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AN ANALYSIS OF AUDITORY STIMULUS GENERALIZATION IN CHILDREN
WITH AUTISM FOLLOWING TWO DIFFERENT TRAINING PROCEDURES

by

Steven N. Corry

A thesis submitted in partial fulfillment of
the requirements for the degree

of

EDUCATIONAL SPECIALIST

in

Psychology
(School Psychology)

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2013

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ABSTRACT

An Analysis of Auditory Stimulus Generalization Gradients in Children with
Autism Following Two Different Training Procedures

by

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Utah State University, 2013

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Department: Psychology

Previous research suggests learning of children with autism often fails to successfully generalize across changes in settings and stimuli. Much of this research has assessed generalization by first teaching a behavior in one setting and measuring the transfer of the behavior to extra-treatment stimuli and settings. Procedures from basic research, measuring generalization gradients, offer more precise means of characterizing the extent of generalization and the basic processes underlying it. The present study obtained generalization gradients for children with autism spectrum disorders (ASD) according to an auditory modality after two different training procedures. First, after teaching three children with ASDs to discriminate between tone-present and tone-absent conditions, the present study obtained generalization gradients for the children as a measure of the extent to which their operant responses generalize to changes in an auditory stimulus signaling reinforcement as the stimulus was varied without

reinforcement across the dimension of tone frequency. Although the shape of resulting generalization gradients differed between participants, all three participants in the present study showed a pattern of responding consistent with generalization. Gradients for two of three participants were orderly and decremental. Next, after teaching participants to discriminate between the same tone frequency signaling reinforcement and a higher tone frequency signaling extinction, generalization gradients were again obtained. Predictable changes in the shape of gradients were noted for two of three participants. Results are discussed with regard to stimulus control, the behavioral processes of reinforcement and extinction, and the “peak shift” effect.

(121 pages)

PUBLIC ABSTRACT

An Analysis of Auditory Stimulus Generalization Gradients in Children with
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by

Steven N. Corry, Educational Specialist

Utah State University, 2013

Previous research suggests learning of children with autism often fails to successfully generalize across changes in settings and stimuli. Much of this research has assessed generalization by first teaching a behavior in one context and then measuring the transfer of the behavior to extra-treatment stimuli and settings. The present study measured generalization of learned behavior by systematically varying the tone of an auditory stimulus present during training to obtain generalization gradients. Generalization gradients are graphical representations of the strength of a response produced by stimuli that vary from the training stimulus along some stimulus dimension. By obtaining generalization gradients, this research may offer a more precise means of characterizing the extent of generalization and the basic processes underlying it. The study also went beyond previous research with children with autism by examining the effects of two different training procedures upon the resulting generalization gradients. Participants were first taught to discriminate between the presence and absence of a

specific stimulus, and later, to discriminate between two stimuli varied along the same dimension. Gradients were measured following both trainings.

In the first training procedure, three children with autism were taught to engage in a simple communicative request in the presence of a specific tone and to withhold the request when there was no tone. The researchers then measured the extent to which these children continued to engage in the request as the tone was changed in frequency. They graphed the resulting data in the form of a generalization gradient. Although the shape of resulting generalization gradients differed between participants, all three participants in the present study showed a pattern of responding consistent with generalization.

Gradients for two of three participants were orderly and decremental. In the second training procedure participants were taught to discriminate between two tones of different frequencies. Generalization gradients were again obtained. Predictable changes in the shape of gradients, consistent with basic research on generalization gradients, were noted for two of three participants. Results are discussed with regard to stimulus control, the behavioral processes of reinforcement and extinction, and what has been called the “peak shift” effect.

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Steven N. Corry

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CHAPTER I

INTRODUCTION

Stimulus control refers to the relationship between stimuli and behavior (Mazur, 2006). Specifically, behavior is said to be under stimulus control when the presence or absence of the stimulus influences the probability of behavior. For example, if an adult calls a typically developing child by name, the child may turn toward the adult because of a history of reinforcement. If the adult were to call out the name of a different child, the first child would be less likely to respond in the same manner because, in the past, responding to another child's name was unlikely to produce reinforcement. In this case, the term stimulus control refers to the degree to which the sound of the child's name influences her gaze. The child's tendency to respond differently to the sound of two different names is evidence of *stimulus discrimination*. The capacity to discriminate between two or more stimuli enables people to behave differentially in different contexts and is therefore fundamental to academic and social development.

Just as discrimination between stimuli can lead to adaptive responses, so can generalization among stimuli. *Stimulus generalization* occurs when a response emitted in the presence of a particular stimulus is also emitted in the presence of other, perhaps similar, stimuli (W. D. Pierce & Cheney, 2008). People frequently encounter novel stimuli in the real world. Whether this occurs in family and social contexts, at school, or in a career, successful functioning and survival may depend on the ability to adaptively respond to these novel stimuli (Mazur, 2006).

A frequently cited problem in children with autism is that newly acquired

behavior is rarely observed to generalize across different stimulus situations (Lovaas, Koegel, & Schreibman, 1979). This failure to generalize has important implications for the transfer of learning across environments. For example, if a child has been taught how to perform a skill at school, such as appropriately asking for a snack, this learned adaptive behavior may not transfer to the home environment. Therefore, this and many other benefits gained in school may be limited to the school setting.

One reason implicated for this maladaptive lack of generalization is that, relative to other children, children with autism tend to be overselective when responding to stimuli (Lovaas et al., 1979; Ploog, 2010). In other words, behavior for these individuals tends to be under tight stimulus control of only a narrow subset of stimuli in the environment. For example, in a study by Rincover and Koegel (1975), children with autism were taught to respond in accordance with a simple directive (e.g., “touch your head”). A portion of these children failed to transfer this newly acquired behavior to an extra-treatment setting. When an analysis of stimulus control was conducted, by systematically introducing minor extraneous components from the treatment setting into the extra-treatment setting, the authors found idiosyncratic components from the original setting (e.g., the table and chairs in the treatment setting) had gained exclusive control over responding. Stimulus overselectivity appears to interfere with generalization.

Previous studies involving children with autism have frequently focused on generalization from the perspective of intervention and treatment (e.g., Rogers, 2000; Stokes & Baer, 1977). To do this, studies have often assessed generalization by teaching behavior in one setting and subsequently measuring the transfer of treatment gains to

extra-treatment stimuli and settings (Handleman, 1979; Handleman & Harris, 1980; Koegel, Egel, & Williams, 1980; Lovaas, Koegel, Simmons, & Long, 1973; K. Pierce & Schreibman, 1995; Zifferblatt, Burton, Horner, & White, 1977). However, the methods of measuring stimulus generalization used in such studies provide only limited information with respect to the extent of stimulus generalization and the basic underlying processes influencing it.

More precise means of characterizing the extent of generalization comes from basic research with animals. In these studies, experimenters first train subjects to respond to a particular stimulus and then measure responding as the stimulus is varied incrementally across a single stimulus dimension (e.g., color, location, pitch, volume, etc.; Honig & Urcuioli, 1981). This procedure and its variations yield generalization gradients. Generalization gradients “show the relationship between probability of response and stimulus value” (W. D. Pierce & Cheney, 2008, p. 180). This relationship can be seen when gradient data is graphed. An orderly gradient, sloping away from the original stimulus value, demonstrates the stimulus control held by the original training value and the degree of generalization to similar stimuli as the stimuli gradually become more different from the original stimulus (Figure 1).

Other fields of study, like medicine, have benefited from the development of methods or instrumentation that allows researchers to obtain more precise measures of a phenomenon being investigated. For example, physicians can make far more precise diagnoses by running blood tests than they can by simply observing the symptoms of an illness. Likewise, more precise measures of generalization (e.g., obtaining generalization

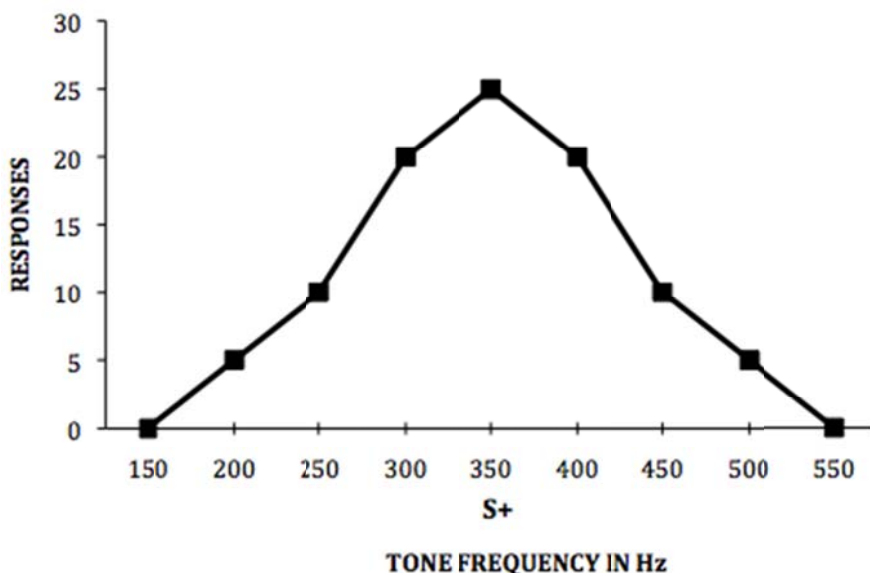


Figure 1. A hypothetical decremental generalization gradient. This is a hypothetical gradient for responding tone frequencies, with 350 Hz as the original training value (i.e., the discriminative stimulus signaling reinforcement [S+]).

gradients) can help researchers better understand the basic processes influencing it.

Studies examining generalization in children with autism have rarely used methods that yield generalization gradients. Furthermore, each of the few studies that obtained generalization gradients made exclusive use of stimuli that vary according to visual modalities (Matthews, Shute, & Rees, 2001; Miyashita, 1985; Rincover & Ducharme, 1987). No studies have obtained generalization gradients for children with autism when the stimulus dimension was varied along an auditory modality. Considering the important role of the auditory modality in the development of speech and communication, and the difficulties children with autism often have with speech and communication (American Psychiatric Association [APA], 2000), assessing stimulus generalization across this modality may lead to a better understanding of these deficits. Additionally, because some children with autism are known to evidence a

hypersensitivity to sound and other unusual sensory responses (APA, 2000), generalization across visual, auditory, or other modalities may not be equivalent.

Basic research on stimulus generalization indicates that the particular training procedures used will influence the form of gradients obtained (Honig & Urcuioli, 1981). Each of the past studies reporting generalization gradients for individuals with autism have included intradimensional discrimination training prior to generalization testing. In intradimensional discrimination training, participants are taught to discriminate between two or more stimuli that differ across the same dimension (e.g., color, size, location, frequency, etc.). For example, the subject may receive reinforcement when responding in the presence of one stimulus (S+), while the other stimulus (S-) is presented under conditions of extinction. This type of discrimination training is known to cause changes in stimulus control and gradients of generalization (Mazur, 2006). Specifically, the experience of extinction in the presence of S- reduces responding in the presence of that stimulus, may raise the gradient, may steepen the gradient between the values of S+ and S-, and may cause the highest rate of responding (i.e., the peak) to shift from S+ to a stimulus value in the direction away from S- (Honig & Urcuioli, 1981). This phenomenon is known as *peak shift* (Figure 2).

Therefore, previous research ostensibly examining generalization in children with autism has actually followed procedures designed to teach discrimination.

Concomitantly, the lack of observed generalization commonly reported in individuals with autism may be confounded with an increased sensitivity to discrimination training procedures, the phenomenon of peak shift, or both. Given that intradimensional training

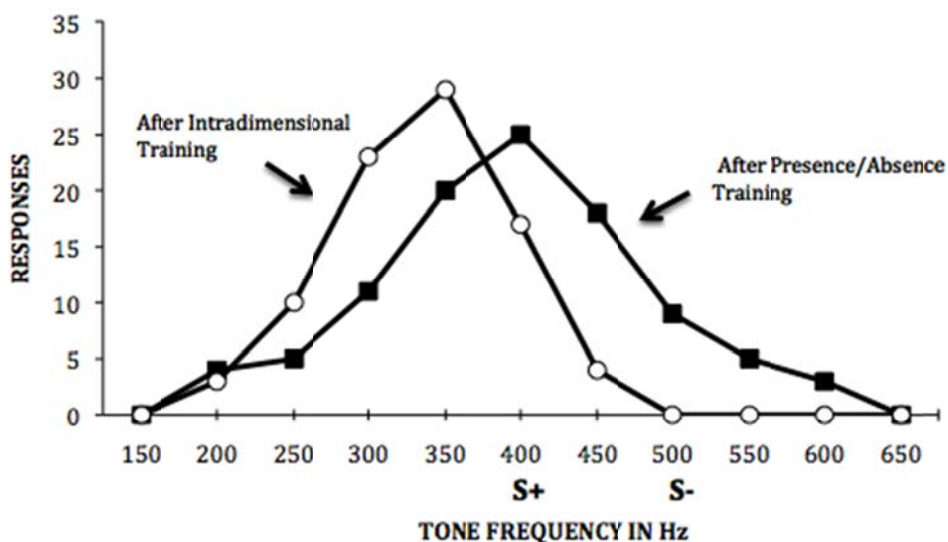


Figure 2. Two hypothetical generalization gradients. The gradient with filled square markers represents the presence/absence condition wherein there is no intradimensional S-. This gradient is orderly and decremental, with the highest rate of responses occurring at the S+ value (i.e., 400 Hz). The other gradient (with unfilled circles) represents generalization after intradimensional discrimination training with 400 Hz as S+ and 500 Hz as S-. Peak shift can be seen in this gradient in that the highest rate of responding has shifted from the 400 Hz tone (S+) in a direction away from the 500 Hz tone (S-).

procedures are unnecessary for obtaining generalization gradients (Honig & Urcuioli, 1981), it would seem beneficial to isolate the effects of reinforcement (generalization) and the effects of extinction (discrimination and peak shift) in individuals with autism. This could be done by obtaining generalization gradients both before and after intradimensional discrimination training.

Research suggests that the behavior of children with autism does not successfully generalize to changes in stimuli because of a tendency to be overselective (Lovaas et al., 1979). However, such findings say little about differences in terms of fundamental behavioral processes of reinforcement (generalization) and extinction (discrimination) in individuals with autism. Such differences, if identified, might have profound implications

for understanding why treatments do not generalize for children with autism. No previous studies have assessed generalization gradients for individuals with autism without using intradimensional discrimination procedures. Therefore, previous research has not isolated the separate behavioral processes of reinforcement (which would cause generalization) and extinction (which would cause discrimination and peak shift). Furthermore, no previous studies have measured generalization gradients according to auditory stimuli in children with autism. Such a study could be useful when examining generalization of tasks that involve spoken prompts across different instructors. The purpose of this study is to measure the extent to which operant responses of children with autism generalize to changes in an auditory stimulus as the stimulus is varied across a single dimension (e.g., frequency), both before and after intradimensional discrimination training.

CHAPTER II

REVIEW OF LITERATURE

Although many studies have explored the phenomenon of generalization in children with autism, few of these have obtained generalization gradients by parametrically varying a single stimulus dimension. The primary purpose of this literature review is to synthesize and critique those studies that have explored the use of generalization gradients as a measure of the phenomenon of stimulus generalization in children with autism. Prior to this, the present review will also discuss relevant research findings regarding generalization and stimulus control in children with autism and basic research on generalization gradients. The specific objectives of this review included the following.

1. To provide background information about generalization and stimulus control in children with autism.
2. To describe the current state of research on obtaining generalization gradients as a measure of stimulus generalization in children with autism and to compare the relative strengths and weaknesses of previous studies.
3. To discuss procedural and trait variables that may influence auditory stimulus generalization for children with autism.
4. To draw conclusions based on this information from which the research questions and strategies for this study were formulated.

Autism and Generalization

“The essential features of Autistic Disorder are the presence of markedly abnormal or impaired development in social interaction and communication and a markedly restricted repertoire of activity and interests” (APA, 2000, p. 70). These children typically do not seek or voluntarily accept the attention of others (Lovaas et al., 1979). They often have difficulty understanding social cues, and may benefit from support and intervention to improve social functioning and acceptance by others in social contexts (Boutot, 2007). Language development may be delayed or entirely absent in children with autism, but when language is present it is often characterized by idiosyncrasies, including abnormal intonation, pitch, rhythm, stress, or rate (APA, 2000). Individuals with autism also frequently exhibit stereotyped behavior and repetition in patterns of speech (e.g., echolalia; APA, 2000). Such children “are generally unresponsive to their physical environment. They are inconsistent in their response to sensory input, they typically do not show a startle reflex, and their parents have suspected them to be blind or deaf” (Lovaas et al., 1979, p. 1,236).

In addition to the preceding deficits, researchers have found that children with autism frequently have difficulty generalizing learned behavior across settings and stimuli (Lovaas et al., 1979). Treatment gains have been found to be “situation specific” (Lovaas et al., 1973, p. 160). In other words, following training, newly acquired behavior may occur only within the training environment or in association only with teachers and stimuli present during training. Training for children with autism often occurs with adult teachers and in small group classrooms with limited distractions. One of the most popular

and extensively studied approaches for teaching children with autism is discrete trial training (DTT; Smith, 2001). In DTT, teachers implement discrete trials by working with a child one to one in a distraction-free setting. Although such training situations can be effective in helping children with autism learn behaviors and skills, failure to generalize this learning across different, and less tightly controlled, situations can still be a problem. This failure to generalize across situations has been a target of research and some procedures that may help increase generalization effects have been identified. For example, researchers have found it is possible for children with autism to achieve successful generalization of behavior across home and school settings if they practiced daily (Zifferblatt et al., 1977). The training stimuli and environment can also contribute to generalization effects. For example, using naturalistic stimuli in training procedures has resulted in improved generalization effects, such as when training of social behavior is implemented by siblings or peers instead of by adults (Bass & Mulick, 2007; K. Pierce & Schreibman, 1995; Rogers, 2000; Stokes & Baer, 1977). Moreover, rather than training in tightly controlled settings, like a cubicle, training in a variety of locations that more closely approximate natural settings can improve generalization (Handleman, 1979; Handleman & Harris, 1980; Stokes & Baer, 1977). Generalization and maintenance of responding beyond training can also improve when training takes place directly in the natural environment. For example, Harper, Symon, and Frea (2008) found that two elementary school children with autism who were taught to engage in social behavior during recess continued to engage socially at recess after training prompts were removed.

 Koegel and colleagues (1980) suggested that, the difficulties with generalization

for children with autism may be due, in part, to “behavioral contrast.” In other words, the difference between levels of responding in treatment and extra-treatment settings may be a consequence of differences between the particular reinforcement procedures (i.e., the particular schedules of rewards or punishments) in each setting. They demonstrated that generalization effects for children with autism could be mediated by the particular reinforcement procedures operative in different environments when the procedures were highly discriminable. For example, if a child receives continuous rewards for displaying an appropriate behavior in a treatment setting, but receives no rewards in the extra-treatment setting, his behavior may not generalize across settings. Alternatively, if the reinforcement procedures between settings are made similar (i.e., continuous reinforcement in both settings) the contrasting trends in responding across settings can be eliminated. Stokes and Baer (1977) also noted success by researchers in achieving generalization after making contingencies indiscriminable across settings.

Overselective Stimulus Control

Although difficulties with generalization may be due, in part, to the extent of difference between the stimuli or reinforcement procedures in treatment and extra-treatment settings, another important variable to consider is the tendency of children with autism to be overselective when attending and responding to stimuli (Lovaas et al., 1979; Ploog, 2010). Stimulus control in children with autism differs from that of typically developing children because it is more restricted. In both natural and treatment environments, many stimuli have the potential to control behavior and not just those

planned by the therapist (e.g., the room, the trainer's shirt, a particular inflection of voice, etc.). In the presence of multiple or complex stimulus inputs, responding for children with autism often comes under the control of an atypically restricted range of input.

Furthermore, the particular stimulus cues that gain control over responding are often idiosyncratic.

Overselective stimulus control is a phenomenon with practical significance in the daily life of a child. Schreibman (1997) related the anecdotal example of a child who had worked with a therapist for 6 months. When the therapist suddenly changed her hairstyle, the child no longer had any recognition of her. Additionally, a child who had previously had no difficulty recognizing his father, no longer recognized him when his father had removed his eyeglasses (Schreibman, 1997). In these examples, overselective stimulus control appears to function by interfering with the child's ability to recognize and generalize to slight changes in relevant social stimuli (i.e., other people). Furthermore, overselective stimulus control appears to be contributing to the social dysfunction of these children, one of the hallmark features of autism.

The term *stimulus overselectivity* was first coined by Lovaas, Scheibman, Koegel, and Rehm (1971). They conducted a study in which children with autism, typically developing peers, and children with mental retardation were taught to respond by pressing a lever in the presence of a multicomponent stimulus. This compound stimulus contained auditory, visual, and tactile components. After discriminated responding in the presence of the compound stimulus had been established, the researchers separated the components of the stimulus and assessed the stimulus control of each component

independently. The researchers found that typically developing children continued to respond equally to each stimulus component. In other words, each component retained functional stimulus control over responding for these children. The children with autism, on the other hand, responded primarily to only one of these cues, while responding by the children with mental retardation functioned between these two extremes.

While this initial study demonstrated overselectivity when each of the cues fell within different sensory modalities, subsequent studies have also demonstrated an overselective pattern of responding for children with autism when the multiple cues all fall within the same sensory modality. Overselective response patterns have appeared when children with autism respond to multicomponent visual stimuli (Fein, Tinder, & Waterhouse, 1979; Schreibman & Lovaas, 1973), dual-component auditory stimuli (Reynolds, Newsom, & Lovaas, 1974), and compound-tactile stimuli (Ploog & Kim, 2007).

In a study by Schreibman and Lovaas (1973), overselectivity was demonstrated with social stimuli experimentally. They analyzed this phenomenon by first teaching children with and without autism to discriminate between differentially clothed boy and girl dolls. Next, they systematically swapped clothing components between the two dolls, one at a time, such as exchanging the girl's shirt with the boy's shirt and the girl's skirt with the boy's trousers. The researchers also exchanged doll heads.

After making each exchange, the children were asked to point to either the boy or girl doll. The experimenters found that the typically developing children had learned the discrimination between the two dolls primarily on the basis of doll heads, but they could

also discriminate accurately between figures on the basis of clothing items when the doll heads were removed. In contrast, the children with autism demonstrated overselectivity because they had learned the discrimination between boy and girl dolls on the basis of idiosyncratic components that were not as socially meaningful as doll heads. For example, one child with autism made the discrimination between boy and girl dolls primarily on the basis of shoes. In this study, the children failed to generalize responding to alterations in social stimuli because they had responded overselectively. Considering that social behavior—from identifying other people, to language development and communication, interpersonal interaction, modeling, and understanding social mores—is complex and full of nuanced cues, it is understandable how a deficiency in responding to multiple cues could lead to impairment in social functioning.

