actuality she or he was not. The picture had stimulus control over responding (i.e., reading), not the printed words! If a teacher had removed the pictures on the page and/or presented the words of the text in a different order, children who had appeared to read might have been "stumped." Where there was once fluent performance, there would now be hesitation, errors and guessing. Unfortunately, many teachers and parents were so elated with the young child's skills involving reading and illustrating that few tested whether such decoding of text would occur without pictures!

In summary, attending to a restricted small subset of discriminative features within a stimulus presentation can produce a deleterious effect on skill acquisition. This paper will examine error patterns that arise due to the learner's inability to attend to more than one feature within a compound stimulus presentation. A diagnostic and classification system that could identify and detect the source of stimulus control of such response patterns would aide clinicians who work with children who portray stimulus overselectivity.

A DIAGNOSTIC SYSTEM FOR ERROR PATTERNS

Given the research on stimulus overselectivity (Fabio, Oliva, & Murdaca, 2011), it should be apparent that stable error patterns are neither unpredictable nor random. Rather, consistent error patterns occur as a result of some form of restricted stimulus control. I have identified the following three conditions as potential sources of error patterns when learner's attend to only one feature of a compound stimulus: (a) a discrimination task involving the presentation of two compound stimuli, with a feature that is identical to both stimuli (Etzel, Bickel, Stella, &LeBlanc, 1982) controlling the behavior, (b) stimulus control via an irrelevant feature (Etzel, et al., 1982) that was correlated with reinforcement in a previously trained (and mastered) discrimination task involving two compound stimuli, but is not correlated with reinforcement across the entire stimulus class, or (c) single feature stimulus control in discrimination learning across a stimulus class that involves compound elements, both discriminative and non-discriminative features. For clarity, I will respectively term these sources of restricted stimulus control as the following: (a) identical feature control, (b) irrelevant feature control, and (c) incomplete stimulus control.

DETECTING IDENTICAL FEATURE CONTROL

Examples. When a child's behavior is under stimulus control of a single feature that is identical to both stimuli, the percentage of correct responses rate would mimic chance levels. For example, a therapist is attempting to teach a two-choice conditional discrimination involving matching different colors. On one index card is a circle colored red. On the other index card is a circle that is colored blue. The child is given a sample index card with one of the colors and required to match it with the stimulus display. Note that with respect to this discrimination task, all the elements except the color (discriminative feature) are the same (identical). Both of these compound stimuli have all the same features except the key feature or element which varies, i.e., color; it is assumed that high rates of correct responding would ensue. However, suppose the individual is unable to match colors despite hundreds of training trials? This is an indication that one of the features not discriminative for reinforcement is controlling the response, with the reinforcement ratio being about 50%. Unfortunately, this reinforcement ratio may be enough to maintain such behavior and not produce a change in stimulus control to a discriminative feature. One begins to suspect that the individual might be color-blind. But failing to attend to this element could also be a case of overselectivity. For example, even adept learners might demonstrate difficulty in forming this discrimination if the contrast between the two different colors is an infinitesimal shade difference.

Another example would be a therapist who prints two words on two separate white index cards. The therapist wants the child to read each word aloud. The discriminative elements are obviously the letters of the two words being different. A feature that is identical to both stimuli is the white index card. If responding is under control of the white index card, one can see that the student will respond at chance levels when asked to designate which card has a specific word on it. If the child's attention is never directed to the discriminative features, and away from the identical features, hundreds and thousands of trials can accrue without any progress.

The identical feature, also known as redundant elements in earlier writings (Etzel, et al., 1982), can also be contained within the two words presented. Suppose one word on the index card is "when" and the word on the other index card is "where." Both words have the first three letters in common ("whe"). Hence, continuously attending to only the first three letters, or the first two letters, or only the first letter, would not allow the learner to acquire this discrimination. This child might receive daily rehearsal on words that begin with "wh" and fail to demonstrate mastery because of restricted stimulus control. Can such overselectivity explain why some children diagnosed with dyslexia fail to acquire such complex discriminations? Perhaps it is the manner in which reading instruction proceeds.

