An Examination of Stimulus Generalization in Generalized Imitation

by

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Abstract

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This study examined the extent to which imitation generalizes within a set of stimulus models that can be arrayed along a physical continuum. The participants, three typically developing children, were presented with a choice to imitate one of two stimulus models during both probe and training trials. During training trials, one of two stimulus models that occasioned reinforcement was presented with one stimulus model that never occasioned reinforcement. Probe trials, which were interspersed among training trials, were used to measure the extent to which imitation generalized within a set of stimulus models. Imitation of the stimulus models used during probe trials was never reinforced. Following training, tests of generalization were conducted under extinction conditions. The data showed that as the physical similarity of the probe models to the S+ models increased, the level of imitative responding increased. The results are discussed in terms of stimulus control of imitative responding.

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An Examination of Stimulus Generalization in Generalized Imitation

"Generalized imitation" a term first used by Baer and Sherman (1964), provides explicit recognition that the term "imitation" does not refer to an individual response, but to a set of functional relations between a set of modeled stimuli and sets of responses. The term "generalized imitation" refers to behavior that (a) is topographically similar to that of a model, (b) temporally follows the modeled stimuli, (c) is controlled by virtue of the fine-grained topography of the model's behavior, (d) has never occasioned reinforcement for its occurrence.

Studies of generalized imitation have shown that imitation of stimulus models that do not occasion reinforcement is acquired and maintained while reinforcement is delivered for the imitation of other stimulus models (Baer & Sherman, 1964). When reinforcement for imitation of the stimulus models is discontinued, a decrease in the imitation of all of the stimulus models is observed (Baer & Deguichi, 1985).

Various arguments have been hypothesized to describe the underlying learning processes involved in generalized imitation. This introduction presents a brief review of each empirical and theoretical account of generalized imitation. Divided into five sections, this introduction reviews generalized imitation as a case of (a) discrimination difficulty; (b) social control variables; (c) conditioned reinforcement; (d) stimulus classes that occasion classes of responses; and (e) stimulus generalization.

Generalized imitation as a case of discrimination difficulty

To identify the underlying learning processes involved in generalized imitation, some researchers have suggested that the discriminability of those stimulus models that occasion reinforcement from those that do not may determine the level of generalized imitation (Bandura & Barab, 1971; Bucher & Bowman, 1974; Bufford, 1971; Gewirtz & Stingle, 1968). According to Gewirtz and Stingle (1968) as well as other researchers (Bandura & Barab, 1971; Bucher & Bowman, 1974; Bufford, 1971; Gewirtz & Stingle, 1968), the procedures used in establishing a class of imitative responses contribute to the discrimination difficulty.

In the procedures used in studies of generalized imitation, a different stimulus model is presented to the participant on each trial. Imitation of some of the stimulus models (S^D) produces reinforcement, and imitation of other stimulus models (S^Δ) produces no programmed consequences. The trials in which an S^Δ model is presented to the participant are referred to as probe trials. The probe trials are interspersed among the trials with S^D models at various ratios, often 1 S^Δ model to 2 or 3 S^D models. The probe trials are intended to provide a non-intrusive measure of the extent to which imitation generalizes from the S^D models to the S^Δ models (Baer, Peterson, & Sherman, 1967).

In most studies of generalized imitation, a successive discrimination procedure is used. With a successive discrimination procedure, either one S^D model or one S^Δ model is presented to the participant during each trial. When the successive discrimination procedure is used, a block of trials consists of the interspersed presentation of S^D and S^Δ models.

Alternatively, a simultaneous discrimination procedure can be used in which both an S^D model and an S^Δ model are presented to the participant during each trial. During each trial, the participant is given a choice to imitate either of the two stimulus models. Therefore, the simultaneous discrimination procedure is a forced-choice procedure.

It has been suggested that when the successive discrimination procedure is used, participants might have difficulty discriminating which stimulus models occasion reinforcement (Gewirtz & Stingle, 1968). To decrease this discrimination difficulty, some studies have used a higher-order stimulus to signal the availability of reinforcement, or the absence of reinforcement, for imitative responding. The results of these studies showed that when a higher-order stimulus was used differential responding to the S^D and S^Δ models was observed.

For example, Bucher and Bowman (1974) used an orange triangle as a higher-order stimulus to signal the availability of reinforcement, or the absence of reinforcement, for imitation of the S^D and S^Δ models. Stimulus models were presented to four children with mental retardation using a simultaneous discrimination procedure. Immediately before the presentation of the S^Δ models, the experimenter placed an orange triangle in front of the participant. The use of this higher-order stimulus resulted in a decrease in imitation of the non-reinforced models in comparison to the imitation of these models when the higher-order stimulus was not presented.