Although it is commonly observed in children with autism, not all children with autism have been found to show overselectivity and overselective stimulus control does not appear to be exclusive to children with autism (Lovaas et al., 1979). Overselective stimulus control has been reported in other populations, including adults with autism (Matthews et al., 2001), young typically developing children (Bickel, Stella, & Etzel, 1984; Schover & Newsom, 1976), and individuals with mental retardation (Dube & McIlvane, 1999). Typically developing university students have also been shown to respond overselectively, but only if they are concurrently engaged in a distracting task (Broomfield, McHugh, & Reed, 2010).

Rather than being a feature unique to children with autism, some have argued that stimulus overselectivity may actually be a function of low mental age, regardless of

diagnosis (Lovaas et al., 1979; Schover & Newsom, 1976). Nevertheless, mental age alone may not completely account for stimulus overselectivity. In their study, Lovaas and colleagues found that children with mental retardation and children with autism both demonstrated restricted stimulus control; however, they found that the children with autism were more overselective. In a comprehensive review of literature on overselectivity, Matthews (as cited in Matthews et al., 2001) found that 18 out of 20 studies looking at differences between groups, both with and without intellectual disability, reported more overselectivity in the children with autism than the comparison group. More recently, Dickson, Wang, Lombard, and Dube (2006) found that children with higher scores on the Autism Diagnostic Observation Schedule were more likely to display overselective stimulus control. Although it has relevance to other groups of people, overselectivity appears to be a phenomenon with special application toward individuals with autism.

Besides having implication for social and other deficits (see Lovaas et al., 1979), overselective stimulus control has been associated with prominent difficulties that children with autism have in generalizing treatment gains across settings. As mentioned previously, Rincover and Koegel (1975) found that stimulus overselectivity can confound the generalization. Specifically, idiosyncratic components from the training environment can gain exclusive control over responding. When this occurs, learned behavior does not transfer to new environments because the idiosyncratic components that have gained control over responding are not present.

Stimulus overselectivity is best understood as a “problem of dealing with stimuli

in context, a problem of quantity rather than quality of stimulus control” (Lovaas et al., 1971, p. 219). Stimulus overselectivity occurs in the context of multiple cues. Burke and Cerniglia (1990) demonstrated that stimulus overselectivity increases as stimuli become more complex. Although the extent to which stimulus control is restricted for children with autism may depend on specific stimulus variables (Anderson & Rincover, 1982), such as the salience of particular stimulus components (Leader, Loughnane, McMoreland, & Reed, 2009), the stimulus feature most clearly implicated in overselectivity is the extent of stimulus complexity.

Given that stimulus overselectivity increases as stimulus complexity increases (Burke & Cerniglia, 1990), it is difficult to study the basic behavioral process of generalization when using complex stimuli, varied across more than one dimension, because the study of generalization may be confounded by overselectivity. Yet, studies that assess generalization in children with autism have taken that route as opposed to following the procedures used in basic research that would allow the characterization of behavioral processes responsible for generalization, or the lack thereof. Such procedures could include steps to increase the degree of control exerted by the relevant dimension (i.e., the dimension varied along a continuum during generalization testing) and could allow researchers to assess the process of generalization unconfounded by the phenomenon of overselectivity.

Measures of Generalization

As mentioned previously, studies have often assessed generalization by teaching

behavior and subsequently measuring the transfer of treatment gains to extra-treatment stimuli and settings (Handleman, 1979; Handleman & Harris, 1980; Koegel et al., 1980; Lovaas et al., 1973; K. Pierce & Schreibman, 1995; Zifferblatt et al., 1977). While the results of these studies have confirmed that children with autism experience difficulties with generalization, these studies have not attempted to study the basic process of generalization, unconfounded by overselectivity. Furthermore, previous research on generalization in individuals with autism has seldom observed or described the generalization gradients produced by parametrically varying a simple stimulus along a single dimension. Those studies that have measured generalization gradients for individuals with autism have always measured generalization only after teaching intradimensional discrimination. Because teaching an intradimensional discrimination involves introducing extinction, the specific process responsible for the results (e.g., reinforcement or extinction) is obscured. Moreover, many of the above studies included punishment-like procedures during intradimensional training, which would further occlude the effects of particular behavioral processes. Therefore, previous research provides only limited information with respect to the basic process of stimulus generalization in children with autism.

In the behavioral literature, numerous classical studies have yielded a wealth of findings about the variables that influence stimulus generalization (Honig & Urcuioli, 1981). These studies have addressed the phenomenon of generalization with a more systematic approach than simply measuring the transfer of responding across settings. By incrementally varying simple stimuli across a single stimulus dimension (e.g., color,

location, time, frequency, volume, etc.), and presenting these incrementally varied stimuli to the subject, researchers can obtain orderly generalization gradients (Honig & Urcuioli, 1981; Mazur, 2006).

Until the work of Guttman and Kalish (1956), generalization gradients were not considered empirical phenomena, but mere theoretical entities (Honig & Urcuioli, 1981). In their landmark study, Guttman and Kalish obtained generalization gradients for pigeons as a function of light wavelength. Four groups of pigeons were trained to peck a key lighted by one of four wavelength values. A steady rate of responding was established by providing reinforcement on a variable interval (VI) schedule. After responding to the training value was established, the pigeons were tested for stimulus generalization. Under extinction conditions, the researchers randomly and repeatedly presented the pigeons with 10 different wavelengths, in addition to the training wavelength. These additional stimuli consisted of wavelength values above and below that of S+ (i.e., the original training stimulus that signals reinforcement). After responding in the presence of each stimulus was recorded and plotted, orderly decremental generalization gradients were evident. Response rates for each group of pigeons were highest at the training stimulus and trended progressively lower as the stimulus wavelength values became more distant from the wavelength value of the training stimulus. Thus, it would appear that the extent to which the pigeon's responding generalized to novel stimuli was a function of how similar each novel stimulus was to the original training stimulus.

“The major impact of [the] work [of Guttman and Kalish (1956)]...was to

establish stimulus generalization as a productive area of research in its own right, particularly with the use of operant methods” (Honig & Urcuioli, 1981, p. 406). Numerous studies followed their work, exploring conceptual and methodological issues, including investigations into the different variables impacting the slope and form of gradients (Honig & Urcuioli, 1981). For example, Jenkins and Harrison (1960) explored the effect of experience on the shape of generalization gradients. Specifically, they sought to determine the effects of different training procedures on the generalization gradients of pigeons in response to a pure tone auditory stimulus.

They trained two groups of pigeons according to two separate procedures. The first group received nondifferential training, in which conditions for every trial were the same. In each of these trials responding was reinforced on a VI schedule, and both the key light and a 1000-Hz tone were on. The second group received presence/absence training. Presence/absence training involved two types of trials wherein the discriminative stimulus (i.e., the 1000-Hz tone) was either present or absent. One type of trial involved conditions identical to conditions for the first group of pigeons in which reinforcement was given on a VI schedule while the key light and 1000-Hz tone were present. In the other type of trial, the key light was lit but the tone was absent and no reinforcers were given for responding.

Generalization testing followed the training for both groups. During generalization trials, eight different stimuli were presented one at a time under extinction conditions and response rates to the separate stimuli were recorded. These stimuli consisted of the original 1000-Hz tone, six novel tones, and a no-tone condition. Three of

the novel tones had lower frequencies than 1000-Hz and three had higher frequencies. Response rates during generalization testing for each stimulus presentation were plotted. Results of generalization testing for both groups of pigeons revealed relatively flat gradients for pigeons that received nondifferential training, while gradients for the differential, presence/absence training group were orderly and decremental, peaking at 1000-Hz and tapering off as a function of relative difference in tone frequency.

The flat gradients for pigeons in the nondifferential training group can be seen as indicative of a lack of stimulus control by the experimental stimulus (i.e., the tone) along the dimension it was altered (frequency). For the nondifferential group, training took place within a stimulus context containing numerous incidental stimuli, such as the light and various other features of the apparatus. Reinforcement was given in the presence of these incidental stimuli and the 1000-Hz tone. Therefore, each of these stimuli was equally predictive of reinforcement. The incidental stimuli “may [have] predominate[d] control of the response with the result that the gradient of generalization observed upon varying the experimental stimulus [was] flat or nearly so” (Jenkins & Harrison, 1960, p. 251). On the other hand, although the presence/absence training also took place in the context of the same incidental stimuli, the experimental stimulus acquired functional control over responding during the presence/absence training because it was the only environmental stimulus that varied between reinforced and unreinforced training trials. Therefore, the 1000-Hz tone became a discriminative stimulus for reinforcement (S+) and its absence signaled extinction (S-), while the other incidental stimuli had no predictive value.

Jenkins and Harrison (1962) extended their study of training effects by providing further discrimination training. Whereas their previous study compared nondifferential training with presence/absence training, this experiment measured the effect of an intradimensional training procedure. Instead of teaching a discrimination between the presence and absence of a stimulus, the researchers taught pigeons to discriminate between two stimuli lying at separate points on the same stimulus continuum. Specifically, they trained two pigeons to discriminate between a 1000-Hz tone and a 950-Hz tone. To do this, the researchers presented the 1000-Hz tone under conditions of reinforcement on a VI schedule, while presenting the 950-Hz tone during extinction. Thus, the 1000-Hz tone became a discriminative stimulus for reinforcement (S+) while the 950-Hz tone came to signal extinction (S-). After conducting a generalization test, the experimenters found discrimination training resulted in a much steeper gradient than that of the presence/absence training procedure. Additionally, one of the pigeons evidenced a shift in the gradient peak away from S+ in the direction opposite of S-. This training procedure has been called *intradimensional training* (Mazur, 2006) because S+ and S- are both located within the same stimulus dimension (i.e., frequency). This effect came to be known as peak shift. Peak shift effects are commonly found in other studies after subjects receive intradimensional discrimination training (e.g., Bloomfield, 1967; Honig & Urcuioli, 1981).

As apparent in the preceding studies, researchers have explored stimulus generalization with operant methods in multiple sensory modalities. Generalization gradients have been measured according to visual stimuli (Guttman & Kalish, 1956),

auditory stimuli (Jenkins & Harrison, 1960, 1962), and even with tactile stimuli (Dougherty & Lewis, 1993). Additionally, stimulus generalization gradient research has moved beyond nonhuman animals and has also been conducted with human subjects (Droit-Volet, 2002), including children with mental retardation (Furnell & Thomas, 1976; Lalli, Mace, Livezey, & Kates, 1998; Lane & Curran, 1963), and individuals with autism (Matthews et al., 2001; Miyashita, 1985; Rincover & Ducharme, 1987).

Autism and Generalization Gradients

To date, only three studies have reported stimulus generalization gradients for individuals with autism (Matthews et al., 2001; Miyashita, 1985; Rincover & Ducharme, 1987). Another study also measured stimulus generalization using methods that could yield a generalization gradient (i.e., by recording response rates occurring in the presence of a simple stimulus varied along a single dimension); however, the findings were not reported as generalization gradients (Fein et al., 1979). Because of their primary relevance to the objectives of the present study, these four research articles were analyzed and coded based on several different study features. These features include: sample size, chronological age, stimulus modality, stimulus dimension varied, and the training procedures used as well as possible behavioral processes produced by those procedures (e.g., reinforcement, extinction, and/or punishment). A detailed summary of these coded features can be found in Table 1, and each of these studies will be briefly discussed in the present review.

Of particular interest, each of these four studies of stimulus generalization for

Table 1

Study Features

Authors & year	Sample size (by group)	Mean chronological age (by group) in years	Stimulus modality	Training procedure prior to generalization testing & potential behavioral processes involved	Stimulus dimensions varied	Summary of results
Fein et al. (1979)	Autism & psychotic: 8 Typical: 8	Autism & psychotic: 10.30 Typical: 9.65	Visual	Intradimensional discrimination S+ → reinforcement S- → extinction & punishment	1. Line orientation 2. Idiosyncratic components of a complex figure (not a continuum)	1. No differentiation between groups for the simple line orientation task. 2. In a separate task, with a complex stimulus, children with autism were found to respond overselectively.
Miyashita (1985)	Autism: 10 Typical: 10	Autism: 11.75 Typical: 6.08	Visual	Intradimensional discrimination S+ → reinforcement S- → extinction	1. Parallelograms, varied by angular displacement 2. Number of spots	1. No generalization gradient found for angular displacement, while a mild generalization gradient was found for number of spots. 2. No significant difference between groups
Rincover & Ducharme (1987)	Autism: 8 Typical: 8	Autism: 12.0 Typical: 3.25	Visual	Intradimensional discrimination S+ → reinforcement S- → extinction & punishment	1. Image color 2. Image form	1. Overselectivity is not an all-or-nothing phenomenon. Even when children responded overselectively, the other dimension acquired some degree of stimulus control. 2. Overselectivity correlates with mental age.
Matthews et al. (2001)	Autism: 5 Intellectual disability: 5	Autism: 26.5 Intellectual disability: 35.25	Visual	Intradimensional discrimination S+ → reinforcement S- → extinction & punishment	1. Image size 2. Image location	3. Stimulus variables impact the occurrence of overselectivity. Specifically, physical separation of cues during training leads to more overselectivity than when cues are physically connected. 1. Adults with intellectual disability responded more overselectivity than adults with autism. 2. Gradients obtained were considered “comparable to other populations” (Matthews et al., 2001, p. 161).

individuals with autism included some form of intradimensional discrimination training prior to generalization tests. In other words, generalization tests were conducted after participants were taught to discriminate between S+ and S- values that differed along at least one dimension. Basic research on stimulus generalization, however, has indicated that intradimensional comparisons are not necessary for obtaining peaked gradients (Honig & Urcuioli, 1981). Additionally, intradimensional discrimination procedures confound the interpretation of gradients because they conflate the separate behavioral processes of reinforcement (which leads to generalization and is introduced with S+) with extinction (which leads to discrimination and peak shift and is introduced with S-). This conflation makes it difficult to derive a clear understanding of the basic process of generalization. Not only do most of these studies involve the use of extinction along the same continuum tested, three of these studies also included potential punishment (e.g., verbal reprimands, like “no”) during the intradimensional discrimination training. Punishment is a separate behavioral process (Lerman & Vorndran, 2002) and the use of it further conflates any interpretation of generalization gradients.

Four Studies of Stimulus Generalization

Recognizing that stimulus overselectivity may lead to an undergeneralization to stimuli by children with autism when the stimuli were complex, Fein and colleagues (1979) conducted a study to determine if this tendency to undergeneralize was “also present with a simple stimulus” (Fein et al., 1979, p. 326). They measured stimulus generalization of children with autism and typically developing peers by using simple

stimuli, consisting of four projected images of lines, differing from each other only in the degree of angular displacement.

Prior to generalization testing, the authors taught children to discriminate between an S+ and an S- for each condition. Intradimensional discriminations were taught for a 15° line (S+) and a 75° line (S-) by reinforcing responses to the 15° line and withholding reinforcement (i.e., extinction) for, and mildly punishing, responses to the 75° line. Next, the authors conducted generalization probes. Generalization probes consisted of presenting S+, S-, and two other line images (one of 30° and one of 45°) during discrete trials. Response rates to these stimuli were recorded. The authors did not analyze or report their data as generalization gradients. Instead, they performed statistical analyses to detect a significant difference in response rates between the two sample stimuli (i.e., the 30° and 45° lines). Only one child with autism showed a difference of more than 10% in responding to the two sample stimuli. The authors reported “no obvious differences” (Fein et al., 1979, p. 331) between the response patterns of children with autism and typically developing children. However, given that the training involved a combination of reinforcement, extinction, and punishment, it is unclear what caused the lack of observed differentiation.

Miyashita (1985) also conducted a study to measure stimulus generalization in a group of children with autism and a group of typically developing children. Prior to generalization testing, children received intradimensional discrimination training to distinguish between one S+ and one S- for each of the two separate tasks. The author provided no depictions of the stimuli used, only providing a brief description. Stimuli in

the first task consisted of six parallelograms, differing in degree of angular displacement, ranging from 130° to 45° (with a 90° square as S+ and a parallelogram rotated 45° as S-). The second task consisted of discriminating the number of spots (ranging from one to six) on a white magnetic panel (with 1 spot as S+ and 6 spots as S-).

During generalization testing for the first task, response rates were highest for both groups at S+; however, the forms of the gradients were not orderly. For the second task, mild gradients were revealed for both groups. Testing for both groups on both tasks revealed no significant differences between groups. The authors concluded, “The ability of generalization between the autistic and the normal group was not different” (Miyashita, 1985, p. 227). However, as with the study by Fein and colleagues (1979), it is unclear what caused this lack of differentiation because the training procedures involved a combination of reinforcement (at S+) and extinction (at S-).

In separate studies by Rincover and Ducharme (1987) and Matthews and colleagues (2001), generalization gradients were measured as part of an assessment of stimulus overselectivity. In each study, the authors used generalization gradients to help determine the degree of stimulus control acquired by separate cues of the same stimulus. Like the studies by Fein and colleagues (1979) and Miyashita (1985), these studies also relied on intradimensional discrimination procedures. However, rather than presenting the subjects with an S+ and S- that varied along one dimension, these authors varied S+ and S- along two separate dimensions simultaneously. Specifically, during the discrimination training phase, Rincover and Ducharme (1987) presented subjects with stimuli varied by both form and color and Matthews and colleagues (2001) presented

stimuli varied according to both location and size.

During generalization testing, subjects in each of these studies were presented with two separate sets of sample stimuli. Each set of sample stimuli was varied on only one relevant cue (e.g., location), while the other set was varied on the other relevant cue (e.g., size). By presenting participants with separate sets of generalization stimuli, the researchers could assess the extent to which stimulus control was held by both relevant cues or the extent to which participants overselectively attended to only one cue. For example, if a participant had been taught to discriminate between a stimulus varied according to both location and size, and that participant was later presented with a set of sample stimuli varied only by location, with size held constant, and the child responded equally to each card, the child may be overselectively responding to the size, without reference to location. If the child were attending to both relevant cues, on the other hand, one would expect the highest rate of responses to occur at the S+ value, which contains both the original location and the original size.

The focus of these two studies was on overselectivity, rather than generalization, and the authors provided little interpretation of the gradients in terms of generalization. Although Matthews and colleagues considered the gradients obtained to be “comparable to other populations” (Matthews et al., 2001, p. 161), the results of their study, and the results of the study by Rincover and Ducharme (1987), are difficult to interpret in terms of the basic process of generalization because both of these studies included extinction and punishment during the intradimensional discrimination training. Furthermore, the S+ and S- used in both studies had more than one relevant dimension altered (often leading

subjects to respond overselectively). Therefore, many of the gradients obtained are not measures of generalization as much as they are measures of stimulus overselectivity. For example, if a participant in the study by Matthews and colleagues (2001) were assessed for generalization according to stimuli varied only by location and the gradient obtained was flat, this may indicate that the size of the stimulus had acquired stimulus control to the exclusion of the location. It would not indicate anything about whether the process of generalization as resulting from reinforcement is different in individuals with autism. Rather, it would be evidence that overselectivity can confound generalization.

Stimulus Modality and Auditory Trait Variables

It is significant to note that each of the preceding studies involving stimulus generalization for people with autism relied solely on visual stimuli. Although there is still much to learn about stimulus generalization in the visual modality for individuals with autism, even less is known about other stimulus modalities.

Considering that some individuals with autism are known to display unusual responses to various sensory stimuli, such as being oversensitive to sounds (APA, 2000), there is a need for further research exploring the ways in which individuals with autism process stimuli within particular sense modalities. Individuals with autism have been found to evidence an enhanced ability to discriminate between changes in pitch for simple tones (Bonnell et al., 2010). Enhanced pitch discrimination appears in around 1 out of 5 individuals with autism and is especially relevant to those who also have a history of delayed onset of language (Jones et al., 2009). This enhanced ability to discriminate

stimuli may suggest that children with autism, or at least a subset of them, can be expected to evidence steeper generalization gradients than their typically developing peers. Nevertheless, to date, no studies have been conducted to measure generalization gradients for children with autism according to an auditory modality.

Purpose and Objectives

Although there has been significant research on the nature of stimulus control for children with autism, including the finding that a tendency to respond overselectively inhibits the transfer of learning across contexts, other variables related to stimulus control, such as stimulus generalization, have received less attention. Very little research has attempted to assess the basic behavioral process of generalization unconfounded by the effects of overselectivity, and the effects of extinction and punishment in children with autism.

Given this, it is clear that more research is needed. Specifically, studies are needed to isolate the separate behavioral processes of reinforcement and extinction when measuring generalization gradients. This may be done by measuring generalization gradients without first teaching an intradimensional discrimination. Alternatively, generalization gradients could be obtained after teaching a discrimination between an S+ and an S- differing along a dimension orthogonal to the dimension being assessed (e.g., presence/absence training). Additionally, considering that all of the previous attempts to measure generalization gradients in children with autism have exclusively used visual stimuli, studies are needed to assess generalization gradients according to other sensory

modalities.

The present study may lead to an increased understanding of why children with autism often do not generalize learning across contexts. Also, it may help answer the call for further development of a behavioral technology for teaching generalization (Stokes & Baer, 1977). Furthermore, it has been suggested that an “assessment of stimulus control processes following various training procedures may allow the development of useful assessment procedures. These would provide detailed information on individual learning characteristics” (Matthews et al., 2001, p. 175). Thus, considering that individuals with autism are not a homogeneous group, this study may contribute to the development of assessment procedures that can help define the processes of generalization and the effects of discrimination learning for individual children. Such an assessment would allow therapists to adapt treatment approaches to the generalization capacity of individual clients.

The purpose of the present study is to measure the extent to which behavior, reinforced in the presence of a specific tone (i.e., a simple auditory stimulus), occurs in the presence of other tones of varied frequency. Furthermore, this study will measure generalization both before and after teaching an intradimensional discrimination, thereby isolating the fundamental behavioral processes of reinforcement and extinction in relation to the dimension of tone frequency. This study addressed the following questions.

1. To what extent does the behavior of children with autism generalize to a simple auditory stimulus when it is varied across a single dimension?
2. What are the relative effects of different training procedures (presence/absence

and intradimensional discrimination training) and different behavioral processes (reinforcement and extinction) on the resulting gradients of generalization?

CHAPTER III

METHODS

Recruitment, Participants, and Setting

Participants for the current study were recruited from the Albany County School District One in Laramie, Wyoming. After receiving permission to conduct this research within the school district, a list of students who had been determined eligible for special education under the ASD classification, according to the Wyoming Rules and Regulations (2010), was obtained from the school district's Director of Special Services. From this list, parents or guardians of all students attending kindergarten through sixth grade and under 13 years old (a total of 20 students) were sent a recruitment letter briefly describing the research and requesting those interested in participating or learning more about the study to contact the researcher (see Appendix A). Efforts were later made to contact by telephone all parents/guardians of prospective participants who had not responded to the recruitment letter. From these efforts, one parent responded to the recruitment letter by contacting the researcher, and four additional parents/guardians expressed interest in participation or learning more about the research when contacted by telephone. In-person meetings were then scheduled with each of these parents/guardians (representing five prospective participants) to explain the research, answer questions, and obtain signed, informed consent for participation (see Appendix B). Four out of five parent meetings resulted in parents/guardians providing informed consent for their child to participate in the study. Prior to beginning participation, each of the four recruited

participants provided signed assent to the study.