It should be evident that when the restricted stimulus control is due to an identical feature within a compound stimulus (therefore not discriminative for reinforcement), learning can be impeded significantly. For example, in teaching a child to be able to pick up items to his left or right, a therapist would alternate those two commands in a lesson. The command, "pick up the ball to your left," involves multiple words (which entail multiple phonemes within words) and multiple displayed items that may be on the child's left hand side. Additionally, the command may be given at a certain voice intensity and decibel level. The alternate command would be picking up an item to the right side of the child. Note that in both commands, the majority of the spoken words in the two different commands are the same: "pick up the ball to your." Only the last word in the respective command is therefore correlated with reinforcement of a specific behavior. If the child essentially "hears" the same command (i.e., attends to one of the identical features only), the child will not master this right/left discrimination task.

Diagnostic test for identical feature control. A test to determine identical feature control within a simple discrimination task can be conducted. For the baseline phase of this diagnostic test, the same alphabet letter (e.g., "B") is presented on two different index cards. On one index card, the letter is in red. On the other it is in green. The child is told to touch the index card with the green letter "B" when presented with these two stimuli. The child fails to acquire this behavior after 100 trials (see Table 2).

In the second phase of this diagnostic test, the therapist makes the size of the alphabet letters different, thus superimposing an additional discriminative feature on this presentation. For example, the therapist makes the red alphabet letter larger, and keeps the size of the blue letter "B" on the other index card as is. If the child was not responding correctly before (as the data indicate in Table 2) and now responds correctly to this revised task (see Table 3), one can see that the identical feature (i.e., letter "B") was the source of stimulus control. Errorless learning techniques (Cipani & Schock, 2011, see Appendix C) would be indicated as a result of this test. Another technique that has been verified in overselectivity research is the imposition of ob-

Table 2. Data indicating overselectivity in baseline condition

	% Correct	
	Red	Green
Session 1	40%	60%
Session 2	30%	40%
Session 3	50%	40%

Table 3. When size of index card is also made discriminative

	% Correct	
	Red	Blue
Session 1	100%	100%
Session 2	90%	100%
Session 3	100%	90%

serving responses during observational trials (Doughty & Hopkins, 2011; Dube & McIlvane, 1999; Walpole, et al., 2007).

Stimulus control involving identical features is possibly a major reason for the inability of many persons with severe disabilities to acquire receptive language (mand compliance). In a hypothetical instructional session, a child with severe disabilities is asked to touch one of several objects. The therapist is addressing the following instructional objective involving identifying common objects: able to receptively identify 10 common objects. She has selected the first benchmark for the objective as differential responding to the following two commands: (a) *Touch the fork* and *(b) Touch the cup*. Given these two commands, the critical (discriminative) feature is the last word in the sentence. To reiterate, the voice of the presenter and the first two words of each command ("touch the") are identical in both compound stimulus presentations. The first initial diagnostic test is to remove all the words of the command except the last word. All that would be left are the words, "*fork*" and "*cup*." If alternately presenting these two words still does not evoke discriminative responding after a few point prompts, an additional diagnostic would be required.

The additional diagnostic procedure superimposes an additional discriminative stimulus on each word. The therapist still presents these two words in alternate random fashion. However, the command "fork" is ushered in a whisper. The command "cup" is given in normal conversation tone. The therapist would provide several trials with point prompts for each command to develop the correct selection, but quickly fade these from the stimulus presentation. If the child is now responding differentially to a whisper versus normal conversation tone, the contrasting results depict identical feature control. For this child, the differentiated sounds comprising the English language are not differentiated to him. What this child will respond to differentially is the decibel level of one's voice. I have found that loud versus soft voiced language can easily control discriminative responding when used for a two choice discrimination task. This ability to respond differentially is probably due to a child's history of responding on the basis of normal conversation tone versus screams and scolding, which often evokes some desisting behavior.

The training implications are that such differentiations will need to be targeted in a very precise and sequenced approach. The use of voice intensity as a prompt will have to be used and then systematically faded so that the phonemes of the individual words "fork and *spoon*" begin to control responding, eventually with the other words in the commands faded in.