In another phase of the study, the opportunity to engage in an alternative task, which occasioned reinforcement, was available to the participants while the S^D and S^Δ models were being presented. The participants could choose to imitate the stimulus model or they could choose to engage in the alternative task. When the alternative task was presented without the orange triangle, similar levels of responding to the S^D and S^Δ models were observed. Nonetheless, when the alternative task was presented together with the orange triangle, differential responding to the S^D and S^Δ models was observed. That is, when the orange triangle was present, participants engaged in the alternative task when it was presented together with S^{Δ} models. When the alternative task was presented with S^{D} models, a higher level of imitative responding was observed. The authors concluded that responding to S^{Δ} models in generalized imitation is more likely if the contingencies are more difficult to discriminate (Bucher & Bowman, 1974).

Other studies have used a higher-order stimulus to signal the availability or non-availability of reinforcement for imitation of stimulus models (Bandura & Barab, 1971). For example, Bandura and Barab (1971) used two different experimenters to signal the different contingencies associated with S^{D} and S^{Δ} models that were gross motor movement of the hands and arms (i.e. motor models). In this study, one experimenter presented the motor models that occasioned reinforcement and a different experimenter presented the motor models that did not occasion reinforcement. Participants, four young children with mental retardation, imitated significantly more S^{D} motor models than S^{Δ} motor models. In studies of generalized imitation, one experimenter presents both S^{D} and S^{Δ} models and differential responding is not observed. In this study, differential responding was observed when two different experimenters signaled the different contingencies associated with the S^{D} and S^{Δ} models. Given the different results obtained with the two different experimenters, the authors suggested that when one experimenter presents all stimulus models, participants may have difficulty discriminating those stimulus models occasion reinforcement from those that do not (Bandura and Barab, 1971).

In Bandura and Barab's (1971) study, the S^{D} and S^{Δ} models were presented using a successive discrimination procedure. It is not clear how participants would have responded if the S^{D} and S^{Δ} models had been presented using a simultaneous discrimination procedure. Other studies have examined the differences in imitative responding observed when a simultaneous discrimination procedure is used in comparison to when a successive discrimination procedure is used. The results of these studies show that when the simultaneous discrimination procedure is used, participants readily discriminate the reinforcement contingencies associated with S^D and S^Δ models. For example, when a simultaneous discrimination procedure was used, Steinman and Boyce (1971) found that participants, four 5-year-old girls, responded differentially to the S^D and S^Δ models that consisted of motor movement with hands. Nonetheless, when S^D and S^Δ models were presented in a successive discrimination procedure, the same participants imitated both S^D and S^Δ models.

<u>Generalized imitation and social control variables</u>

Some researchers have argued that the consistent imitation of both S^D and S^Δ models is a function of the instructional or social discriminative stimulus control that is exerted by the adult model (Steinman, 1970a; 1970b; 1977). This argument suggests that participants come to the experimental setting with a social history of reinforcement for compliance with adult instruction and punishment for non-compliance with adult instruction, whether overt or covert (Bufford, 1971; Peterson & Whitehurst, 1971; Peterson, 1968; Steinman, 1970b).

To investigate the extent to which the history of reinforcement for following instructions influences imitative responding, Steinman (1970b) examined generalized imitation using two different experimenters. One experimenter presented only the S^D models, and the other experimenter presented only S^Δ models to six elementary-school-aged girls who served as participants. A successive discrimination procedure was used.

The use of the two different experimenters did not result in differential responding. That is, participants were just as likely to imitate the models presented by the experimenter who never reinforced imitation as those presented by the experimenter who consistently reinforced imitation. These results do not support those of Bandura and Barab (1971). Interestingly, in the Steinman (1970b) study, when the adult experimenter delivered instructions not to imitate the S^{Δ} models, a decrease in the imitation of S^{Δ} models was observed. This study provided a demonstration of the discriminative stimulus control exerted by the instructions delivered by the adult experimenter (Steinman, 1970b).

Further evidence for the social control hypothesis has been found in studies that have examined imitative responding in the absence of the experimenter (Redd, 1976; Peterson, Merwin, Moyer, & Whitehurst, 1971; Peterson & Whitehurst, 1971). These studies have shown that participants responded differentially in the presence and absence of the adult experimenter. The results of these studies suggest that although the S^{D} models control the topography of the imitative response, various social control variables in the experimental setting exert control over imitative responding.

Generalized imitation and the conditioned reinforcement hypothesis

Baer and Sherman (1964) noted that in studies of generalized imitation, responding similarly to the stimulus model is immediately followed by reinforcement. Baer and Sherman proposed that the temporal contiguity of responding similarly to the model and the delivery of reinforcement may result in behavioral similarity that may become discriminative for reinforcement. As a stimulus that is discriminative for reinforcement, behavioral similarity can acquire conditioned reinforcement properties (Schwartz & Robbins, 1995).