Although research was initiated with four participants, one was withdrawn by his parent following the baseline phase. This participant's parent cited difficulty seeing how the study could benefit her son as one reason for ending participation. The three remaining participants (Mark, Walter, and Devin) were all boys between the ages of 8 and 12. Each participant was receiving special education services because they had been evaluated and determined eligible by a school-based team to meet the criteria for Autism Spectrum Disorder (ASD) according to the Wyoming Rules and Regulations (2010). The definition of autism used by the Wyoming Rules and Regulations is based on the definition of autism found in the Individuals with Disabilities Education Improvement Act (Individuals with Disabilities Education Act [IDEA], 2004).

The Wyoming Rules and Regulations (2010) defined ASD as “a developmental disability significantly affecting verbal and nonverbal communications and social interaction, generally evident before age three (3) that adversely affects a child's educational performance” (Wyoming Rules and Regulations, 2010, p. 4). These rules further identify, “engagement in repetitive activities and stereotyped movements, resistance to environmental change or change in daily routines, and unusual responses to sensory experiences” (Wyoming Rules and Regulations, 2010, p. 4) as characteristics often associated with ASD. According to these rules, for a student to be identified as a child with ASD, the evaluation team must determine the child meets four of the five following criteria: impaired communication, inappropriate relationships, abnormal sensory processing, impaired cognitive development, and abnormal range of activities.

Each of these criteria is defined within the rules and regulations.

Prior to participation, informed consent was obtained from the parents of each child. Because some children with autism have been reported to experience distress in the presence of some sounds (Bettison, 1996), parents were also asked to indicate whether they anticipated their children to show distress to sounds similar to those used in this study. All parents indicated they did not anticipate this.

All sessions were conducted with individual children in a quiet room away from disruptions. The participant was seated at a table. Two researchers were present during all sessions to implement the procedures and record participant responses.

It was anticipated that idiosyncratic behavioral characteristics and cognitive abilities of participants would have some impact on learning processes and generalization gradients obtained in this study. For example, participants with higher cognitive abilities may be expected to learn discriminations between stimuli at a faster rate and with more accuracy than those functioning at a lower cognitive level. It is unclear at this time, however, what specific influences particular behavioral characteristics (e.g., those associated with ASDs) may have upon gradients of generalization. Information regarding participant characteristics, including adaptive, behavioral and cognitive level was obtained through a review of previous evaluation records in each student's special education file. A summary of assessment results from standardized measures and clinical tools from previous evaluations for each participant can be found in Tables 2, 3, and 4. Additional details regarding age, hearing screenings, diagnoses, and behavioral characteristics for each participant are summarized following the tables.

Table 2
Participant Characteristics: Mark

Age (yy:mm)	Assessment Instrument	Results
06:08	ADOS-Module 3	<p>“When [Mark’s] social behavior on the ADOS is compared to social behavior of other children, his behavior is similar to the social behavior of children who have ASD diagnoses.”</p> <p>“His difficulties in the area of communication were consistent with the kinds of difficulties seen in children with ASD diagnoses.”</p> <p>“The scores generated from examining [Mark’s] behavior in the ADOS-G were more similar to children who have ASDs on both the Communication and Reciprocal Social Interaction subscales and on the total score.”</p>
06:08	BASC-2 PRS	<i>Clinically significant</i> for atypicality, withdrawal, adaptability and leadership <i>At risk</i> for attention problems and depression
06:08	BASC-2 PRS	<i>At risk</i> for hyperactivity, atypicality, withdrawal, attention problems, adaptability, social skills, leadership, activities of daily living and functional communication.
06:08	BASC-2 TRS	<i>Clinically significant</i> for anxiety, depression, somatization, atypicality and withdrawal <i>At risk</i> for adaptability and leadership.
06:08	SIB-R	Broad independence SS = 95 “His [parent] indicated that his abilities in the areas of fine and gross motor development, social and communication behaviors, and personal living skills are well developed and are in the average range. [Mark’s] community living skills are less well-developed and are in the limited-to-age-appropriate range.”
06:08	WISC-IV	FSIQ SS = 99, VCI SS = 100, PRI SS = 100, WMI SS = 97, PSI SS = 94
06:11	PPVT-III	SS = 99
06:11	EVT	SS = 105
06:11	CELF-4	Core Language SS = 98, Receptive Language SS = 115, Expressive Language SS = 96, Language Content SS = 123, Language Structure SS = 103 Pragmatics Profile: Teacher and parent ratings were below criterion

Note. SS = Standard Score; ADOS = Autism Diagnostic Observation Schedule; BASC-2 = Behavior Assessment System for Children, 2nd Edition; PRS = Parent Rating Scales; TRS = Teacher Rating Scales; SIB-R = Scales of Independent Behavior, Revised; WISC-IV = Wechsler Intelligence Scale for Children, 4th Edition; FSIQ = Full Scale Intelligence Quotient; VCI = Verbal Comprehension Index; PRI = Perceptual Reasoning Index; WMI = Working Memory Index; PSI = Processing Speed Index; PPVT-III = Peabody Picture Vocabulary Test, 3rd Edition; EVT = Expressive Vocabulary Test; CELF-4 = Clinical Evaluation of Language Fundamentals, 4th Edition.

Table 3
Participant Characteristics: Walter

Age (yy.mm)	Assessment instrument	Results
04:07	CELF-Preschool-2	Core language SS = 108
04:11	TRF	Clinical range for somatic complaints (T = 70)
04:09	CBCL	Internalizing and Externalizing behavior problems "within normal limits"; High Average range for Social Withdrawal (T=63)
04:09	DAS	General conceptual ability SS = 113, verbal cluster SS = 113, nonverbal cluster SS = 106
05:05	YCAT	Early achievement composite SS = 113, general information SS = 103, reading SS = 112, mathematics SS = 112, writing SS = 112, spoken language SS = 109
05:05	BASC-2 TRS-P	Clinically significant for atypicality (T = 77) At risk for anxiety (T = 65), withdrawal (T = 65), behavioral symptoms index (T = 61), adaptability (T = 38), social skills (T = 36), adaptive skills (T = 38)
05:05	BASC-2 TRS-P	Clinically significant for atypicality (T = 70) At risk for anxiety (T = 65), withdrawal (T = 68), attention problems (T = 60), behavioral symptoms index (T = 65), adaptability (T = 33), social skills (T = 36), adaptive skills (T = 37)
05:05	BASC-2 PRS-P	Clinically significant for atypicality (T = 98), behavioral symptoms index (T = 72) At risk for hyperactivity (T = 66), aggression (T = 63), externalizing problems (T = 66), attention problems (T = 61), adaptability (T = 35), functional communication (T = 39), adaptive skills (T = 33), activities of daily living (T = 31)
05:05	BASC-2 PRS-P	Clinically significant for atypicality (T = 81), functional communication (T = 25), adaptive skills (T = 25) At risk for hyperactivity (T = 62), withdrawal (T = 61), attention problems (T = 61), behavioral symptoms index (T = 66), adaptability (T = 37), social skills (T = 31), activities of daily living (T = 31)
05:11	BASC-2 TRS-P	Clinically significant for aggression (T = 72), anxiety (T = 78), atypicality (T = 78), behavioral symptoms index (T = 70) At risk for hyperactivity (T = 62), externalizing problems (T = 68), internalizing problems (T = 64), withdrawal (T = 64), attention problems (T = 60), adaptability (T = 37), social skills (T = 38), adaptive skills (T = 38)
05:11	BASC-2 TRS-P	Clinically significant for atypicality (T = 73) At risk for hyperactivity (T = 62), aggression (T = 62), externalizing problems (T = 63), anxiety (T = 61), somatization (T = 61), internalizing problems (T = 62), withdrawal (T = 67), attention problems (T = 60), behavioral symptoms index (T = 67), adaptability (T = 34), social skills (T = 38), adaptive skills (T = 36)
05:11	BASC-2 PRS-P	Clinically significant for atypicality (T = 86), behavioral symptoms index (T = 70) At risk for hyperactivity (T = 66), aggression (T = 61), externalizing problems (T = 65), withdrawal (T = 63), adaptability (T = 32), social skills (T = 39), adaptive skills (T = 33), activities of daily living (T = 33)

(table continues)

Age (yy:mm)	Assessment instrument	Results
05:11	BASC-2 PRS-P	Clinically significant for atypicality (T = 93), behavioral symptoms index (T = 71) At risk for hyperactivity (T = 60), withdrawal (T = 61), attention problems (T = 66), adaptability (T = 34), social skills (T = 35), functional communication (T = 36), adaptive skills (T = 30), activities of daily living (T = 33)
Between 05:11 & 06:00	GADS	Parent ratings SS = 107 (high/probable range) Teacher ratings SS = 98 (high/probable range)
Between 05:11 & 06:00	ABAS-II	Parent ratings: GAC SS = 95, Conceptual Composite SS = 97, Social Composite SS = 92, Practical Composite SS = 96 Parent ratings: GAC SS = 63, Conceptual Composite SS = 67, Social Composite SS = 68, Practical Composite SS = 56 Teacher ratings: Conceptual Composite SS = 47, Social Composite SS = 49, Practical Composite SS = 49
Between 07:10 & 07:11	PPVT-R or PPVT-III	SS = 115
Between 07:10 & 07:11	EVT	SS = 123
Between 07:10 & 07:11	CELF-4	SS = 126 Pragmatics Profile: ratings from 5 raters (ratings = 123, 110, 111, 122 & 112) were below age level criterion (criterion ≥ 123).
Between 07:10 & 07:11	TOPL	SS = 118
Between 08:11 & 09:00	GADS	Parent ratings SS = 93 (High/Probable range) Teacher ratings SS = 68 (Low/Not Probable range)
Between 08:11 & 09:00	BASC-2 TRS & PRS	Averages across parent and school staff ratings: -Clinically significant for atypicality (T = 76.7) -At risk for hyperactivity (T = 63.3), aggression (T = 68), externalizing problems (T = 62.7), behavioral symptoms index (T = 65.7), adaptability (T = 35.7), social skills (T = 38.7), adaptive skills (T = 36)
Between 08:11 & 09:00	ABAS-II	Parent ratings: GAC SS = 62, Conceptual Composite SS = 59, Social Composite SS = 81, Practical Composite SS = 68 Teacher ratings: GAC SS = 72, Conceptual Composite SS = 84, Social composite SS = 70, Practical Composite SS = 70
Between 08:11 & 09:00	WJ-III ACH	Basic reading skills SS = 110, reading fluency SS = 91, reading comprehension SS = 114, math calculation skills SS = 98, math reasoning SS = 104, written expression SS = 87, academic skills SS = 102, academic fluency SS = 79, academic applications SS = 107

(table continues)

Age (yy:mm)	Assessment instrument	Results
Between 08:11 & 09:00	WASI	FSIQ SS = 147, VIQ SS = 146, PIQ SS = 137
11:11 (age at report)	CELF-4	Pragmatics Profile: ratings from 4 raters (ratings = 125, 122, 123 & 122) were below age level criterion of 136
11:11	GADS	Parent ratings SS = 92 (high/probable range) Teacher ratings SS = 52 (low/not probable range)
11:11	WJ-III ACH	Broad reading SS = 103, written expression SS = 74, broad math SS = 130, oral expression SS = 110, academic skills SS = 108, academic fluency 77, academic applications 110

Note. SS = standard score; T = t score; BASC-2 = Behavior Assessment System For Children, 2nd edition; PRS = Parent Rating Scales; PRS-P = Parent Rating Scales, Preschool Version; TRS = Teacher Rating Scales; TRS-P = Teacher Rating Scales, Preschool Version; WASI = Wechsler Abbreviated Scale of Intelligence; FSIQ = Full Scale Intelligence Quotient; VIO = Verbal Intelligence Quotient; PIQ = Performance Intelligence Quotient; PPVT-R = Peabody Picture Vocabulary Test, Revised; PPVT-III = Peabody Picture Vocabulary Test, 3rd Edition; EVT = Expressive Vocabulary Test; CELF-4 = Clinical Evaluation of Language Fundamentals, 4th Edition; CELF-Preschool-2 = Clinical Evaluation of Language Fundamentals Preschool, 2nd Edition; GADS = Gilliam Autism Rating Scale; ABAS-II = Adaptive Behavior Assessment System, 2nd Edition; GAC = General Ability Composite; TOPL = Test of Pragmatic Language; DAS = Differential Ability Scale; TRF = Achenbach Teacher Report Form; CBCL = Achenbach Child Behavior Checklist.

Table 4
Participant Characteristics: Devin

Age (yy:mm)	Assessment instrument	Results
Between 03:02 & 03:04	BSID	Composite scores: General adaptive = 94 (34 th percentile), cognitive = 85 (16 th percentile), social-emotional = 80 (9 th percentile);
03:04	PLS-4	Auditory comprehension SS = 53, expressive communication SS = 68, total language score SS = 56
04:00	SIB-R	Broad independence SS = 108 “Scores earned on all of the subscales were within the average range”
04:00	BASC-TRS & PRS	Summary of results from four raters: “Respondents rated [Devin’s] behavior in the <i>At Risk</i> to <i>Clinically Significant</i> range in areas of Atypicality, Withdrawal, and Attention Problems. These concerns were noted in the home and school settings.” “Two respondents rated [Devin’s] Functional Communication in the <i>At Risk</i> range.” Some specific behavior difficulties in “include acting confused and babbling to himself, playing by himself when he has the opportunity to play with others, and difficulty attending and communicating with others.”
04:00	MSEL	<i>t</i> scores: Visual reception = 29 (2 nd percentile), fine motor = 38 (12 th percentile), receptive language = <20 (<1 st percentile), expressive language = 35 (7 th percentile)
04:00	ADOS-Module 1	“[Devin’s] communication abilities resulted in a score on the Communication section of the algorithm that was consistent with the scores of children who have autism diagnoses” “When [Devin’s] overall social behaviors were compared with other children, his difficulties resulted in a score on the Reciprocal Social Interactions section of the algorithm that was consistent with the scores of children who have autism diagnoses.” “When [Devin’s] behavior on the Communication and Reciprocal Social Interactions sections are combined to create a Total Score on the ADOS, his score is similar to children who have autism disorder diagnoses.”
4:00	ADI-R Diagnostic Algorithm	-Qualitative abnormalities in reciprocal social interaction: “His skills in this area were more consistent with children who do not have autism spectrum diagnoses. His score was one point below the ASD cut-off for this area.” -Qualitative abnormalities in communication: “His behaviors were more consistent with children who have autism spectrum diagnoses. His score in this area was above the autism spectrum cut-off for children who have developed language at the level of phrase speech.” -Restricted repetitive, and stereotyped patterns of behavior: “[Devin’s] behaviors were more consistent with children who have autism spectrum diagnoses in that he has some areas of interest that appear overly intense such as his interest in numbers and letters” -Abnormalities of development evident at or before the age of 36 months: “[Devin’s] early development is more consistent with children who have ASD. Specific concerns in this area included early concerns about social communication noted at 18 months of age.”
Around 06:11	CSI-4	-Clinically significant concerns with symptoms on the ASD scale

(table continues)

Age (yy:mm)	Assessment instrument	Results
Around 06:11	CSI-4	-Concerns in the areas of Inattention and ASDs
Around 06:08	CSI-4	-Clinically significant concerns with symptoms on the Inattention, Hyperactivity, Oppositionality, Social Anxiety and ASD Scales
Around 06:08	CSI-4	-Clinically significant concerns with symptoms on the Inattention, Social Anxiety, and ASD scales
Around 06:11	BASC-2 PRS	Combined scores for two raters: -Clinically significant for atypicality, withdrawal, leadership -At risk for attention problems, adaptability, activities of daily living
Around 06:11	BASC-2 PRS	-Clinically significant for atypicality and withdrawal -At risk for somatization and adaptability
Around 06:08	BASC-2 PRS	-Clinically significant for atypicality, withdrawal, leadership, functional communication -At risk for hyperactivity, conduct problems, somatization, attention problems, adaptability and activities of daily living
Around 06:08	BASC-2 PRS	-Clinically significant for atypicality, withdrawal, leadership, functional communication -At risk for attention, hyperactivity, conduct problems, somatization, adaptability, social skills, and activities of daily living
07:03	BASC-2 TRS	-Clinically significant for no areas -At risk for attention problems, behavioral symptoms index, atypicality, withdrawal, adaptability
07:03	BASC-2 TRS	-Clinically significant for no areas -At risk for anxiety, attention problems, behavioral symptoms index, atypicality, withdrawal, adaptive skills composite, adaptability, social skills, functional communication
07:03	ABAS-II	Teacher ratings: General adaptive composite SS = 92, conceptual functioning SS = 96, social functioning SS = 92, practical functioning SS = 95 Parent ratings: General adaptive composite SS = 68, conceptual functioning SS = 84, social functioning SS = 70, practical functioning SS = 68 Parent ratings: General adaptive composite SS = 91, conceptual functioning SS = 92, social functioning SS = 75, practical functioning SS = 101
07:03	WJ-III ACH	Broad reading SS = 99, broad math SS = 96, broad written language SS = 100, oral language SS = 59, academic skills SS = 104, academic fluency SS = 77, academic application SS = 99, total achievement SS = 98
07:03 (age at report)	CELF-4	Ratings from 4 out of 5 raters (ratings = 118, 102, 111, 103 & 101) were below age level criterion of 115
07:03 (age at report)	TOLD-4	-Subtest scaled scores: Picture vocabulary = 4, relational vocabulary = 5, oral vocabulary = 5, syntactic understanding = 4, sentence imitation = 3, morphological completion = 5 -Listening SS = 66, organizing SS = 66, speaking SS = 70, grammar SS = 65, semantics SS = 67, spoken language SS = 62

Note: SS = Standard score; MSEL = Mullen Scales of Early Learning; ADOS = Autism Diagnostic Observation Schedule; BASC-2 = Behavior Assessment System for Children, 2nd Edition; PRS = Parent Rating Scales; TRS = Teacher Rating Scales; PLS-4 = Preschool Language scale, 4th Edition; SIB-R = Scales of Independent Behavior; CSI-4 = Child Symptom Inventory, 4th Edition; ABAS-II = Adaptive Behavior Assessment System, 2nd Edition; WJ-III ACH = Woodcock Johnson Tests of Achievement, 3rd Edition; CELF-4 = Clinical Evaluation of Language Fundamentals, 4th Edition; TOLD-4 = Test of Language Development, 4th Edition.

Mark

On the first day of participation in the present study, Mark was 11 years, 2 months old. A licensed clinical psychologist evaluated Mark at age 6 years, 8 months. He received an Axis I diagnosis of Asperger's Disorder at that time. Previous testing indicated average range intellectual ability. Further information obtained through a review of previous evaluation records indicates Mark's history was notable for difficulty in the areas of reciprocal social interactions, and restricted, repetitive, and stereotyped patterns of behavior consistent with ASDs. Mark's language development was described as developing in a typical way.

An audiologist had screened Mark's hearing at age 9 years, 7 months. At that time, the audiologist reported no history of acute or chronic ear infections or ear surgery, and no known family history of progressive hearing loss at an early age. Mark's left and right ears passed an otoscopy (visual inspection), immittance (middle ear test), and pure tone (hearing test) screening. Mark exhibited no hearing problems and passed the screening within normal limits.

Walter

On the first day of participation in the present the study, Walter was 12 years, 1 month old. Walter's diagnostic profile was less clear than that of other participants. Walter had received several evaluations since age 4 and some discrepancies in professional opinions were noted. At age 4 years, 9 months, a licensed psychologist at a medical center evaluated Walter and the diagnosis of "Consider Asperger's disorder, mild" was advanced. That same year, at age 4 years, 11 months, Walter received a

neuropsychological evaluation from a different licensed psychologist at the same medical center. This psychologist reported, “Asperger Disorder characteristics were not prominent during [Walter’s] neuropsychological evaluation, though should continue to be monitored over time. Without a doubt however, [Walter] does have unusual information processing capacity that is different from that of his peers.” She further indicated, “[t]he diagnosis of Asperger’s Disorder is not advanced as a result of this current evaluation.” Later school psychologist reports from age 5 years, 0 months, age 9 years, 0 months, and age 11 years, 11 months, affirm Walter’s behavioral characteristics continued to be consistent with a high functioning ASD.

Previous testing indicated very superior range intellectual ability for Walter. Based on a review of records, Walter’s history was significant for behavioral characteristics including limited eye contact, behavioral rigidity, monotone speech, difficulty transitioning, difficulty gaining his attention, difficulty with visual scanning, over-reaction to normal changes in the environment or in normal transitions from one task or setting to another, “picky” eating habits, difficulties with social interaction, deficits in pragmatic social language use, a tendency to over attend to details, unusual reactions to sensory experiences at times and a tendency to over focus on sights or sounds or other sensations in the environment at times, and self-stimulating behaviors, including watching his own finger movements.

An audiologist had screened Walter’s hearing at age 5 years, 4 months and again at 8 years, 5 months. On both occasions, the audiologist reported no history of acute or chronic ear infections or ear surgery, and no known family history of progressive hearing

loss at an early age. On both occasions Walter's left and right ears passed an otoscopy (visual inspection), immittance (middle ear test), and pure tone (hearing test) screening. On both occasions Walter exhibited no hearing problems and passed the screening within normal limits.

Devin

On the first day of the study Devin was 8 years, 0 months old. Devin had previously been diagnosed with Autistic Disorder at age 4 by a licensed clinical psychologist. The psychologist reported, "when [Devin's] pattern of difficulties in the areas of communication, social interactions, inflexibility in play, ridged adherence to routines, and early development are examined in relation to the criteria of the Diagnostic and Statistical Manual—Fourth Edition—Text Revision (DSM-IV-TR), he meets criteria for Autistic Disorder (299.00). Specifically, he exhibits three of four symptoms in the area of impaired social interactions, three of four symptoms of impairments in communication and two of four symptoms under the restricted repetitive and stereotyped patterns of behavior, interests, and activities."

Previous testing indicated low average range cognitive ability. According to a review of records, Devin's history is notable for pragmatic communication challenges, lack of flexibility, a need to adhere to rigid routines, unusual or delayed social and language development consistent with ASDs, difficulty transitioning during the school day, difficulty initiating and sustaining peer interactions, some emotional outbursts at school, difficulty following group discussions and participating in group activities without one-on-one support, frequently repeating phrases, numbers, and letters, and

unusual interest in numbers and letters, difficulty with sustained eye contact, reversing pronouns, and becoming easily upset by changes in routine and introduction to new people.

An audiologist had screened Devin's hearing at age 7 years, 3 months. At that time, the audiologist reported no history of acute or chronic ear infections or ear surgery, and no known family history of progressive hearing loss at an early age. Devin's left and right ears passed an otoscopy (visual inspection), immittance (middle ear test), and pure tone (hearing test) screening. Devin exhibited no hearing problems and passed the screening within normal limits.