IRRELEVANT FEATURE CONTROL

Examples. In most instructional contexts, once an initial two-choice discrimination is acquired, the therapist is then interested in developing a response that generalizes to a class of stimuli. This class of stimuli has a specific discriminative feature that should exert control over a specific behavior. Teaching a child her "colors" would be a good example. Young children are taught to identify (by selecting) the color "red" across a variety of items. All the shades of red existing on a variety of items form a stimulus class. Competent learners can select the red item (upon the request to do so) irrespective of the different sizes, shapes and types of items that are presented, and contrasted with an item of a different color. Color is the discriminative element and the other elements that may be present within the presented stimuli are irrelevant to the instructional task. The clinical concern can present as a child's failure to generalize the selection of the red item past the initially trained stimulus discrimination. This is often termed as a failure to generalize.

The phenomenon I characterize as irrelevant feature control can transpire when a feature that was correlated with reinforcement in the initial two-choice task is not correlated across the stimulus class. The particular feature is irrelevant within the stimulus class, but obtained stimulus control because of its (unfortunate) pairing with the discriminative feature in the initial discrimination. The result would be the learner's discriminative behavior failing to generalize (across relevant members of the stimulus class). Concurrently, it will generalize (incorrectly) when the irrelevant feature is temporally paired with non-members of the stimulus class.

Irrelevant feature control presents as the following scenario. The learner acquires an initial two-choice discrimination task, but subsequently fails to master additional discrimination tasks across the pertinent stimulus class. Therefore, an error pattern does not become evident until additional examples of the stimulus class are used, or one tests for the source of stimulus control (Schreibman & Lovaas, 1973). Schreibman and Lovaas used a task that targeted the development of discriminated behavior between life-like male and female dolls. Upon acquiring the initial discrimination with a boy doll and a female doll, these researchers tested which of the elements were responsible for the performance. In contrast to non-handicapped children, the children with autism used one irrelevant element to respond differentially. For example, with one child, the basis of (correct) responding was a function of the different shoes the boy doll had on versus the girl doll. When the researchers removed the shoes of the doll, correct discrimination behavior disappeared.

What was the result of this irrelevant feature control? Given that the shoes were different between the boy and girl doll during single example training (one member of each stimulus class), discriminative responding will reach high rates of correct selections. This will only hold true when the same boy doll and girl doll are used throughout the training. If the shoes of the doll are the sole basis for discriminative responding, then it is easy to see how such restricted stimulus control will result in a failure to generalize across additional members of the stimulus class (if they possess different shoes than the original dolls). When the shoes are different in the second exemplar of either the boy and/or the girl dolls, responding correctly breaks down.

Diagnostic for irrelevant feature control. In targeting a discrimination involving only two stimuli comprised of compound elements, there are no irrelevant features. The elements are either discriminative (different) for reinforcement or not (identical to both). However, once the learner is required to respond to a stimulus class, there are identical and irrelevant features as well as discriminative or critical features for that stimulus class. Further, irrelevant features are varied across the stimulus class. Therefore, irrelevant stimulus control only becomes apparent when the curriculum expands from an initial two-choice discrimination task to additional stimuli within that class. The irrelevant feature's presence or absence determines responding, rather than the discriminative feature(s) of the stimulus class. The response rate goes from high levels of correct responses on the initial two-choice task to high error rates across members of the stimulus class.

The diagnostic for this problem would be to run a series of test trials, half with the irrelevant feature present with the stimulus presentation and half without, along the lines of the Koegel and Rincover (1976) study. In their study, they found that testing outside of the therapy session resulted in loss of behavior to the presented discriminative stimulus. Using this methodology, generalization tests would be conducted after the initial training to diagnose irrelevant feature problems. Use someone who is not familiar with the original training in these test trials with a protocol. The new person would also use different exemplars from the stimulus classes. In this manner, if an irrelevant feature was controlling the behavior, the data will be illustrative. Correct responding will decrease from the initial task to the generalization task, when the irrelevant feature that was initially present becomes absent in the generalization test.