Materials

Tone Stimuli

Pure computer-generated tones were used as the discriminative stimulus and the sample stimuli. The tones were created with Audacity version 1.2 digital audio software. A total of 19 6-min audio files were created. Additionally, one 15-s audio file was also created for the purpose of adjusting the speaker volume to a standard tone (600 Hz) prior to sessions. To minimize the possibility that participants may habituate to the stimulus the tones were designed to be intermittent. Specifically, each tone used in the 6-min audio files was designed to alternate between tone and silence every second. The tracks were converted into MP3 files and stored on an Apple iPod Nano. More specific details of these different audio files are described in the procedures section.

During sessions, the tones were generated from a Digital Signature, Inc. Mint 130

speaker oriented toward the subject. A JTS-1357 Sinometer Digital Sound Level Meter (decibel meter) was used to adjust decibel levels. Prior to beginning research, some variability in decibel level was noted among the range of tones used in the present study. Because of this, a 600 Hz tone was chosen as a standard to set decibel levels for each participant. Each day, prior to beginning sessions for each participant, the decibel meter was placed on a table immediately in front of the participant's chair and oriented toward the speaker. As the 600 Hz tone played, the decibel meter was used to adjust the speaker volume to ensure the tones were maintained at or below a non-aversive conversational volume (below 65 decibels). The decibel meter was also used to keep tone volume approximately constant across sessions. Exact decibel levels varied slightly between and within participants. Details on decibel levels set for each participant are described in the results section.

Response Cards

A cardboard card (approximately 2" x 3") was available for subjects to emit arbitrary responses. The first two subjects used a card that was orange on both sides. The third subject used a card with a brown side and a green side.

Data Collection Devices and Software

Handheld devices (one Apple Ipod Touch and two Apple Ipad 2s) were used by trained data collectors to record responses. Data collection software programs used in the present study included DataVault and ABC Data Pro.

Data Collection and Reliability

A trained observer recorded the total number of responses emitted during each phase of the study. Each observer (the primary researcher and research assistant) successfully completed a reliability-training course, through video training (Dempsey, Iwata, Fritz, & Rolider, 2012) at Utah State University prior to participating in the present study. A second trained observer collected interobserver reliability data for at least 25% of sessions for each type of session (baseline, nondifferential training, intradimensional discrimination training, presence-absence training, and generalization) of the study for each participant. The total interobserver agreement (IOA) for each session was calculated by first summing the number of times each observer scored each behavior in each 10-s interval. Next, the smaller number in each interval was divided by the larger. Intervals during which neither observer recorded a given behavior and intervals in which both observers recorded the same count for a given behavior were calculated as having perfect agreement for that interval. The mean agreement across intervals was then calculated by summing the resulting quotients and dividing that number by the total number of 10-s intervals within a session. Finally, the result was multiplied by 100 (mean count-per interval IOA; Cooper, Heron, & Heward, 2007). Results of IOA for each participant, including mean and range of IOA for each type of response, separated by phase of study, are reported in Table 5.

Experimental Design

The present study analyzed and compared auditory stimulus generalization

Table 5

Interobserver Agreement

Participant	Phase/type of session	Total sessions	Percent of sessions with reliability data	Independent responses		Prompted responses	
				Mean IOA (%)	Range of IOA (%)	Mean IOA (%)	Range of IOA (%)
Mark	Baseline	4	50	100	100 – 100		
	Nondifferential	13	38	91	78 – 95	92	61 – 100
	Presence/absence	6	67	92	88 – 100		
	Generalization after presence/absence	3	33	93	93 – 93		
	Intradimensional	8	50	96	94 – 97		
	Generalization after intradimensional	2	100	94	91 – 97		
	Intradimensional with verbal prompt	1	100	99	99 – 99		
Generalization after verbal prompt	1	100	96	96 – 96			
Walter	Baseline	4	50	100	100 – 100		
	Nondifferential	6	100	85	84 – 86	100	100 – 100
	Presence/absence	17	53	88	78 – 94		
	Generalization after presence/absence	3	33	89	89 – 89		
	Intradimensional	8	25	87	85 – 90		
	Generalization after intradimensional	3	33	89	89 – 89		
	Generalization after intradimensional	3	66	100	100 – 100		
Devin	1 st baseline	3	66	100	100 – 100		
	2 nd baseline	3	100	100	100 – 100		
	Nondifferential	8	38	94	90 – 100	91	72 – 100
	Presence/absence	15	27	96	94 – 99		
	Generalization after presence/absence	4	50	94	93 – 94		
	Intradimensional	21	33	92	88 – 97		
	Generalization after intradimensional	4	25	92	92 – 92		

gradients obtained from children with autism both before and after intra-dimensional discrimination training.

Procedures

Preference Assessment

The purpose of this phase was to identify a potent reinforcer for use throughout the study. Parents or caregivers of participants were asked to suggest seven edible items known to be highly reinforcing to their child and that could be delivered in small quantities. These items were then included in a paired-stimulus preference assessment (Fisher et al., 1992). First, the participant was prompted to sample each item. During the assessment, each edible item was paired once with every other edible item. These pairs were presented as choices in a randomized order to the participant. When the participant approached one edible item, he received access to it and the other item was removed. If the child did not approach either item, both items would have been removed and a new trial began with a different pair; however, this did not occur in the present study. A preferred edible item was identified from the assessment as the item selected on the highest percentage of trials.

Baseline

The purpose of the baseline phase was to identify an arbitrary response that could be used throughout the remainder of the study. The following baseline procedure was intended to help rule out the possibility that the child already had a history with the particular response or found the response itself reinforcing. Following the identification

of a preferred edible item, responding on a simple arbitrary response (either touching the experimenter's arm with a card, or turning the card over, flat on the table) was measured during 6-min sessions in which no programmed consequences were provided following the target response. Sessions were ended if no responding occurred during a 1-minute period.

Prior to beginning baseline sessions, the participants were prompted to perform the response using a three-step graduated procedure (Horner & Keilitz, 1975). Specifically, the trainer first provided a verbal instruction. The verbal instruction given to Mark was, "Use the card to touch his arm." The verbal instruction given to Walter was, "To ask for a snack, use the card to touch his arm." Devin was initially told, "Use the card to touch his arm." If the child had not responded to the prompt appropriately within approximately 5 s, the trainer then demonstrated the response while providing the same verbal instruction. If the child still had not performed the response within approximately 5 s, the trainer physically guided the child to perform the response while providing verbal instruction. However, all participants successfully performed the selected response after only verbal instruction. For Mark, only the first session on each day involved a pre-session verbal prompt. Walter and Devin were prompted to perform the response prior to each baseline session. No responses resulted in delivery of reinforcement at this point in the study.

During the baseline sessions, if high rates of responding were observed, alternative responses were evaluated until one was identified that occurred at low to zero rates during extinction. Alternative responses were not needed for Mark and Walter. Due

to high rates of responding, the verbal instruction given to Devin was changed to “Turn the card over on the table.”

Nondifferential Training and Out-of-Session Prompting

The purpose of the nondifferential training phase of the study was to teach and reinforce the arbitrary response, and increase the rate of responding by fading the schedule in preparation for subsequent sessions. As with the baseline phase, verbal prompts were also used prior to nondifferential sessions. However, this time these prompts occurred in the presence of an intermittent 400 Hz tone stimulus (i.e., S+) and were immediately followed by reinforcement. A 400 Hz tone was selected as the training value because it falls within the standard range of human hearing (i.e., 20 Hz to 20,000 Hz) and was judged by the researcher to be a more comfortable tone to listen to than higher tones. A similar tone frequency (500 Hz) was used in auditory generalization gradient studies with human subjects conducted by Lane and Curran (1963) and Droit-Volet (2002). For Mark, as with the baseline phase, only the first session of each day involved a pre-session verbal prompt. Because the first two nondifferential training sessions for Mark were conducted on the same day and immediately following baseline sessions, no prompt was given immediately prior to these two sessions. Walter and Devin were prompted to perform the response prior to each nondifferential training session.

This same pattern of prompting participants to perform the response in the presence of the intermittent 400 Hz tone prior to the start of sessions continued throughout all following phases of this study (presence/absence training, intradimensional

training, generalization testing, and reminder sessions). Mark continued receiving prompts before the first session of each day, and Devin and Walter continued receiving prompts prior to every session for the remainder of the study. The same verbal prompts used for Walter and Devin during the baseline phase were used during this and all following phases. For Mark, to encourage independent responding, the verbal prompt given immediately prior to the third nondifferential training session was altered. Instead of saying, “use the card to touch his arm,” the assistant experimenter used the following prompt: “To ask for a snack, use the card to touch his arm. You can do this as often as you want.” Throughout the remainder of Mark’s participation in the study, this new verbal prompt was given prior to the first session of each day.

Within nondifferential training, the intermittent 400 Hz tone stimulus was played for the duration of each 6-min nondifferential training session. During nondifferential training sessions only, if they did not respond independently, the participants were prompted to emit the target response according to the three-step graduated procedure previously described. No participant needed more than a verbal prompt to perform the response. Responses during nondifferential training resulted in delivery of the preferred item.

Following response acquisition, the schedule of reinforcement was faded from a fixed ratio 1 (FR 1) to a variable interval 30-seconds (VI 30-s) schedule according to the following sequence for each participant: FR 1, fixed ratio 2 (FR 2), fixed ratio 3 (FR 3), variable ratio 3 (VR 3), variable ratio 5 (VR 5), variable ratio 7 (VR 7), VI 30 s. Variable ratio schedules used in this study were generated by using Microsoft Excel macros,

following the procedure described by Bancroft and Bourret (2008). The VI 30-s schedule was generated in Microsoft Excel by randomizing a list of specific numbers with an average of 30. The randomized list was comprised of 10 of each of the following discrete numbers: 15, 22, 30, 38, and 45. All nondifferential training sessions lasted 6 min long and continued until stability in responding as judged by visual inspection.

Presence/Absence Training

Next, the presence/absence training phase was conducted in order to teach the participants to discriminate between tone present and tone absent conditions with the intent of focusing stimulus control on the relevant stimulus (i.e., the tone). During presence/absence discrimination training, participants were taught to respond in the presence of an intermittent 400 Hz tone (S+) and to withhold responding when the tone was absent (S-). The S+ and S- conditions were each presented during discrete trials lasting 1-min each, within a 6-min audio file. Six unique 6-min audio files, with alternating 1-min S+ and S- trials, were created for use during this phase. As soon as one 1-min S+ or S- trial was complete, the next trial immediately followed. The total amount of playtime for S+ and S- trials was equal (3 minutes each) for each audio file, but the order of presenting each 1-min S+ and S- trial was randomized for all but one of these six audio files. The one file not ordered randomly was planned as the first file to be used for each participant. In this file S+ and S- trials alternated every minute. After each of the six audio files had been used (during the first six presence/absence training sessions with each participant), the participants were exposed to the same sequence of audio files, beginning with the first audio file. All presence/absence training sessions lasted 6 min.

Reinforcement during presence/absence training sessions was delivered for responding in the presence of S+ on a VI 30-s schedule. Reinforcement was withheld when the child responded during the S- condition. Response rates in the presence and absence of the tone were recorded. Presence/absence training continued until the discrimination had been learned with a preponderance of responses reliably occurring in the presence of S+, as judged by visual inspection.

Intradimensional Discrimination Training

The intradimensional discrimination training phase was conducted to teach the participants to discriminate between two different stimulus values along the same stimulus dimension (i.e., frequency). By doing so, it was anticipated that stimulus control would be further focused upon the relevant dimension (i.e., tone frequency) and the effects of this type of training could be measured and compared with previous research indicating specific effects (e.g., peak shift) from this type of training upon generalization.

Intradimensional discrimination training was conducted in the same manner as presence/absence training; however, the absence condition was replaced with a tone differing in frequency from the 400 Hz tone. Specifically, a tone of 500 Hz was presented as the S-. Previous research with human subjects has also taught discriminations between tone stimuli differing in value by 100 Hz intervals (Galizio, 1985). Additionally, each of the six unique 6-min audio files created for use during this phase consisted of randomly ordered 1-min S+ and S- trials.

Generalization Testing and Reminder Sessions

The purpose of generalization testing was to obtain generalization gradients. Generalization testing consisted of 6-min sessions. Generalization tests consisting of three to four 6-min sessions followed presence/absence training, and later, additional tests consisting of three to four 6-min sessions followed intradimensional discrimination training. Each generalization session followed identical procedures. During generalization testing, the 400 Hz tone, 500 Hz tone, a period of silence, and 9 novel stimuli, consisting of tones ranging from 150 to 650 Hz, were presented to the participants during discrete trials lasting 30 s each. The range from 150 Hz to 650 Hz was selected because tones at these frequencies fall within the standard range of human hearing and the researcher judged these tones as more comfortable to listen to than tones at higher frequencies. Each stimulus was presented one time per session in random order. All tone stimuli and the absence of tone were presented under extinction conditions. These 30-s trials immediately followed one another on the 6-min audio file and trained observers recorded all responses in the presence of each stimulus or period of silence. Six unique 6-min audio files with randomly ordered 30-s trials were created for use during this phase.

To maintain high rates of responding throughout generalization testing, there was one 6-min reminder session between each generalization session. These reminder sessions consisted of 1-min presentations of the S+ while responses were reinforced on a VI 30 s schedule, and 1-min presentations of S- (i.e., either absence of sound or a 500 Hz tone, depending on the generalization phase) during which responses produced no

programmed consequences (extinction). The reminder sessions followed the same procedures described for the presence/absence training or intradimensional discrimination training phases, depending on the type of discrimination training immediately preceding generalization testing.

Data Analysis

For each subject, the total number of responses made during each generalization test were plotted as a function of tone frequency before and after intradimensional training. Mean gradients both before and after intradimensional training were also graphed. Mean gradients for each participant were derived by calculating the mean number of responses in the presence of each frequency across generalization probes. Because response rates varied across participants, to make gradients across participants more comparable, mean gradients were also calculated according to percentage of responding for each participant. This was done by first obtaining mean gradients and then dividing the mean number of responses in the presence of each frequency by the total mean number of responses. Finally, an overall gradient across participants was obtained for both presence-absence and intradimensional training gradients by calculating the mean of each participant's mean percentage of responding gradients. Gradients were examined by visual inspection. Specifically, the gradients obtained after presence/absence training only were examined to determine the extent to which the participants generalized responses across different tone frequencies without being taught an intradimensional discrimination. It was anticipated that these gradients would peak at S+ and slope downward as the stimulus values became more distant from S+. Any

abnormalities are noted in the results section, such as unusually flat or steep gradients.

The post-intradimensional discrimination gradients were also analyzed by visual inspection. These gradients were analyzed for evidence of the peak shift effect and other changes related to intradimensional discrimination training. Following intradimensional discrimination training, a shift in the gradient peak from S+ to a stimulus value more distant from S- was anticipated. These gradients were also examined for decreased responding in the presence of S-, an increase in the highest point of the gradient, and for a steepening of slope between S+ and S- values as compared to the pre-intradimensional discrimination gradient (Honig & Urcuioli, 1981).

CHAPTER IV

RESULTS

Mark

Mark attended a total of 38 research sessions on 10 separate days, over the span of a 16-day period. For sessions including a tone stimulus, the speaker volume was previously set using the 600 Hz tone to within the range of 55 to 61 decibels. Results for Mark during each phase of the study are detailed below.

Preference Assessment

The preference assessment was completed in one session on the first day of participation for Mark. Preference assessment results for Mark indicate the most preferred item as strawberry pieces (Figure 3).

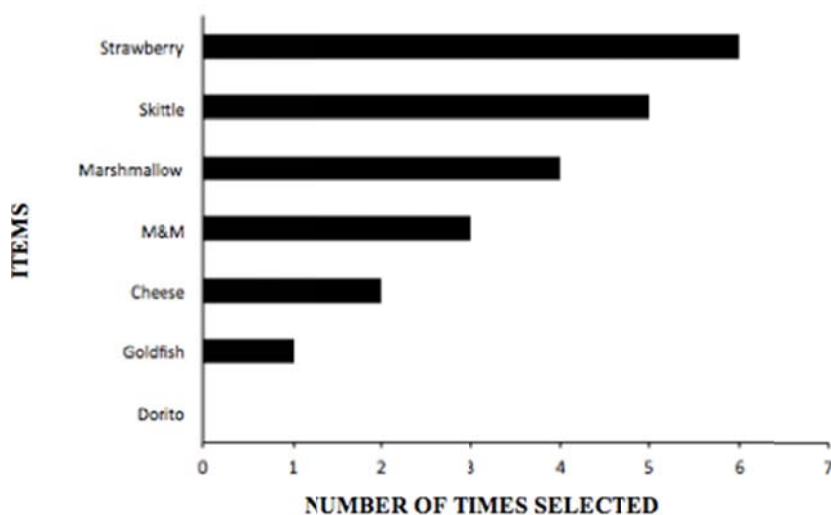


Figure 3. Preference assessment results for Mark. Parent recommended items used in the preference assessment are listed on the y-axis. The x-axis represents the number of occasions each item was selected.

Baseline

For Mark, the arbitrary response chosen was for him to press an orange response card to the arm, defined as anywhere between shoulder and fingertip, of the experimenter seated near Mark at the table. Immediately prior to the initial baseline session only, Mark was given the following verbal prompt: "Use the card to touch his arm." He promptly responded accordingly and did not receive any reinforcement for doing so.

Four baseline sessions were conducted for Mark, all on the same day. He independently responded one time during the initial baseline session. He did not respond again during the remainder of the baseline phase (Figure 4). Interobserver reliability data was recorded for 50% of Mark's baseline sessions with 100% agreement regarding frequency of independent responding.

Nondifferential Training

During the first two nondifferential training sessions, Mark only responded when a verbal prompt was given. He made no independent responses. To encourage independent responding, the verbal prompt given immediately prior to the third session was altered. Instead of saying, "use the card to touch his arm," the assistant experimenter used the following prompt: "To ask for a snack, use the card to touch his arm. You can do this as often as you want." Throughout the remainder of Mark's participation in the study, this new verbal prompt was given prior to the first session of each day of sessions. As can be seen in Figure 4, Mark began responding independently in the third session and required no more prompts throughout the remainder of the nondifferential phase. Mark's response rate rose as the schedule of reinforcement was faded to VI 30 s by session 11. A

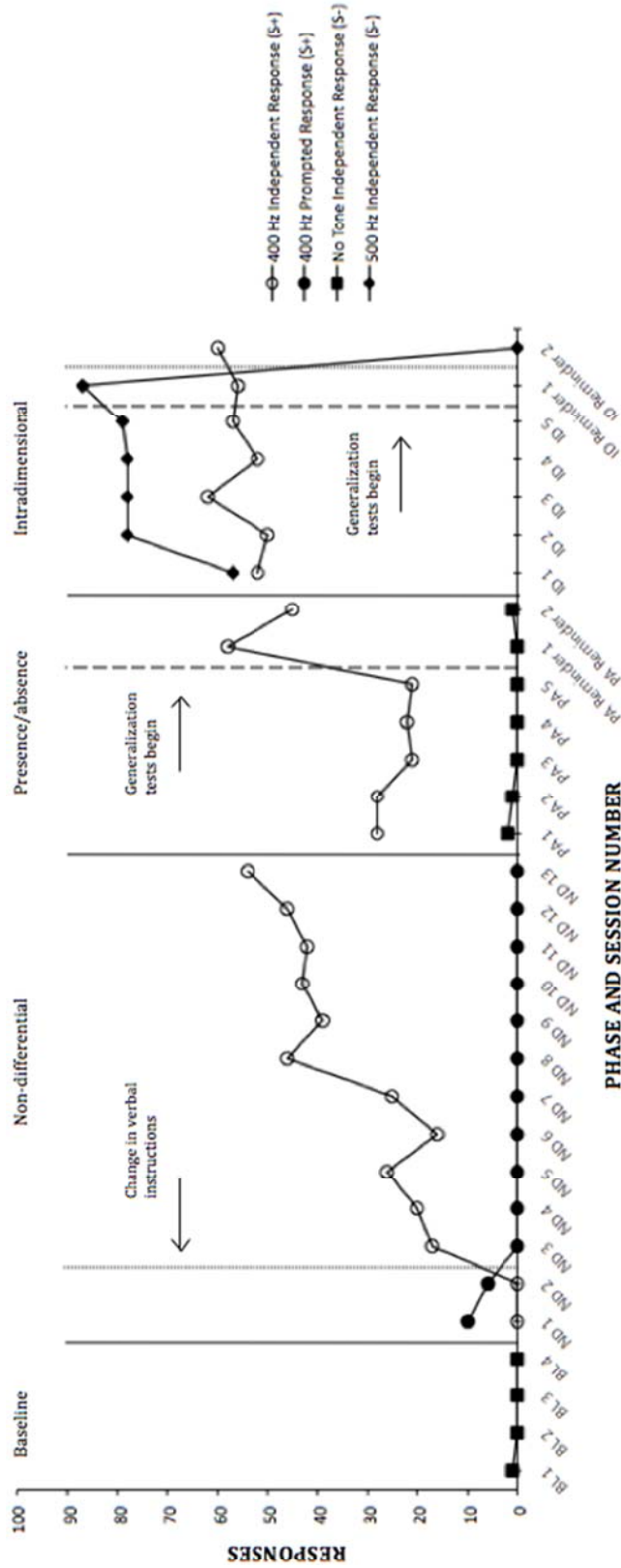


Figure 4. Phase data for Mark. The y-axis designates response frequency. The x-axis designates sessions. Baseline (BL), nondifferential (ND), presence/absence (PA), and intradimensional (ID) training sessions are labeled along this axis. Phases are sequenced according to when they occurred. Solid lines divide separate phases. The dashed line, with short dashes, in the nondifferential phase represents a change in verbal instructions. The dashed lines, with longer dashes, in the presence/absence and intradimensional phases indicate when generalization testing began (i.e., generalization testing occurred prior to and following each reminder session). The dashed line, with small dashes, in the intradimensional phase indicates a change in verbal instruction.

total of 13 nondifferential training sessions were conducted for Mark. Interobserver reliability data was recorded for 38% of Mark's nondifferential training sessions with an overall agreement of 91% for frequency of independent responding and an overall agreement of 92% for frequency of prompted responding.

Presence/Absence Training

Mark demonstrated rapid learning of the discrimination between tone-present and tone-absent conditions. Response rates in the presence of S+ remained elevated throughout this phase and response rates in the presence of S- were indicated low to zero responses for all sessions (Figure 4). During the first three presence/absence sessions (PA 1, 2, & 3), 96% of Mark's responses occurred in the presence of S+. During the last three presence/absence sessions prior to beginning generalization testing (PA 3, 4, & 5), 100% of his responses occurred in the presence of S+. Although reminder sessions occurred following generalization probes, results from reminder sessions are displayed alongside other presence/absence training sessions in Figure 4 because these sessions followed identical procedures. There was a sharp increase in response rate during the reminder sessions. Including two reminder sessions, presence/absence training lasted seven sessions. Interobserver agreement was recorded for 67% of presence/absence discrimination training sessions with an overall agreement of 92% for frequency of independent responding.