INCOMPLETE STIMULUS CONTROL

Examples. In many advanced instructional tasks, the learner is faced with multiple discriminative elements within a compound stimulus. In addition, to the presence of irrelevant features within the stimulus class, these types of tasks involve multiple discriminative features that define the complex stimulus class. A hypothetical match-to-sample task that illustrates this complex stimulus compound involving three discriminative elements is presented in Table 4.

If the learner has a history of only attending to one element within a compound stimulus presentation, a consistent error pattern would develop. Notice that with just two different shapes, two different colors and two different sizes there are eight stimulus presentations involving these three elements. The child is to take the item and match it on the basis of shape, color, and size given a field of six possibilities. As you can see, if the therapist presents the child with a large red square to match, it is imperative that the child attend to each element when selecting from the eight possibilities. Suppose the child just attends to the color of the match stimulus. If the therapist gives the child the large red square to match, there are four match stimuli that are red. However, only one of the four meets the match criteria for all three elements.

Table 4. Match to sample task with three elements

Shape	Color	Size
Circle	Red	Large
Circle	Blue	Large
Circle	Red	Small
Circle	Blue	Small
Square	Red	Large
Square	Blue	Large
Square	Red	Small
Square	Blue	Small

For some children, teaching matching skills when multiple elements vary can be difficult. Despite having many opportunities to acquire the skill, children with overselectivity would find it difficult to acquire such skills. Such tasks that are difficult for these children develop aversive properties which subsequently make escape from such learning experiences a powerful functional behavior.

Diagnostic system for incomplete stimulus control. The diagnostic method for this category would involve the methodology used in the overselectivity studies conducted in the 1970s. Following the development of a two-choice discrimination task to the compound stimuli, single-cue testing would be initiated subsequently. The correct responses and error rate for each single-cue would be measured. Test trials would involve the alternation of a single-cue involving either color, shape, or size while holding the other two elements constant. For example, the therapist might select color as the basis for responding, with the features red and blue as the contrast. The other two features are held constant, and are the same (i.e., same size of one geometric figure across both stimuli). If this test reveals that a single feature is controlling the response, there are some procedures that have been empirically verified to address such limited repertoires (Koegel & Schreibman, 1977; Schreibman, Koegel, & Craig, 1977). Developing attention to multiple elements can then be progressively introduced, if overselectivity is determined.

SUMMARY

In this paper, I have presented a brief overview of basic research of stimulus over selectivity and then identified three possible sources (or conditions) for restricted stimulus control and the generation of error patterns. In addition, and perhaps more importantly, diagnostic tests have been presented in this paper that allow one to determine the source of the error patterns. Therapists and practitioners need to be cognizant of the reasons for persistent error rates in order to allow the child to progress to more advanced instructional objectives.

Children who present with overselectivity demonstrate difficulty in skill acquisition under usual instructional conditions. Such children may have the same instructional objectives on their individualized education plan for successive years if such a determination involving the presence of stimulus over selectivity is not made. To effectively assist these children, it is not simply a matter of providing more practice, or greater exposure, or enhancing the child's motivation. It requires a sophisticated understanding of behavioral development, or how children learn to respond to very complex compound stimuli and how the instructional design accounts for potential error patterns. An understanding of stimulus overselectivity and diagnostic tests to determine the source of stimulus control needs to be inherent part of a therapist's repertoire when working with children who present such difficulties.

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QUESTIONS

1. Describe the methodology used in the initial Lovaas et al., (1971) research study. Present the experimental procedures used in the initial training phase of the compound stimulus and then the single cue test procedures used subsequently. Describe how the obtained results implicate stimulus overselectivity as a phenomena that can encumber discrimination learning for children with autism.
2. How did the Varni et al., (1979) study illustrate the inability of children with autism to profit from an observational learning paradigm?
3. Present a hypothetical example illustrating the following diagnostic category: identical feature control.
4. What is a *stimulus class* and how does it relate to error patterns that involve irrelevant features?
5. Contrast these two diagnostic categories for error patterns: irrelevant feature control versus incomplete stimulus control.