Intradimensional Discrimination Training

At the time intradimensional discrimination training began for Mark, he could

only participate in the study for three more days before leaving for an extended time with his caregiver. Unlike presence/absence training, Mark showed no clear evidence that he had learned the discrimination for five consecutive sessions. Although he received no reinforcement for it, Mark's frequency of responding during S- (500 Hz) was consistently higher than his responding during S+ (400 Hz). One factor contributing to this difference in response frequency as it appears in figure 4 is the time it took Mark to eat the strawberries. Consumption time was not subtracted from the 6-min sessions during discrimination training for any session for any participant throughout the study. Therefore, although frequency of responding may appear higher for S- than S+, the difference would not appear as dramatic had consumption time been removed. Due to lack of time, generalization sessions began after the fifth intradimensional training session and before evidence that the discrimination had been learned. During the first intradimensional sessions (ID 1, 2, & 3), 44% of Mark's responses occurred in the presence of S+. During the last three intradimensional sessions prior to beginning generalization testing (ID 3, 4, & 5), 42% of his responses occurred in the presence of S+.

As with presence/absence training, reminder sessions are displayed alongside other intradimensional training sessions in Figure 4. Again, two reminder sessions occurred; however, there was a procedural variation prior to the final reminder session. Because Mark had demonstrated no evidence that he had learned the discrimination between S+ and S-, the experimenters provided additional instruction to Mark in an attempt to help him gain the discrimination. Prior to the final reminder session, Mark received an altered verbal prompt combined with the presentation of the two tones.

Specifically, one of the experimenters said, “Ask for a snack when you hear the following sound. Listen carefully.” Immediately following this verbal prompt the intermittent 400 Hz tone was played for 10 s. Next, the experimenter said, “Do not ask for a snack when you hear the following sound. Listen carefully.” Immediately following this verbal prompt the intermittent 500 Hz tone was played for 10 s. The final reminder session commenced following this added instruction.

Results for this final reminder session indicate a dramatic effect for the added instruction. Mark continued responding at a high rate during S+, but he did not respond at all during S- (Figure 4). Including two reminder sessions, intradimensional discrimination training lasted seven sessions. Interobserver agreement was recorded for 50% of intradimensional discrimination training sessions with an overall agreement of 96% for frequency of independent responding.

Generalization Testing

Mark received generalization test sessions following presence/absence discrimination training, and later, following intradimensional discrimination training. Following presence/absence training, Mark received three generalization test sessions. Results from each of these generalization probes, along with the mean gradient, are displayed in Figure 5. There was no clear evidence of a generalization gradient or other predictable pattern in data. However, response rates during S- (silence) remained low during each probe. The mean gradient is elevated among the lower frequencies, peaking at 200 Hz. However, this pattern in the average gradient appears to have been influenced primarily by one generalization probe, probe 3 (Figure 5), during which Mark displayed

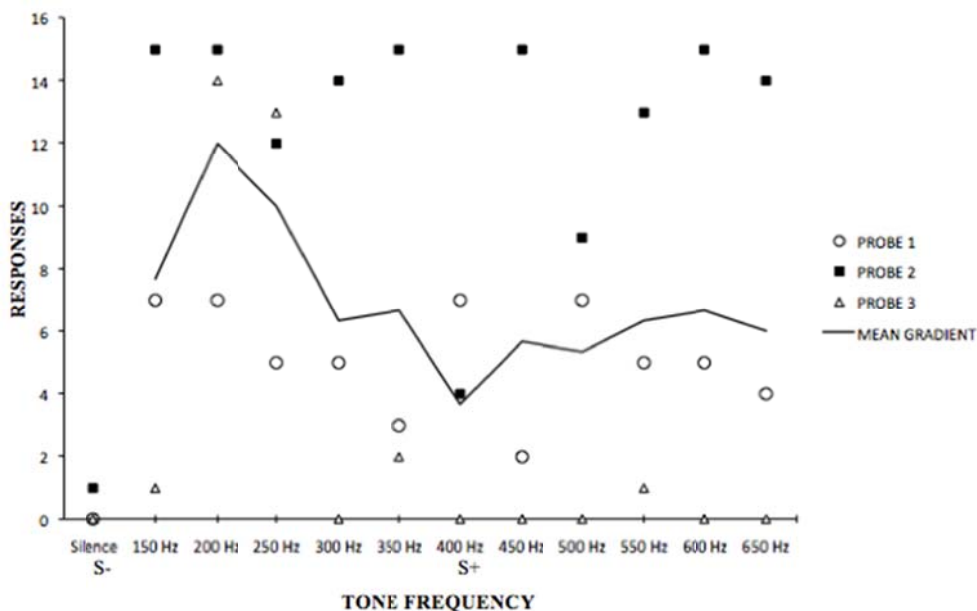


Figure 5. Mean gradient and generalization probe results following presence/absence training for Mark. The y-axis indicates frequency of responding. The x-axis indicates specific tone frequency or silence. The unfilled circles represent responding during the initial session (Probe 1). The filled squares represent responding during the second session (Probe 2). The unfilled triangles represent responding during the third generalization session (Probe 3).

low rates of responding in the presence of all tones higher than 250 Hz. Interobserver agreement was recorded for 33% of post-presence/absence training generalization testing sessions with an overall agreement of 93% for frequency of independent responding.

Following intradimensional training, Mark first two generalization test sessions prior to the final reminder session and altered verbal instruction. Mark received one final generalization session following the final reminder session. Results from the first two post-intradimensional training generalization sessions, along with the mean gradient, are displayed in Figure 6. No clear peak is evident in these results. However, as was the case during intradimensional discrimination training sessions compared to presence/absence

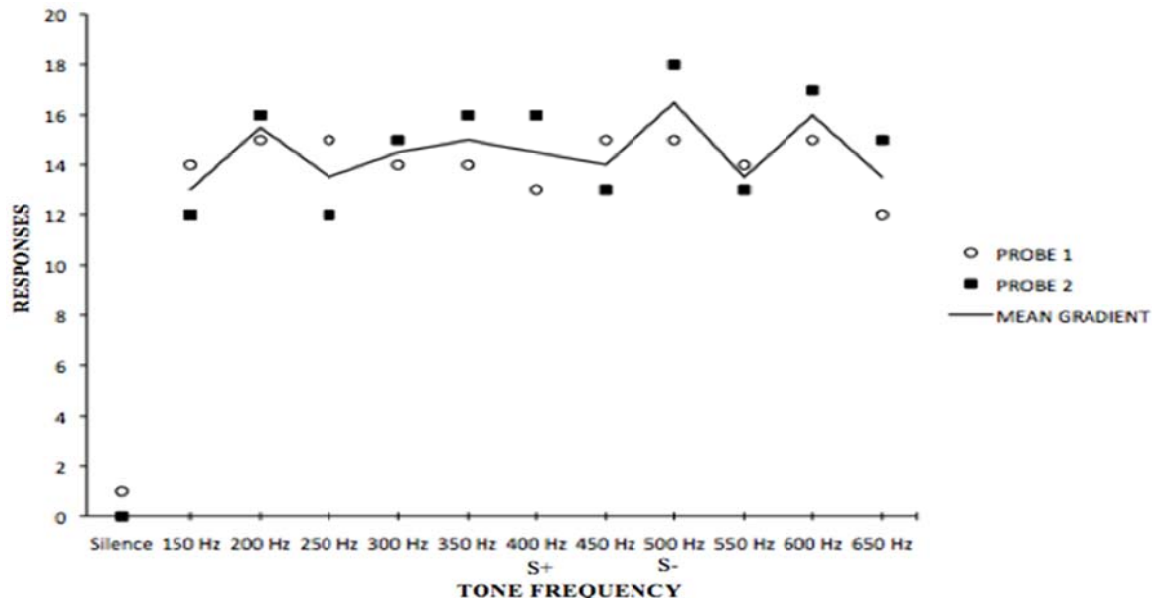


Figure 6. Mean gradient and generalization probe results following intradimensional training for Mark. The y-axis indicates frequency of responding. The x-axis indicates specific tone frequency or silence. The unfilled circles represent responding during the initial session (Probe 1). The filled squares represent responding during the second session (Probe 2).

training sessions, overall response frequency was higher following intradimensional training than following presence/absence training. Interobserver agreement was recorded for 100% of these two post-intradimensional training generalization sessions with an overall agreement of 94% for frequency of independent responding. A comparison of mean gradients before and after intradimensional discrimination training is displayed in Figure 7.

One final generalization test was conducted after the final reminder session that was preceded by the altered verbal prompt. Results of this generalization probe are displayed in Figure 8. Interobserver agreement was recorded also for this session with an overall agreement of 96% for frequency of independent responding.

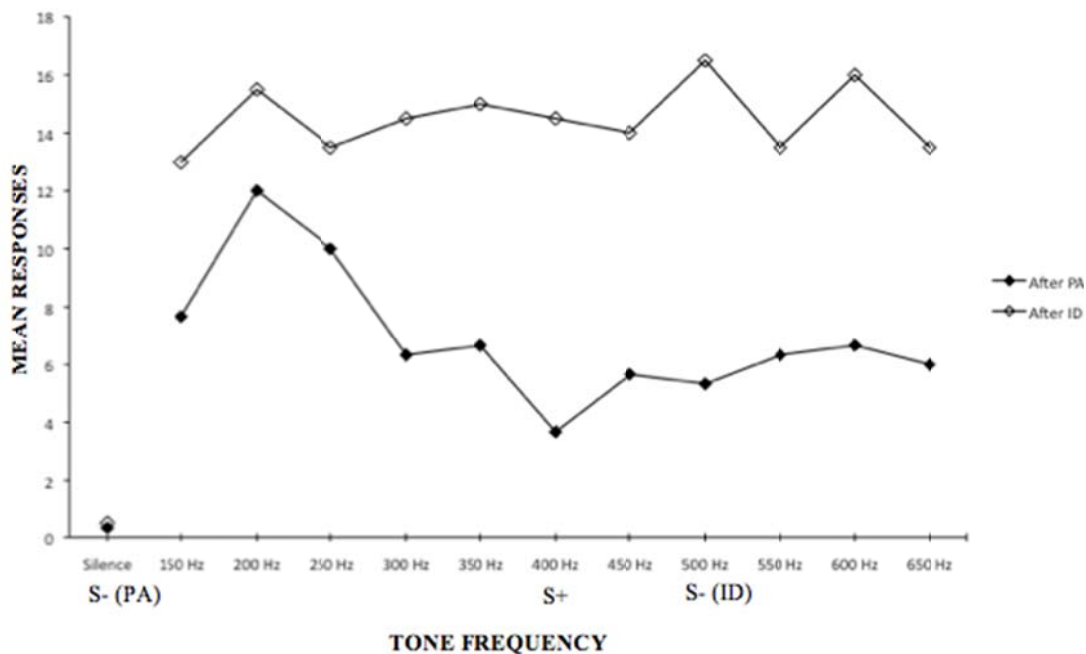


Figure 7. Mean generalization gradients for Mark. The y-axis indicates mean response frequency. The x-axis indicates specific tone frequency or silence. The line with filled diamonds is the mean of three generalization probes following presence/absence training for Mark. The line with unfilled diamonds is the mean of two generalization probes following intradimensional training for Mark. The x-axis indicates frequency of responding.

Walter

Walter attended 42 research sessions on 8 separate days, over the span of an 11-day period. For sessions including a tone stimulus, the speaker volume was previously set using the 600 Hz tone to within the range of 56 to 60 decibels. Results for Walter during each phase of the study are detailed below.

Preference Assessment

The preference assessment was completed in one session on the first day of participation for Walter. Preference assessment results for Walter indicate the most preferred item as skittles (Figure 9).

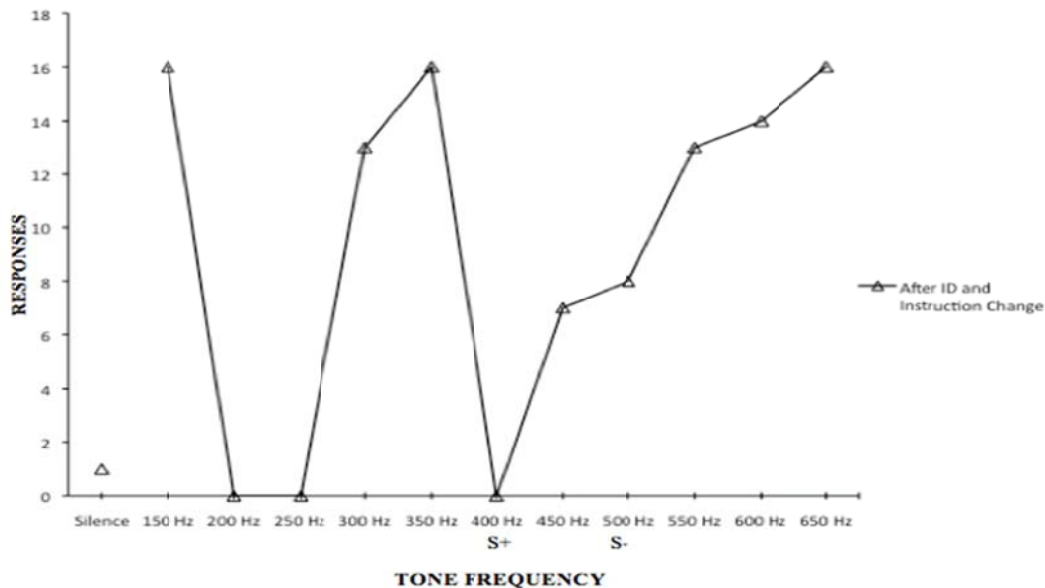


Figure 8. Gradient following an experimental change for Mark. Above is the generalization gradient for Mark obtained during the final session following intradimensional discrimination training and an experimental change of verbal instructions given to Mark.

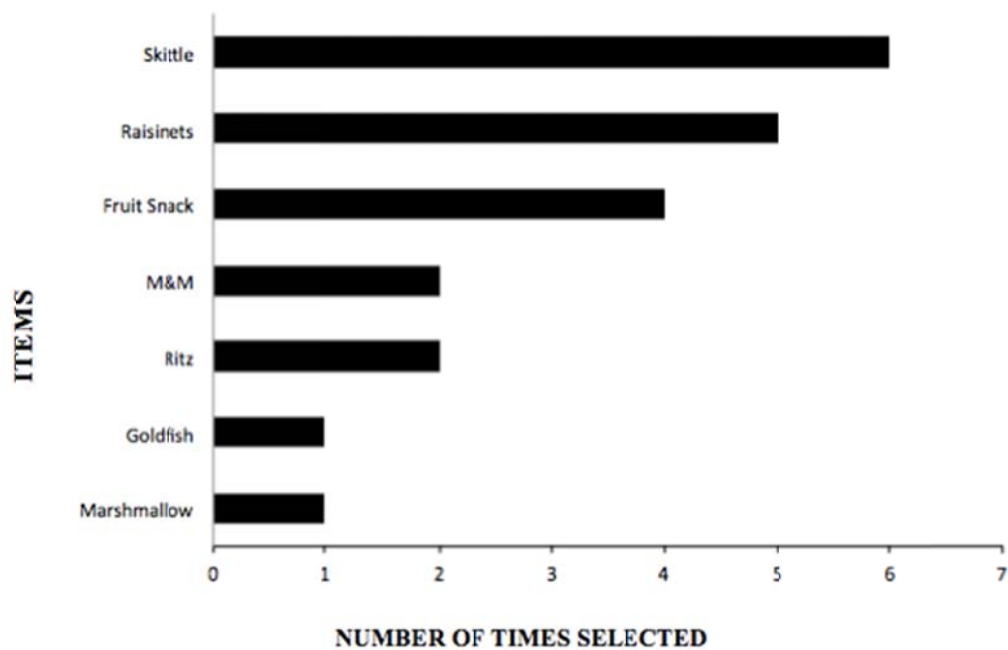


Figure 9. Preference assessment results for Walter. Parent recommended items used in the preference assessment are listed on the y-axis. The x-axis represents the number of occasions each item was selected.

Baseline

The same arbitrary response used for Mark was used for Walter. Immediately prior to each baseline session, Walter was given the following verbal prompt: "To ask for a snack, use the card to touch his arm." He promptly responded accordingly each time and did not receive any reinforcement for doing so. This same verbal prompt was used prior to all subsequent sessions throughout the study for Walter.

Four baseline sessions were conducted for Walter, all on the same day. He made no attempt at the response during baseline sessions (Figure 10). Interobserver agreement was recorded for 50% of baseline sessions with an overall agreement of 100% for frequency of independent responding.

Nondifferential Training

Walter required no within-session prompting, but began responding independently at the beginning of the first nondifferential training session. Walter's response rate rose, as the schedule of reinforcement was faded to VI 30 s by the second session. Six nondifferential training sessions were conducted for Walter. Results for this session are displayed in Figure 10. Interobserver agreement was recorded for 50% of nondifferential training sessions with an overall agreement of 85% for frequency of independent responding, and an overall agreement of 100% for prompted responding.

Presence/Absence Training

Walter took more time than Mark to learn the discrimination between tone-present and tone-absent conditions. Data points for two presence/absence discrimination

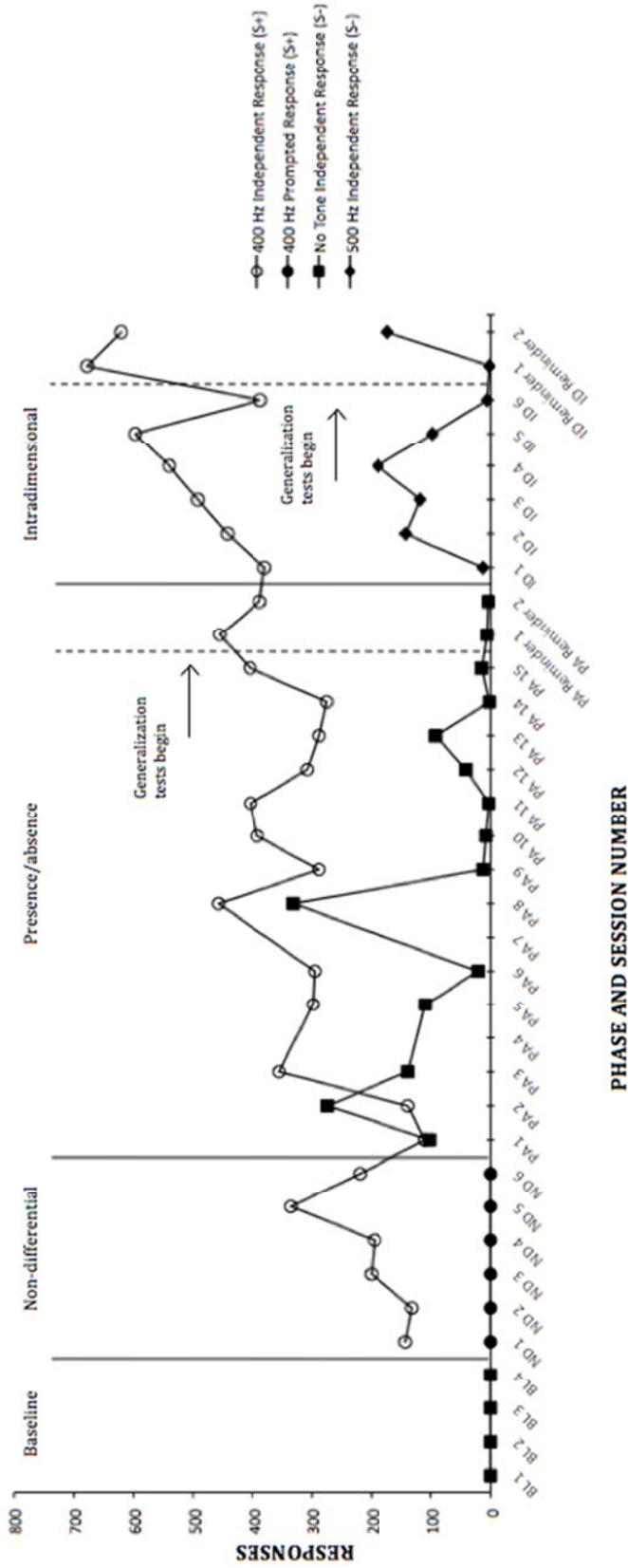


Figure 10. Phase data for Walter. The y-axis designates response frequency. The x-axis designates sessions. Baseline (BL), nondifferential (ND), presence/absence (PA), and intradimensional (ID) training sessions are labeled along this axis. Phases are sequenced according to when they occurred. Solid lines divide separate phases. The dashed lines in the presence/absence and intradimensional phases indicate when generalization testing began (i.e., generalization testing occurred prior to and following each reminder session). Data for two sessions (PA 4 and PA 7) have been omitted due to questionable reliability of data collection software.

training sessions are not included in Figure 10. This is due to potential problems with one of the data collection devices being used (the iPod). Because Walter was responding at an exceptionally rapid pace, the data collection device froze at times. Data from sessions during which the device was judged to freeze for more than 5 s was not included. After session 7, the iPod was no longer used but was replaced with a second iPad 2 for the duration of the study. Walter began to show evidence of learning the discrimination by the third presence/absence discrimination training session; however, the differentiation between responding during S+ and S- conditions became more clear and stable beginning with presence/absence discrimination training session 9 (Figure 10). During the first three presence/absence sessions (PA 1, 2, & 3), 54% of Walter's responses occurred in the presence of S+. During the last three presence/absence sessions prior to beginning generalization testing (PA 13, 14, & 15), 90% of his responses occurred in the presence of S+. Interobserver agreement was recorded for 53% of presence/absence discrimination training sessions with an overall agreement of 88% for frequency of independent responding.

Intradimensional Discrimination Training

Walter received a total of eight intradimensional discrimination training sessions, two of which were reminder sessions. Results from intradimensional discrimination training indicate Walter showed clear differentiation between S+ and S- trials throughout this phase, beginning with the first intradimensional discrimination training session (Figure 10). During the first three intradimensional sessions (ID 1, 2, & 3), 83% of Walter's responses occurred in the presence of S+. During the last three intradimensional

sessions prior to beginning generalization testing (ID 4, 5, & 6), 84% of his responses occurred in the presence of S+. Interobserver agreement was recorded for 25% of intradimensional discrimination training sessions with an overall agreement of 87% for frequency of independent responding.

Generalization Testing

Walter received generalization test sessions following presence/absence discrimination training, and later, following intradimensional discrimination training. Following presence/absence training, Walter received three generalization test sessions. Results from each of these generalization probes, along with the mean gradient, are displayed in Figure 11. Each probe indicated orderly gradients with a peak and decreased responding in the presence of tones most dissimilar from S+. Responding during the tone-absent condition remained low during each probe. Probes 1 and 3 peak at S+. Probe 2 peaks at the 350 Hz tone. The generalization gradient generated following presence/absence discrimination training for Walter appears orderly and decremental. Interobserver agreement was recorded for 33% of post-presence/absence discrimination training generalization sessions with an overall agreement of 89% for frequency of independent responding.

Following intradimensional training, Walter received three more generalization test sessions. Results from each of these generalization probes are displayed in Figure 12. Probes 1 and 3 resulted in decremental gradients peaking at 300 Hz. Probe 2 appears more erratic, containing three peaks. The average gradient for these three probes is

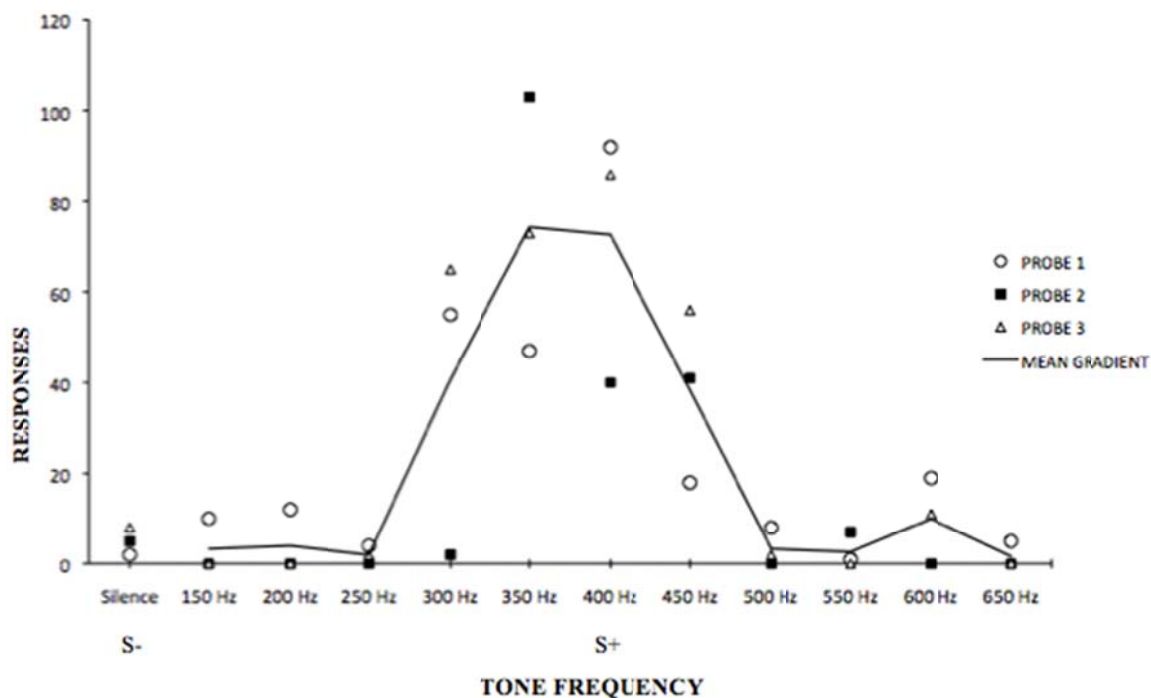


Figure 11. Mean gradient and generalization probe results following presence/absence training for Walter. The y-axis indicates frequency of responding. The x-axis indicates specific tone frequency or silence. The unfilled circles represent responding during the initial session (Probe 1). The filled squares represent responding during the second session (Probe 2). The unfilled triangles represent responding during the third generalization session (Probe 3).

displayed in Figure 13 with the average gradient following presence/absence training. A peak shift appears, with the peak after intradimensional discrimination training shifting further away from the S- value (500 Hz) and centering on 300 Hz. The average post-intradimensional discrimination training gradient also evidences decreased responding in the presence of S+. Interobserver agreement was recorded for 33% of post-intradimensional discrimination generalization sessions with an overall agreement of 89% for frequency of independent responding. A comparison of mean gradients before and after intradimensional discrimination training is displayed in Figure 13.

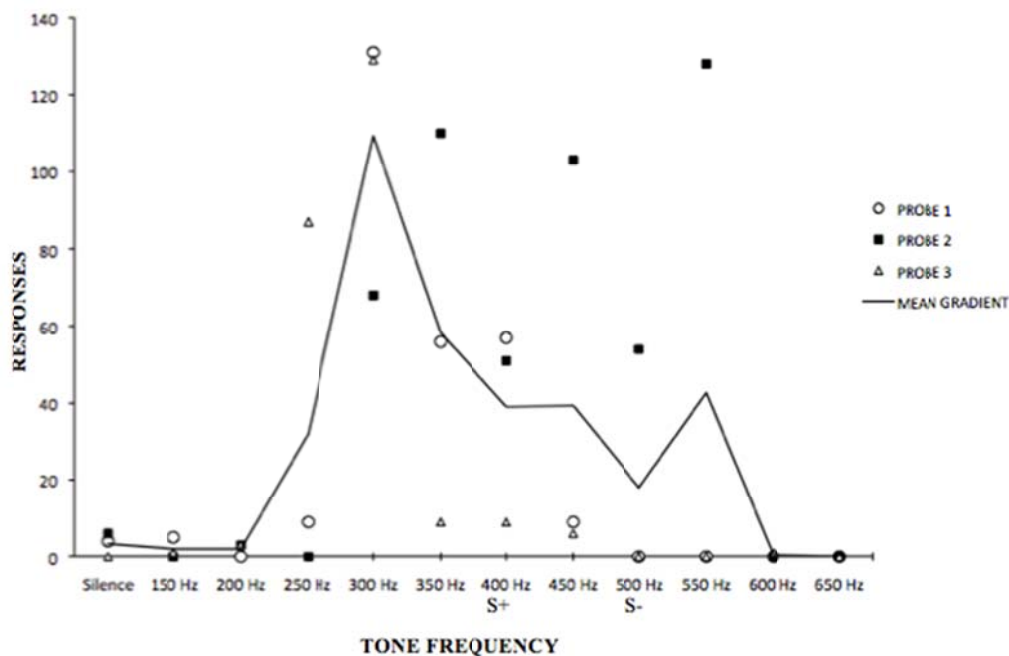


Figure 12. Mean gradient and generalization probe results following intradimensional training for Walter. The y-axis indicates frequency of responding. The x-axis indicates specific tone frequency or silence. The unfilled circles represent responding during the initial session (Probe 1). The filled squares represent responding during the second session (Probe 2). The unfilled triangles represent responding during the third generalization session (Probe 3).

Devin

Devin attended a total of 59 research sessions on 11 separate days, over the span of an 18-day period. For sessions including a tone stimulus, the speaker volume was previously set using the 600 Hz tone. Prior to the first nondifferential training sessions, the speaker volume was initially set to a decibel level comparable to that used for the first two participants (i.e., around 55-60 decibels); however, Devin indicated some mild annoyance toward the sound on the first day of nondifferential training sessions. Therefore, the volume was promptly decreased during a session. When nondifferential training sessions continued on the following day, and for all subsequent research

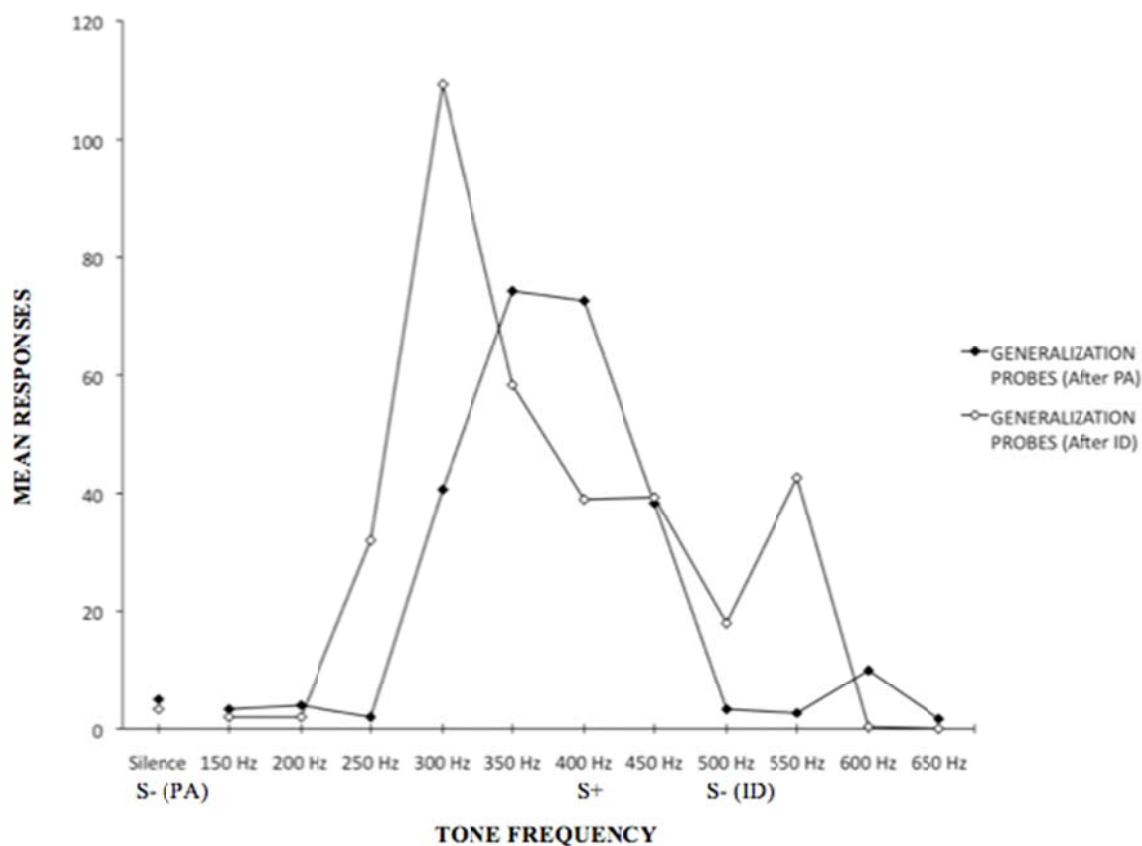


Figure 13. Mean generalization gradients for Walter. The y-axis indicates response frequency. The x-axis indicates specific tone frequency or silence. The line with filled diamonds is the mean of three generalization probes following presence/absence training for Walter. The line with unfilled diamonds is the mean of two generalization probes following intradimensional training for Mark. The x-axis indicates frequency of responding.

sessions, the speaker volume was set to within the range of 49 to 53 decibels. Results for Devin during each phase of the study are detailed below.

Preference Assessment

The preference assessment was completed in one session on the first day of participation for Devin. Preference assessment results for Devin indicate a tie for most preferred item between M&Ms and Skittles (Figure 14). However, during the preference

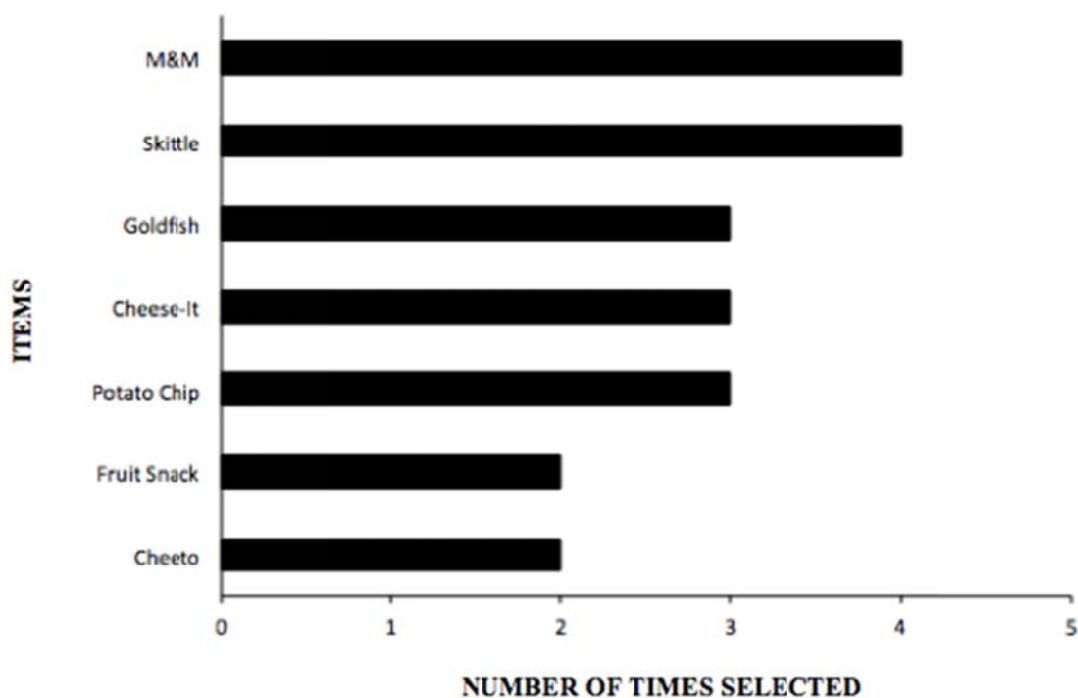


Figure 14. Preference assessment results for Devin. Parent recommended items used in the preference assessment are listed on the y-axis. The x-axis represents the number of occasions each item was selected.

assessment, when Devin was given the choice between M&Ms and Skittles, he chose M&Ms. Therefore, M&Ms were used as reinforcement throughout the remainder of Devin's participation.

Baseline

Devin participated in six baseline sessions. He participated in three baseline sessions on the first day of participation, and the other three on the second day. Initially, the same arbitrary response used for the previous two participants was attempted with Devin. Prior to each of the first three baseline sessions, Devin was prompted to "Use the card to touch his arm." He promptly responded accordingly each time and did not

receive any reinforcement for doing so. Although he never received reinforcement for doing so, Devin began to perform the response at a high rate during the third baseline session. Because of this, a second baseline phase was initiated with a new response. This time, the arbitrary response chosen for Devin was to turn a card over flat on the table. Prior to each baseline session Devin received the following verbal prompt, “Turn the card over on the table.” He promptly responded accordingly, but did not engage in this response during any baseline sessions (Figure 15). Interobserver agreement was recorded for 83% of baseline sessions with an overall agreement of 100% for frequency of independent responding.

Nondifferential Training

Devin required within-session prompting during the first two sessions, but began responding independently during the second nondifferential training session. Devin’s response rate rose, as the schedule of reinforcement was faded to VI 30 s by the fifth session. A total of 8 nondifferential training sessions were conducted for Devin. Results for this session are displayed in Figure 15. Devin’s response rate increased dramatically during the eighth nondifferential training session. Interobserver agreement was recorded for 38% of nondifferential training sessions with an overall agreement of 93% for frequency of independent responding, and an overall agreement of 91% for prompted responding.

Presence/Absence Training

During presence/absence discrimination training, differentiation between

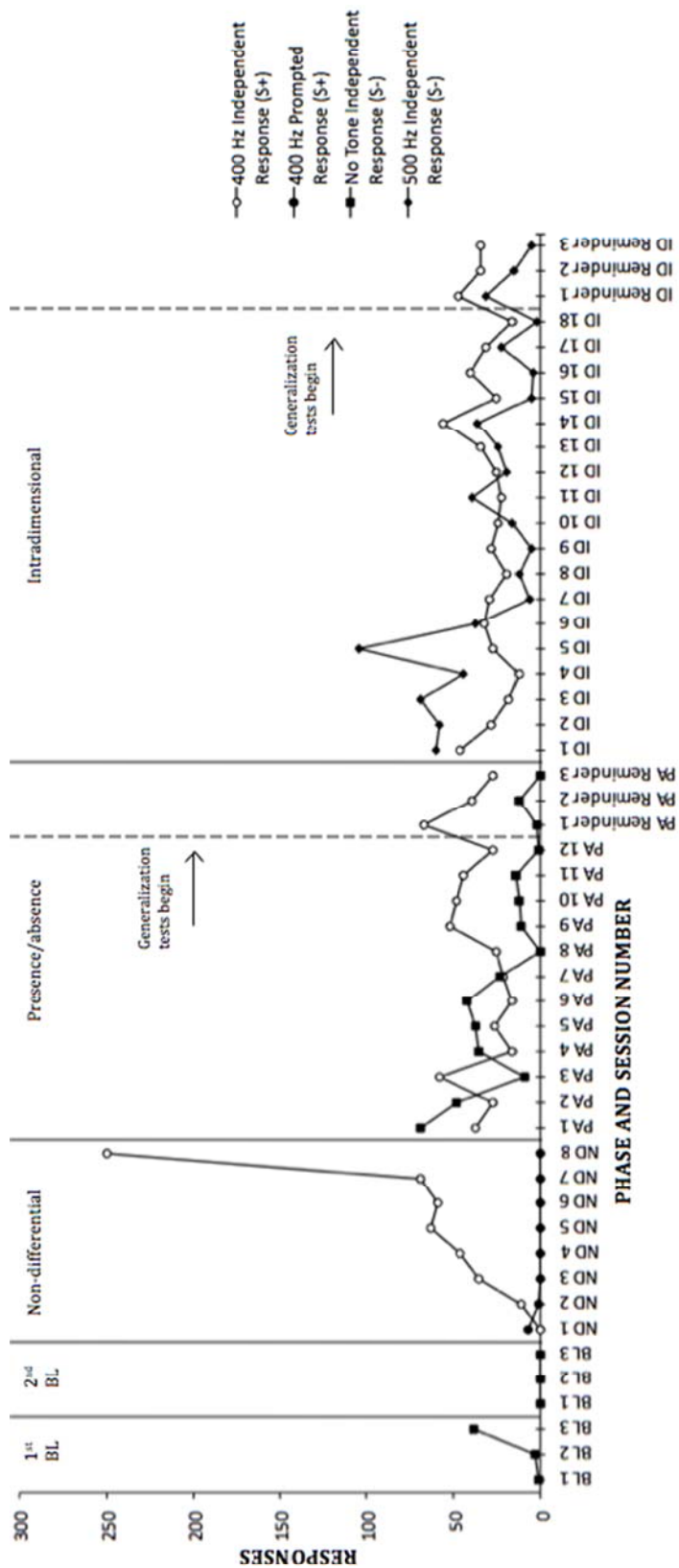


Figure 15. Phase data for Devin. The y-axis designates response frequency. The x-axis designates sessions. Baseline (BL), nondifferential (ND), presence/absence (PA), and intradimensional (ID) training sessions are labeled along this axis. Two baseline phases occurred for Devin, with three sessions each. Phases are sequenced according to when they occurred. Solid lines divide separate phases. The dashed lines in the presence/absence and intradimensional phases indicate when generalization testing began (i.e., generalization testing occurred prior to and following each reminder session).

responding during S+ and S- conditions became clear and stable beginning with presence/absence discrimination training session 8 (Figure 15) for Devin. During the first three presence/absence sessions (PA 1, 2, & 3), 49% of Devin's responses occurred in the presence of S+. During the last three presence/absence sessions prior to beginning generalization testing (PA 10, 11, & 12), 82% of his responses occurred in the presence of S+. Interobserver agreement was recorded for 27% of presence/absence discrimination training sessions with an overall agreement of 96% for frequency of independent responding.

Intradimensional Discrimination Training

Devin received a total of 21 intradimensional discrimination training sessions, three of which were reminder sessions. Results from intradimensional discrimination training appear to indicate Devin began to learn the discrimination around session 7; however, sessions were continued in an effort to gain a clearer discrimination (Figure 15). From session 7 to session 18 Devin's responding was more frequent during S+ than during S- for all but one session. Before beginning generalization sessions, Devin consistently responded more during S+ than he did during S- for 7 sessions. During the first three intradimensional sessions (ID 1, 2, & 3), 33% of Devin's responses occurred in the presence of S+. During the last three intradimensional sessions prior to beginning generalization testing (ID 16, 17, & 18), 76% of his responses occurred in the presence of S+. Interobserver agreement was recorded for 33% of intradimensional discrimination training sessions with an overall agreement of 92% for frequency of independent responding.

Generalization Testing

Devin received generalization test sessions following presence/absence discrimination training, and later, following intradimensional discrimination training. Following presence/absence training, Devin received four generalization test sessions. Results from each of these generalization probes, along with the mean gradient, are displayed in Figure 16. Each probe resulted in high rates of responding in the presence of S+. Probes 1 and 2 were overall less orderly and decremental than were probes 3 and 4. Devin's responding appears to have been more erratic during the first two probes. His

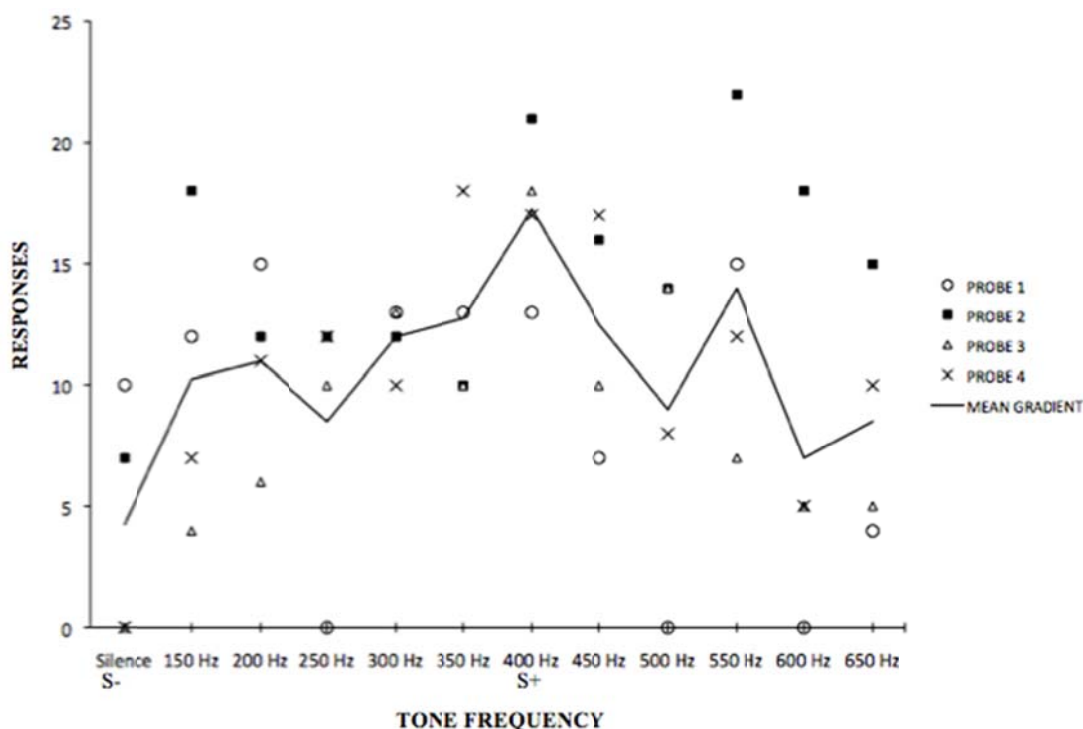


Figure 16. Mean gradient and generalization probe results following presence/absence training for Devin. The y-axis indicates frequency of responding. The x-axis indicates specific tone frequency or silence. The unfilled circles represent responding during the initial session (Probe 1). The filled squares represent responding during the second session (Probe 2). The unfilled triangles represent responding during the third generalization session (Probe 3). The crosses represent responding during the fourth generalization session (Probe 4).

responding during silence (S-) was also elevated during these probes. His responding appears more orderly in the last two probes, which followed additional presence/absence discrimination training occurring as part of reminder sessions. The mean of these last two probes was graphed (Figure 17) and revealed a distinctively orderly response pattern, with the highest number of responses occurring during the 400 Hz tone (S+), the lowest number of responses during silence, and an orderly decrease in responding as tone values became increasingly dissimilar to the S+ value.

The mean gradient for all four probes following intradimensional training (Figure

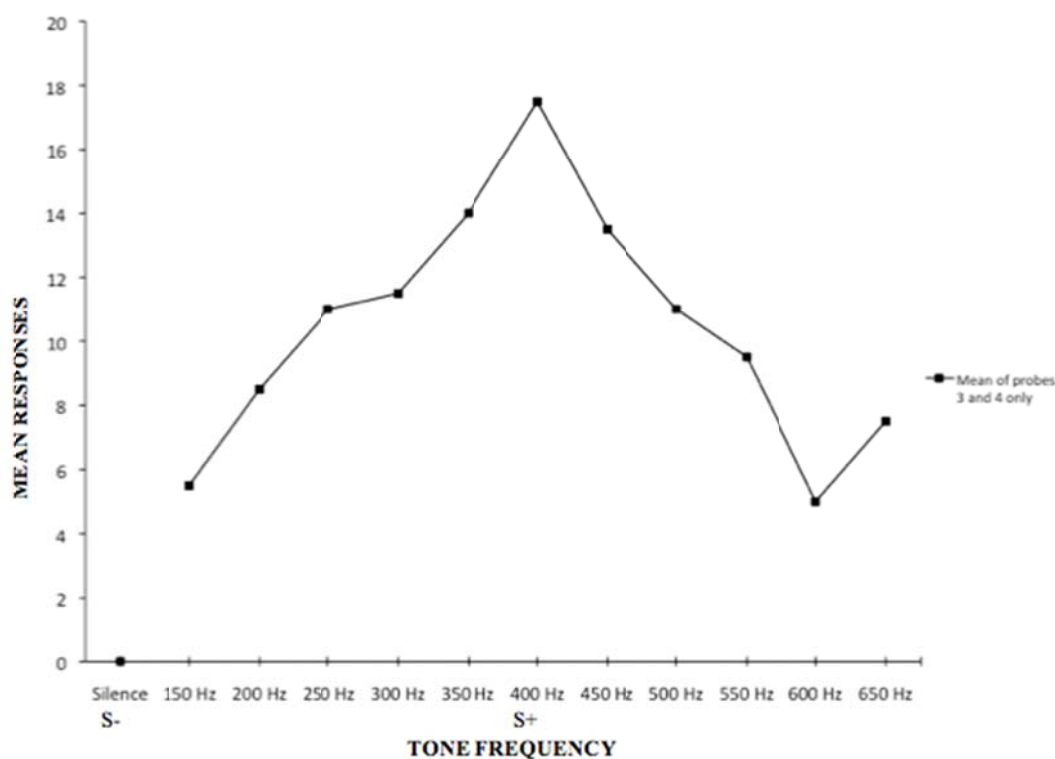


Figure 17. The mean of only the final two generalization probes (Probes 3 and 4) following presence/absence training for Devin. The y-axis indicates frequency of responding. The x-axis indicates specific tone frequency or silence. As can be seen, the gradient generated from Devin's responding following presence/absence training became more clearly symmetrical and peaked. This may be related to further discrimination learning during reminder sessions.

16) peaks at 400 Hz (S+), with a second, smaller peak at 550 Hz. Overall, the gradient is orderly and decremental. Responding was lowest during the period of silence (S-).

Interobserver agreement was recorded for 50% of post-presence/absence discrimination training generalization sessions with an overall agreement of 94% for frequency of independent responding.

Following intradimensional training, Devin received four more generalization test sessions. Results from each of these generalization probes, along with the mean gradient, are displayed in Figure 18. For probes 1 and 2, Devin responded most in the presence of

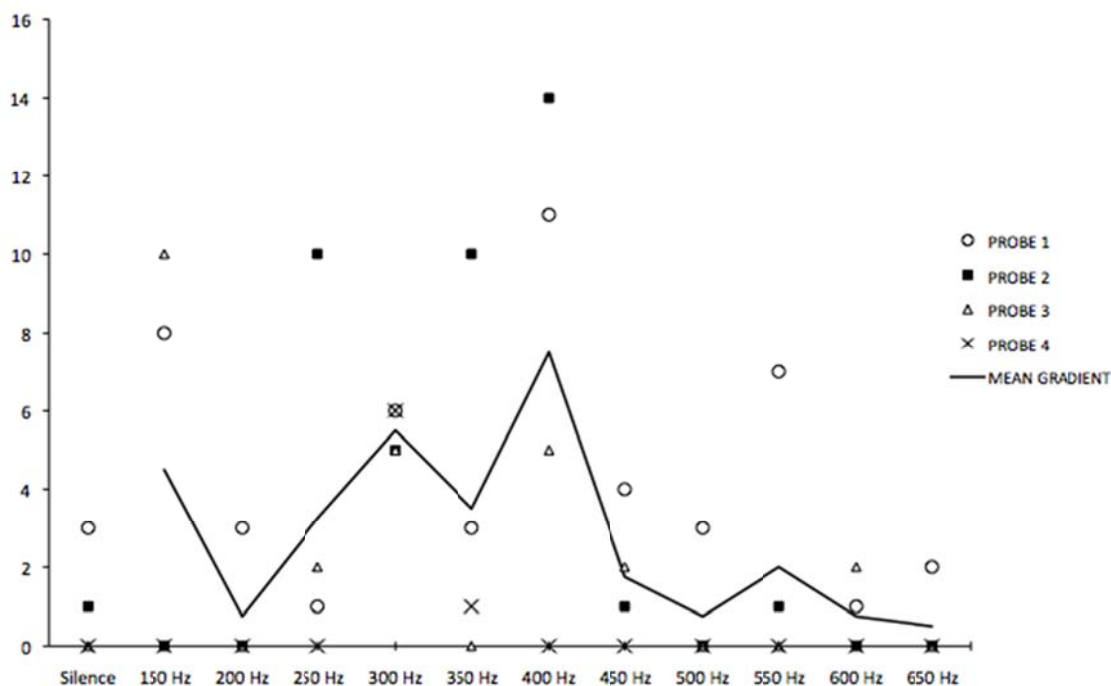


Figure 18. Mean gradient and generalization probe results following intradimensional training for Devin. The y-axis indicates frequency of responding. The x-axis indicates specific tone frequency or silence. The unfilled circles represent responding during the initial session (Probe 1). The filled squares represent responding during the second session (Probe 2). The unfilled triangles represent responding during the third generalization session (Probe 3). The crosses represent responding during the fourth generalization session (Probe 4).

S+. During probe 3, Devin responded most in the presence of 150Hz and during probe 4 he responded most during 300 Hz. Only in probe 1 did Devin engage in any responding during S- (500Hz).

A comparison of mean gradients before and after intradimensional discrimination training is displayed in Figure 19. As with the average gradient following presence/absence training, most of Devin's responding across probes occurred in the presence of the 400 Hz tone. Therefore, peak shift is not evident for Devin. However, a second and third peak occurred at 300 Hz and 150 Hz. Devin's overall responding to tones with frequency values lower than S+ was elevated while his responding to tones of frequencies values higher than S+ was diminished.

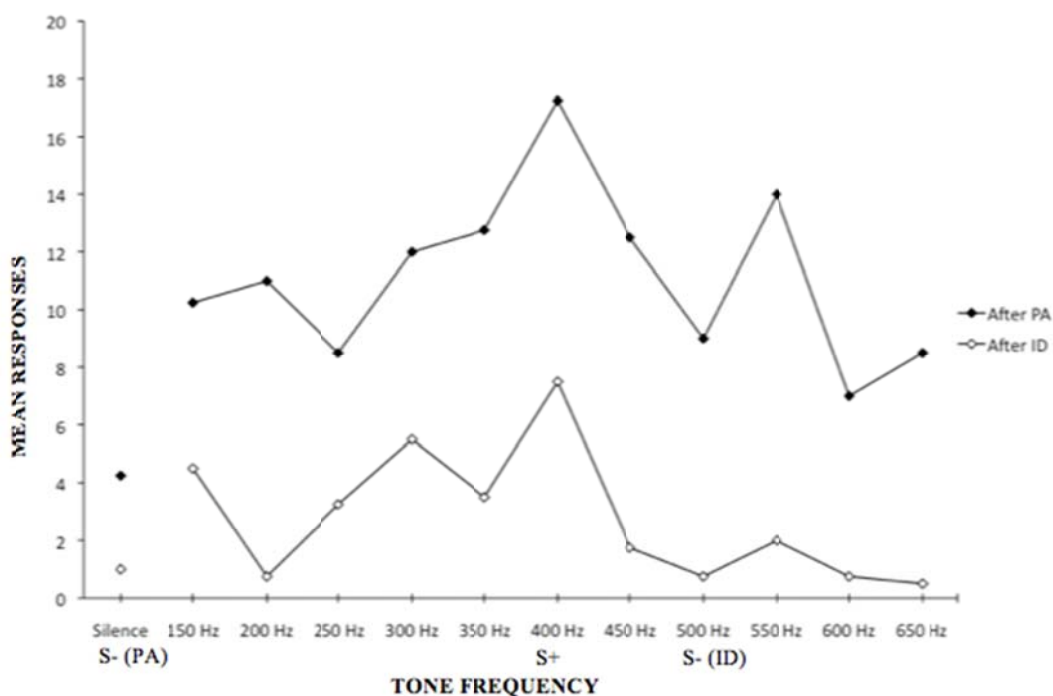


Figure 19. Mean generalization gradients for Devin. The y-axis indicates response frequency. The x-axis indicates specific tone frequency or silence. The line with filled diamonds is the mean of four generalization probes following presence/absence training for Devin. The line with unfilled diamonds is the mean of four generalization probes following intradimensional training for Devin.

Devin's overall response rate was also notably lower during the post intradimensional training probes than it was during post presence/absence training probes. To better visualize and compare overall gradient shapes for each average gradient, a second graph is displayed in Figure 20 showing gradients by percentage of total responses during each generalization phase.

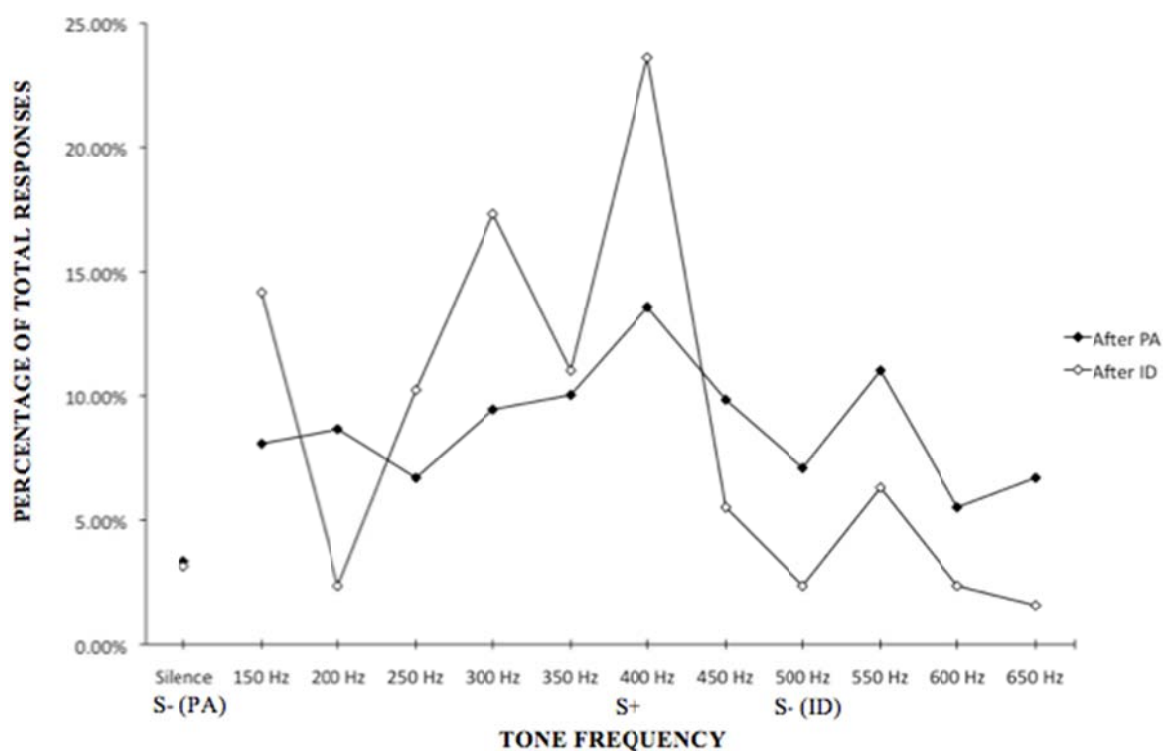


Figure 20. Generalization gradients by percentage of responding for Devin. The y-axis indicates response frequency. The x-axis indicates specific tone frequency or silence. The line with filled diamonds is the mean of four generalization probes following presence/absence training for Devin. The line with unfilled diamonds is the mean of four generalization probes following intradimensional training for Devin. A steepening of the gradient following intradimensional discrimination training can be seen.

Participant Comparisons

Mean gradient results by percentage of responding for each participant following presence-absence training are displayed in Figure 21. Mean gradient results by percentage of responding for each participant following intradimensional training are displayed in Figure 22. Overall mean gradients by percentage of responding for combined participants after each discrimination training phase (presence/absence and intradimensional) are displayed in Figure 23.

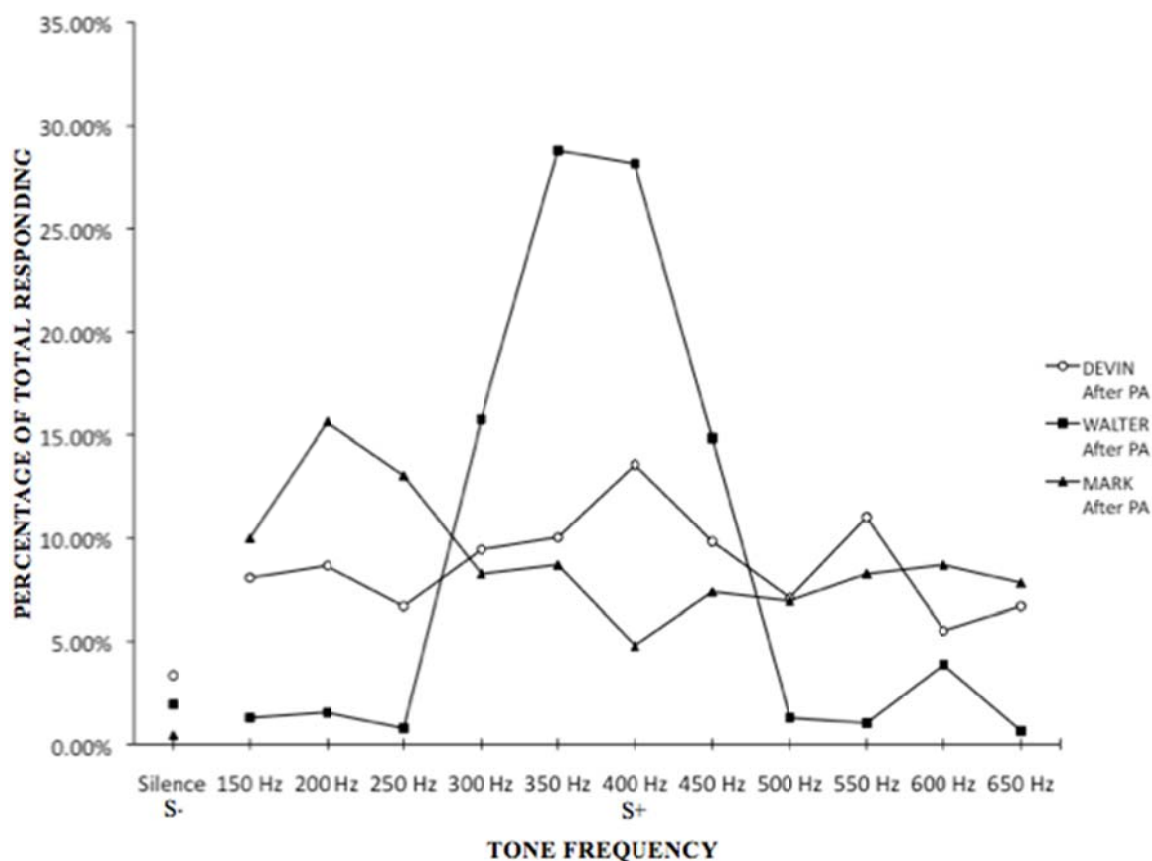


Figure 21. Gradients by percentage of responding following presence/absence discrimination training for Devin, Walter, and Mark. The line with unfilled circles is the gradient obtained for Devin. The line with filled squares is the gradient obtained for Walter. The line with filled triangles is the gradient obtained for Mark.

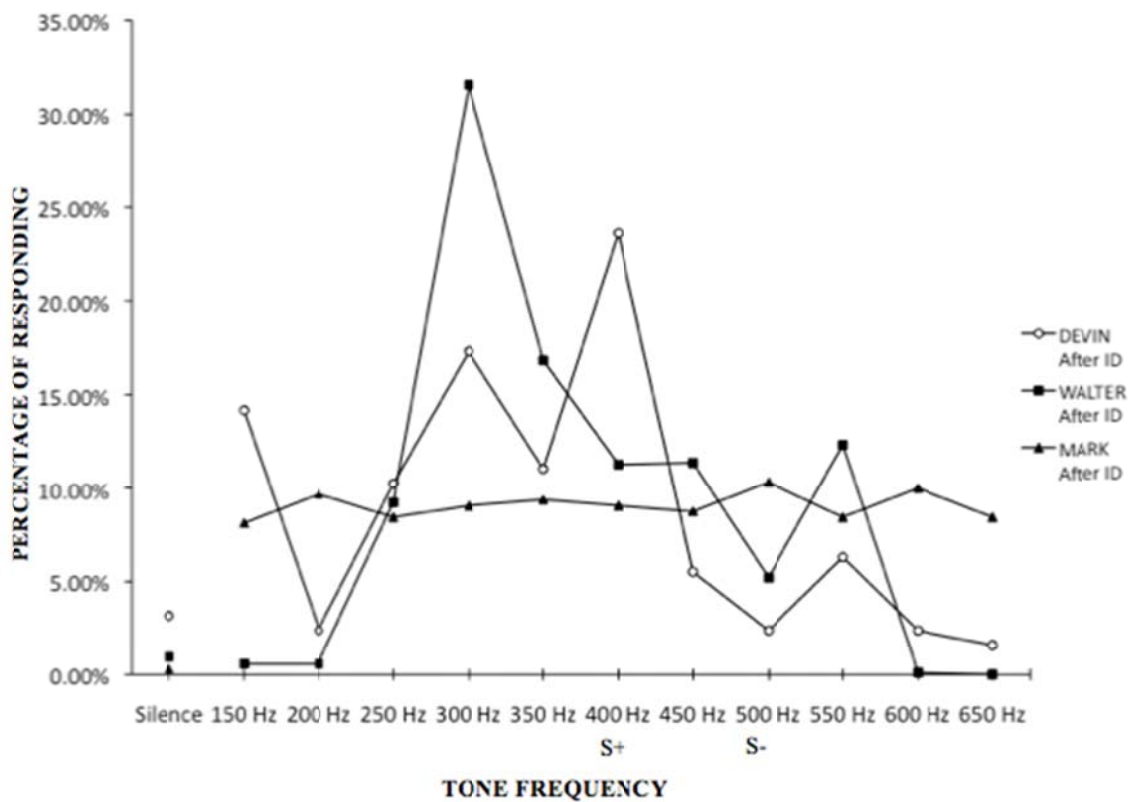


Figure 22. Gradients by percentage of responding following intradimensional discrimination training for Devin, Walter, and Mark. The line with unfilled circles is the gradient obtained for Devin. The line with filled squares is the gradient obtained for Walter. The line with filled triangles is the gradient obtained for Mark.

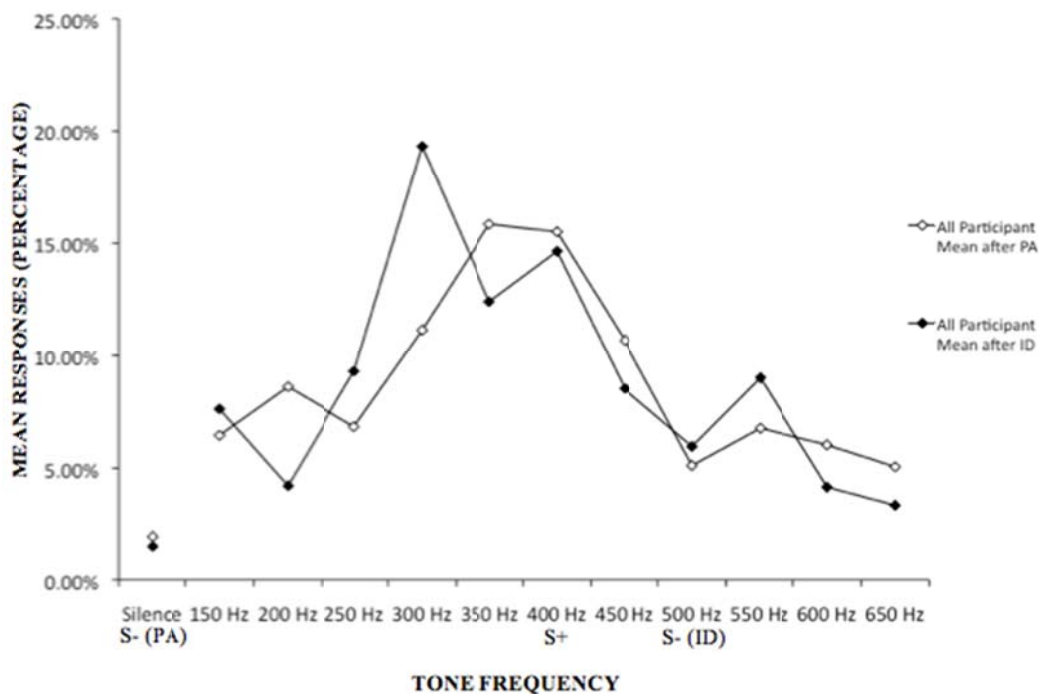


Figure 23. Mean gradients by percentage of responding following presence/absence and intradimensional discrimination training for Devin, Walter, and Mark. The line with unfilled diamonds is the mean gradient obtained for all participants following presence/absence discrimination training. The line with filled diamonds is the mean gradient obtained for all participants following intradimensional discrimination training.

CHAPTER V

DISCUSSION

The present study obtained stimulus generalization gradients as a measure of the extent to which behavior, reinforced in the presence of a specific tone, occurs in the presence of other tones of varied frequency for children with ASDs. The study further assessed the effects of different training procedures (i.e., presence/absence and intradimensional discrimination training) upon the resulting gradients, and thereby demonstrating a procedure to isolate the fundamental behavioral processes of reinforcement and extinction in relation to the process of generalization across the dimension of tone frequency.

Training procedures progressed through a series of steps designed to increase stimulus control by the relevant dimension of tone frequency (Figures 9, 15, and 20). Participants first learned to respond at high rates in the presence of the tone stimulus (nondifferential training). All participants acquired the response. Next, to help participants attend to the relevant cue, they were taught to discriminate between tone-present and tone-absent conditions (presence/absence discrimination training). All participants acquired this discrimination. Additionally, during generalization testing, all participants continued to show this previously learned discrimination between tone-present (S+) and tone-absent (S-) conditions based on low rates of responding for tone-absent trials within generalization testing (Figures 12, 18, and 24).

According to results of the first generalization testing phase, the relevant dimension of tone frequency had acquired stimulus control for two of the three

participants (Walter and Devin) without the need for intradimensional discrimination training (Figures 16 and 21). In other words, Walter and Devin responded differentially in the presence of the S+ as compared to tones of other frequencies. Stimulus control by the dimension of tone frequency was evident when gradients peaked at or near S+ and sloped downward as frequency values became more dissimilar. This finding is consistent with previous research with non-human subjects and demonstrates that intradimensional discrimination training procedures are unnecessary for obtaining generalization gradients (Honig & Urcuioli, 1981; Jenkins & Harrison, 1960). In addition, it is worth noting that all three participants showed a pattern of responding consistent with generalization following presence absence training.

Unlike the other two participants, Mark's responding during the first generalization phase did not indicate clear stimulus control by the dimension of tone frequency. It is not clear why Mark did not respond more like the other participants. One notable difference was observed during presence/absence training for Mark, compared to the other two participants. Specifically, Mark showed clear discrimination between tone-present and tone-absent conditions during the first session of presence/absence training. He did not appear to go through a process of learning this discrimination like the other participants. Mark's response pattern during generalization testing may also be related to stimulus overselectivity (Lovaas et al., 1971; Ploog, 2010). That is, stimulus control for Mark may have been predominated by dimensions of the tone stimulus other than frequency (e.g., texture, volume, intermittent nature of the tones, the presence of a tone), leading Mark to over-generalize his responding to frequencies different from S+. However, it is worth noting previous research has not demonstrated overselectivity with

stimuli such as those used in the present study. Studies of stimulus overselectivity have relied on more complex or compound stimuli, such as two distinct sounds presented together (Reynolds et al., 1974) or spoken stimuli with distinct content and intonation features (Schreibman, Kohlenberg & Britten, 1986), but have not focused on a participant's attentional differences toward these particular and more subtle stimulus dimensions (e.g., texture, volume, intermittent nature of tones, or presence of a tone) of simple auditory stimuli. One purpose in using a simple auditory stimulus for the present study was to avoid the possibility of overselective stimulus control because stimulus overselectivity decreases as stimuli are less complex (Burke & Cerniglia, 1990); however, if Mark responded overselectively, this may not have worked for him.

Stimulus control was further focused on the relevant dimension (tone frequency) by teaching an intradimensional discrimination. Differences between participant behavior during intradimensional discrimination training and in the subsequent generalization gradient results obtained are notable. Mark did not acquire the intradimensional discrimination before generalization testing (partly due to his limited availability to participate). Throughout intradimensional discrimination training, Mark's rate of responding was higher in the presence of the S- than for the S+ (Figure 4), one likely reason for this is the effect of consumption time. Mark's response rate was interrupted more frequently during S+ trials as he ate strawberries. Because time was limited, two generalization probes were taken before Mark had showed signs of learning the discrimination. These probes resulted in a relatively flat gradient (Figure 6), indicating a lack of stimulus control by the relevant dimension of tone frequency (Jenkins & Harrison, 1960).

With the added instruction introduced prior to the final reminder session Mark acquired the discrimination (Figure 4). This procedural modification was made in order to help rule out the possibility that Mark had previously failed to acquire the intradimensional discrimination simply because the difference between tones (S+ and S-) was too small to be detected or beyond his sensory threshold. These results indicate detecting this difference was within his sensory threshold capacity, but he likely had not had sufficient experience within discrimination training to learn the inefficiency of responding in the presence of S-. The results of the final generalization probe (Figure 8) are clearly different than the previous two probes (Figure 6). Still, they do not present an orderly gradient and are difficult to interpret in light of expected results. Had mark received more discrimination training sessions following the added verbal prompt and more generalization probes, a clearer pattern may have arisen.

Based on his generalization gradients following presence/absence training, Walter showed discrimination between the 400 Hz and 500 Hz tones prior to beginning intradimensional discrimination training (Figure 11). This may help explain why Walter showed clear discrimination between the two tones throughout intradimensional discrimination training. The average generalization gradient following intradimensional discrimination training for Walter is consistent with predictions regarding the peak shift effect (Honig & Urcuioli, 1981). There was a clear shift in peak. That is, prior to intradimensional training, Walter emitted the highest rates of responding in the presence of the 350 Hz tone. Following intradimensional discrimination training, during which responding in the presence of the 500 Hz tone was placed on extinction, the highest rates of responding occurred in the presence of the 300 Hz tone, a pattern of responding

consistent with peak shift. Also consistent with previous research, the highest rate of responding observed following intradimensional training was higher than that observed following presence/absence training (Honig & Urcuioli, 1981). For Walter, the behavioral process of extinction, applied to the dimension of tone frequency, shifted his highest rate of responding to stimuli different from S+ in the direction opposite from the S- (essentially, the generalization shifted to the left and became more narrow), though the slope between the S+ and the S- was not steeper as had been predicted. Additionally, Walter's responding in the presence of the 400 Hz tone was reduced following intradimensional discrimination training.

Devin spent more time in intradimensional discrimination training than any other participant. Although he eventually showed signs of acquiring the discrimination, the distinction between response rates in the presence of S+ compared to S- was not as dramatic as it had been for Walter. This difference would have likely appeared more dramatic had consumption time been removed because Devin's response rate during S+ trials was interrupted at times as he ate M&Ms. Inconsistent with predictions, Devin did not show a clear shift in gradient peak following intradimensional discrimination training. Devin also responded less overall during generalization testing following intradimensional training than he did during generalization testing following presence/absence training. One possible explanation for this may be decreased reinforcer potency.

When post-presence/absence and post-intradimensional discrimination training gradients are compared based on percentage of responding, results suggest a steepening of the gradient and decreased responding in the presence of S- following intradimensional discrimination training (Figure 20). Furthermore, although the gradient peak did not shift

away from S+ for Devin, a second peak occurred over the 300 Hz tone value and Devin responded more overall to frequency values below S+ than he did to values above S+. These subtle changes in gradient form suggest influence consistent with the peak shift effect and previous findings regarding the impact of intradimensional discrimination training and the behavioral process of extinction on the form of the gradient (Honig & Urcuioli, 1981). The finding that learning processes and response patterns for all three participants contained idiosyncratic elements is consistent with well-established knowledge that individuals with autism are not a homogeneous group.

Conclusion

The present study attempted to discover the extent to which operant responses of children with autism generalize to changes in a simple auditory stimulus when it is varied across the dimension of tone frequency. It also attempted to identify the relative effects of different training procedures (presence/absence and intradimensional discrimination training) and different behavioral processes (reinforcement and extinction) on the resulting gradients of generalization. The present study also went beyond previous research by obtaining gradients for children with autism that vary according to an auditory, rather than a visual, modality.

The present research differed in methodology from past studies that have suggested a lack of generalization for individuals with autism. Rather than assess generalization by teaching a behavior and subsequently measuring the transfer of learned behavior to extra-treatment stimuli and settings, the present study used a more precise means of characterizing the extent of generalization and the basic underlying processes

influencing it (i.e., by obtaining generalization gradients). Although the shape of generalization gradients differs between participants, all three participants in the present study showed a pattern of responding consistent with generalization following presence/absence training.

A small number of previous studies have obtained generalization gradients for individuals with ASDs; however, these previous studies obtained generalization gradients only after teaching an intradimensional discrimination (Fein et al., 1979; Matthews et al., 2001; Miyashita, 1985; Rincover & Ducharme, 1987). This procedure combined the effects of reinforcement and extinction along the relevant dimension. The present study went beyond previous research on individuals with ASDs by separating the behavioral processes of reinforcement and extinction along the dimension of tone frequency. For two of three participants, orderly decremental generalization gradients were obtained without introducing extinction along the relevant dimension. Reinforcement, without extinction along the relevant dimension, yielded decremental generalization gradients, peaking at S+ for these participants.

Results of the present study are also consistent with other basic research on stimulus generalization in showing that the particular training procedures used will influence the form of gradients obtained (Honig & Urcuioli, 1981). For two of three participants, the behavioral process of extinction had effects on subsequent generalization gradients consistent with findings from basic research with nonhuman subjects.

The present study demonstrated one method for obtaining auditory stimulus generalization gradients for children with ASDs and for measuring an individual's response to alterations in training procedures. The procedures implemented in the present

study have the potential to become a useful assessment procedure, providing “detailed information on individual learning characteristics” (Matthews et al., 2001, p. 175).

Assessing idiosyncratic patterns in the behavioral process of generalization for individuals with autism in this manner may help inform the further development of a behavioral technology for teaching generalization (Stokes & Baer, 1977). For example, procedures similar to those used in the present study could be used to identify individuals who may require more systematic intervention to ensure generalization. This information could suggest the level of need an individual has for exposure to a more varied set of discriminative stimuli when being taught a new skill. If an individual generalized responding across a wide range of stimulus values during generalization testing, that individual may not need as much training with varied stimuli to promote generalization as would an individual whose range of responding was more restricted.

The present study further emphasizes the potential impact of teaching children with ASDs to discriminate between stimuli and confirms that “a property of a stimulus that shows little or no influence on a response after prolonged nondifferential training may gain rather precise discriminative control by means of differential training to discriminate the presence from the absence of the stimulus” (Jenkins & Harrison, 1960, p. 252). Teaching discriminations between relevant and irrelevant cues may help children with autism avoid responding overselectively. Considering the peak shift observed for Walter following intradimensional discrimination training, teaching similar children to discriminate between stimuli varied along a single dimension has the potential to shift stimulus control in a direction away from the stimulus signaling extinction (S-).

Limitations and Future Directions

The present study is limited by some procedural variables. Procedural variables that may limit the interpretation of data gained from the present research include the inclusion of consumption time within discrimination training trials and the lack of tighter control over the stimulus dimension of tone volume. The inclusion of consumption time within discrimination training trials likely resulted in participants having more time to respond during S- trials than S+ trials, thereby causing discriminations learned to appear less dramatic. Although reasonable efforts were made to maintain tone volume within a given range throughout the study by setting tone volume with a decibel meter each day, there was still some slight variability in decibel level as measured by the decibel meter between tones of different frequencies and some slight variability between sessions. Additionally, perceived tone volume is dependent on the participant's proximity to the speaker and can fluctuate as the participant moves or leans closer or further from the source of sound. Furthermore, perception of both loudness and pitch are dependent on psychological processes difficult to control for.

The apparent lack of stimulus control by the relevant dimension of tone frequency for Mark following successful presence/absence discrimination training also raises further questions about the possibility of stimulus overselectivity as it applies to more subtle stimulus features. While much research has been conducted to demonstrate that incidental stimuli in an environment or incidental features of a complex stimulus often acquire stimulus control for children with ASDs, previous research has less to say regarding the extent to which features or dimensions (e.g., volume, frequency, texture,

intermittency, etc.) of the same simple stimulus (e.g., a simple tone) may predominate responding. Further research may be needed to better answer these questions.

Future research may expand on the present study by increasing the small sample size and by including a comparison group. It will be important for researchers to include typically developing participants in future research. This would provide a baseline to make meaningful comparisons between groups. The present study demonstrated that children with ASDs can acquire discriminations between stimuli and generalize learning across changes in a stimulus; however the current results cannot be used to make statements about how individuals with ASDs generalize or acquire discriminations differently than other populations. The current data cannot state whether children with autism generalize across a more or less restricted range of stimuli than typically developing peers.

Considering children with ASDs are not a homogeneous group, the application of present findings is hardly generalizable beyond the individual participants. Further research with more participants is needed to establish trends or patterns and to identify what effect, if any, features such as severity of autistic symptoms or level of cognitive functioning have on the process of learning discriminations and on generalization gradients.

The current study has been a study of stimulus control for children with ASDs. It has assessed the relative effects of different teaching procedures on stimulus generalization. Further development within this line of research may eventually be used to inform applied studies that may improve generalization and teaching strategies for individuals with ASDs.

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APPENDICES

Appendix A
Recruitment Letter

Albany County School District One



OFFICE OF SPECIAL SERVICES

509 S. 5TH STREET
LARAMIE, WYOMING 82070

PHONE (307) 721-4460
FAX (307) 721-4444

[Date]

Dear [Mr. / Ms. LAST NAME],

My name is Steven Corry. I am a school psychologist intern with Albany County School District #1. I am also a graduate student working under the direction of Professor Andrew Samaha in the Psychology Department at Utah State University.

I am conducting a research study about Autism. The purpose of this research is to investigate how children with Autism Spectrum Disorders generalize what they have learned across different contexts. A person is said to "generalize" what they have learned when skills taught in one context (such as school) occur in other contexts (such as home).

This study may lead to an increased understanding of why children with autism often do not generalize learning across contexts. An increased understanding of this may help inform future treatments for children with autism. This research may also provide participants with information about rewards that can be used to help improve behavioral interventions for the participants.

I obtained your name and address and received permission to contact you from Becky Anderson, the director of special services with Albany County School District #1. District records indicate that your child, [CHILD'S NAME], may be eligible to participate in this study.

Your and your child's participation in this study is voluntary. Whether or not you participate in this study will have no effect on your relationship with, or services provided by, Albany County School District #1.

If you are interested in participating or simply learning more about the study, please contact me at 435-238-0197 (cell), or 307-721-4439 (work), or email me at scorry@acsd1.org.

Thank you for your time and consideration. I look forward to hearing from you.

Sincerely,

Steven Corry, MS
School Psychologist Intern
Albany County School District #1

Graduate Student
Department of Psychology
Utah State University

307-721-4439 (work)
435-238-0197 (cell)
scorry@acsd1.org

cc: Becky Anderson

Appendix B
Informed Consent



Department of Psychology
2810 Old Main Hill
Logan UT 84322-2180
Telephone: (435) 797-1460



USU IRB Approval: March 2, 2012
Approval Terminates: 03/01/2013
Protocol # 4188
IRB Password Protected per IRB Administrator

PARENT PERMISSION

An analysis of auditory stimulus generalization in children with autism following two different training procedures

Introduction/ Purpose: Steven Corry, a graduate student in the Department of Psychology at Utah State University, under the direction of Dr. Andrew Samaha, is conducting a study to find out more about how children with autism learn and how learning in one setting might affect behavior in another. Specifically, after teaching children with autism to engage in a simple communicative request in the presence of a tone, we want to know the extent to which these children will continue to engage in that request as the tone changes in frequency. We also want to determine how the specific types of training procedures used to teach the communicative request will impact how these children respond when the tone changes in frequency. We are asking for your permission to have your child take part because he/she has a diagnosis of an autism spectrum disorder. There will be up to 8 participants in this research.

Procedures If you allow your child to be in this research study, the following will happen:

Step 1. Your child will be briefly tested for about 30-minutes, to find out which kinds of food items he/she likes. No foods will be given to your child that he/she is not permitted to have. We will check with you first before we provide any food items.

Step 2. We will teach your child to perform a simple task, for example, pressing a button or touching the experimenter with a card, in order to ask for a reward (the food item). While the task is being taught a particular tone at or below the volume of a normal conversation (65 decibels or below) and with a frequency somewhere between 150 and 4000 Hz (within the range of typical hearing) will be playing. Over the course of several short sessions, as your child becomes proficient at the task for requesting a food item, we will gradually require more work on the task before he/she receives rewards. These sessions will last for 5-10 minutes each and your child will have 0-4 of these sessions per day. Your child's performance during this task and throughout the study will be measured.

Step 3. Next, your child will be taught to tell the difference (or "discriminate") between times when the tone is playing and times when the tone is not playing. To do this, we will only provide rewards when your child performs the task when the tone is playing and we will withhold rewards if he/she performs the task when there is no tone. These sessions will last 6 minutes each. Your child will spend no more than 60 minutes per day in these sessions and will continue in these sessions until he/she has learned to tell the difference between the two conditions sufficiently well.

Step 4. After your child has learned to tell the difference between times with no tone playing and times with a tone playing, he/she will participate in two 11 to 12-minute sessions during which many different tones will be played. As noted in step 2, the tones will be 65 decibels or below in volume and may range in frequency from 150 to 4000 Hz. As these various tones are being presented, your child will have the opportunity to perform the task previously taught; however, no rewards or consequences will follow the performance of the task. In between these two sessions, your child will participate in one 6-minute session that will follow the same procedures described in step 3.

Step 5. This phase of the study will be almost identical to the phase described in step 3. The only difference will be, instead of learning to tell the difference between times with a tone playing and times with no tone playing, your child will be learning to tell the difference between times when the previous



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tone is playing and times when a tone with a higher frequency (still within the range noted previously) is playing.

Step 6. Finally, after your child has learned this discrimination, he/she will again participate in two 11 to 12-minute sessions identical to those described in step 4. As described in step 4, this phase will also involve one 6-minute session; however, this 6-minute session will follow the same procedures described in step 5.

Note: If sessions are conducted during school hours, your child will be removed from the classroom during the time that he or she is in session. A room will be selected that is free from distraction and noise, and is not occupied by others who are not involved in the research. Two researchers will attend sessions with each child.

New Findings During the course of this research study, you will be informed of any significant new findings (either good or bad), such as changes in the risks or benefits resulting from participation in the research, or new alternatives to participation that might cause you to change your mind about continuing to have your child participate in the study. If new information is obtained that is relevant or useful to you, or if the procedures and/or methods change at any time throughout this study, your permission to allow your child to continue participating in this study will be obtained again.

Risks Participation in this research study may involve some minimal risks or discomforts. These include:

1. Sometimes children with autism engage in problem behavior when asked to do work. Therefore, your child may engage in problem behavior, but the researchers will stop the session immediately if the behavior poses a risk to your child or others.
2. Some children with autism are known to experience distress in the presence of certain sounds. The tones used in this study are expected to be non-aversive. The sounds will be maintained at volume levels comparable to a normal conversation. Notwithstanding these safeguards, if your child displays signs of distress in relation to the tones, the session will be ended early.

Benefits Potential benefits of participation in this study include the following:

1. The present study may provide you with information about what things may be used as reinforcers or rewards in other interventions. This information may be used to help improve behavioral interventions and reinforcement-based skill acquisition programs for your child.
2. Because the present study involves an assessment of stimulus generalization, participation in this study may result in findings about how your child generalizes to changes in auditory stimuli. These findings may or may not be useful when planning interventions for your child.
3. This study may also add to the body of scientific knowledge about the behavioral processes of generalization and discrimination in children with autism. Children with autism are known to have difficulties with generalizing learned behavior across different situations. The present study may lead



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to an increased understanding of why children with autism often do not generalize across different settings. An increased understanding of this may have implications for informing treatment efforts, not only for your child, but also potentially for children with autism generally.

Explanation & offer to answer questions Steven Corry has explained this research study to you and answered your questions. If you have other questions or research-related problems, you may reach Mr. Corry by email at stevencorry@gmail.com or you may contact Dr. Samaha by e-mail at andrew.samaha@usu.edu.

Extra Cost/Compensation There are no costs for participation in this research and there is no payment for participation in this research.

Voluntary nature of participation and right to withdraw without consequence Participation in research is entirely voluntary. You may decline to have your child participate, or withdraw your child from participation, at any time without consequence or loss of benefits. Your child may be withdrawn from this study without your permission by the researchers if your child is not appropriate for this study. For example, if your child appears unable to learn the tasks and discriminations required, or if your child engages in excessive problem behavior when participating. If this happens, Steven Corry will notify you.

Confidentiality Federal privacy Regulations provide safeguards for privacy, security, and authorized access. Utah State University shall use appropriate safeguards to protect Personal Health Information (PHI) from misuse or inappropriate disclosure and to prevent any use or disclosure of PHI other than as provided in this Parent Permission document or as otherwise required by law or regulation.

With parent/guardian permission, health and school records that may contain identifiable information such as birth date, school names, city of residence, and medical numbers, may be obtained by the researchers. Social Security numbers will not be used or recorded. These records may include previous psychological, special education, and/or medical evaluations. However, only the researchers, Andrew Samaha, Steven Corry, and Lindsey Corry, will have access to any potentially identifiable data. Records with identifiable information will be stored in a locked file cabinet in Steven Corry's office at Linford Elementary.

To help protect the privacy of your child's identity, all participants will be assigned a code. The code will replace the name of your child and will be associated with research data throughout the duration of the study. The code will be stored with the other identifiable records in a locked file cabinet in Steven Corry's office at Linford Elementary. Your child's name will be removed from the code within one month of your child's completion of participation in this study. Research data on your child will be kept indefinitely, in case it is necessary to review the data in the future, but your child's name and all other identifiable information will be removed from the records or the records will be destroyed within one month after your child has completed participation in this study. Results from this research may be published and/or presented in the future; however, no identifiable information will be included in publications or presentations.



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Besides the researchers, Becky Anderson, Director of Special Services with Albany County School District 1, will be notified of your child's participation in this study. Also, because this research may be conducted at a school, there is some risk that other people not associated with this study may become aware of your child's participation. For example, teachers or students may happen to see your child with the researchers.

IRB Approval Statement The Institutional Review Board for the protection of human participants at USU has approved this research study. If you have any pertinent questions or concerns about your rights or a research-related injury, you may contact the IRB Administrator at (435) 797-0567 or email irb@usu.edu. If you have a concern or complaint about the research and you would like to contact someone other than the research team, you may contact the IRB Administrator to obtain information or to offer input.

Parent Permission: You have been given two copies of this Parent Permission document. Please sign both copies and keep one copy for your files.

Investigator Statement "I certify that the research study has been explained to the individual, by me or my research staff, and that the individual understands the nature and purpose, the possible risks and benefits associated with taking part in this research study. Any questions that have been raised have been answered."

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Lindsey Corry
Student Researcher

Signature of Participant By signing below, I give permission for my child to participate.

Parent/Guardian

Date

Relationship to Participant

Name of Child



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USU IRB Approval: March 2, 2011
Approval Terminates: 03/01/2012
Protocol # 418
IRB Password Protected per IRB Administrator

PARENT PERMISSION

An analysis of auditory stimulus generalization in children with autism following two different training procedures

Do you anticipate that your child may show distress to sounds played at or below conversational volume? (please check one): Yes No

I agree to share my child's health and school records, if available, with respect to his or her hearing ability, cognitive ability, and the diagnosis of an autism spectrum disorder or the qualification to receive services under the autism educational category. **(Please initial one):** _____ Yes _____ No

Child Assent: *(To be signed by children between the ages of 7-17 years of age and who are capable to provide assent).*

I understand that my parent(s)/guardian is/are aware of this research study and that permission has been given for me to participate. I understand that it is up to me to participate even if my parents say yes. If I do not want to be in this study, I do not have to and no one will be upset if I don't want to participate or if I change my mind later and want to stop. I can ask any questions that I have about this study now or later. By signing below, I agree to participate.

Name

Date