The extent to which behavioral similarity functions as a conditioned reinforcer was examined by Baer and Deguichi (1985). The extent to which responding similarly to the stimulus model functions as a conditioned reinforcer was examined by Baer and Deguchi (1985). The subjects were six preschool-aged children. Preference of four activities was measured using a five-panel apparatus. Each panel of the apparatus contained a push button and a colored light. The light on the middle panel was green, and the lights on the four outer panels were red.

During some trials, the green light was illuminated and the red lights were not. When the green light was illuminated, pressing the middle-panel button resulted in reinforcement and the opportunity to imitate a stimulus model that occasioned reinforcement (Baer & Deguchi, 1985).

During other trials, all of the red lights were illuminated and the green light was off. The subjects learned to press one of the push buttons on one of the panels with the illuminated red lights. Each push button was correlated with contingent access to one of four activities. Various stimuli were placed on the each panel to signal the activity correlated with pushing each panel button. The activities were: 1) imitation of a stimulus model (i.e. motor movement) that did not occasion reinforcement; 2) engaging in a motor activity that was different from the stimulus model 3) observing the experimenter engage in a motor activity 4) waiting for the start of the next trial. Pushing the button on a panel was immediately followed by the correlated activity (Baer & Deguchi, 1985).

During trials in which the green light was illuminated, reinforcement was delivered for imitation of the stimulus model. The experimenters hypothesized that behavioral similarity may come to function as a conditioned reinforcer because imitative responding occasioned reinforcement on some trials. The experimenters measured the extent to which behavioral similarity functioned as a conditioned reinforcer by examining subjects' preference for the panel correlated with non-reinforced motor imitation.

With the introduction of reinforcement for motor imitation during the green-light trials, an increase in responding to the push button correlated with imitation of stimulus models that did not occasion reinforcement was observed during the red light trials for four of the six subjects. When motor imitation was no longer reinforced during the green-light trials, responding to the push button correlated with the non-reinforced motor imitation decreased during the red- light trials for the same four subjects. Nonetheless, when the reinforcement contingency for motor imitation was reintroduced, an increase in responding to the push button that signaled non-reinforced imitative responding was observed during red-light trials. Baer and Deguchi (1985) concluded that the results provide support for the account that behavioral similarity comes to function as a conditioned reinforcer in studies of generalized imitation.

Similar results were found by Kymissis and Poulson (1994). In the Kymissis and Poulson study, the results showed that behavioral similarity functioned as conditioned reinforcement for imitation of vocal models in typical preschool children.

In the Baer and Deguchi (1985) study, as well as in the Kymissis and Poulson (1994) study, one of the push buttons was correlated with the opportunity to engage in a motor (or vocal) activity that was different from the motor (or vocal) model presented by the experimenter. Because this activity involved emitting a response that was different from the stimulus model, it involved non-imitative responding. A preference for the push-button response correlated with these activities was not observed. In generalized imitation, the stimulus models come to function as a stimulus class (Catania, 1998) that occasions a class of imitative responses. Therefore, an account of generalized imitation as an instance of stimulus generalization would predict responding to members of the stimulus class that occasion imitative responding, rather than to members of the stimulus class that occasion non-imitative responding.

Generalized imitation as a stimulus class that occasions a class of responses

In studies of generalized imitation, researchers often use the term “response class” to refer to the set of topographically different imitative responses controlled by a set of stimulus models. Although researchers have used the term “response class” in various studies to describe generalized imitation, the present paper will describe generalized imitation as a “stimulus class” that occasions a class of responses (Poulson, 2003).

Various studies have shown that the set of stimuli that come to occasion imitative responding may be limited by “topographical boundaries.” Studies have shown that imitation generalizes to S^{Δ} models that are topographically similar to S^{D} models, but that imitation does not generalize to those dissimilar S^{Δ} models (Garcia, Baer and Firestone, 1971; Poulson, Kyparissos, Andreatos, Kymissis, & Parnes, 2002; Young, Krantz, McClannahan, & Poulson, 1994).

In the above studies of generalized imitation, because stimulus models of a specific topography (e.g. motor responses) are differentially reinforced, the range of the stimulus models to which imitation generalizes may be restricted to stimulus models of that topography. To test this hypothesis, Garcia, Baer & Firestone (1971) examined generalized imitation in four developmentally delayed children across three different sets of stimulus models: small motor, large motor, and short vocal. To determine the extent to which generalized imitation occurs within but not across sets of stimulus models, Garcia, Baer & Firestone (1971) differentially reinforced imitation of stimulus models in one set while imitation of stimulus models in the other two sets was not reinforced.

The results showed that when stimulus models of a specific topography were reinforced, such as models of small motor movement, imitation of S^{Δ} models of similar, small motor movement was observed. Nonetheless, generalized imitation did not occur to stimulus models that were not topographically similar, such as short vocal. Generalized imitation of each specific type of stimulus model was observed when the differential reinforcement procedure was implemented for that type of stimulus model. Therefore, the results of this study show that imitation generalizes within a set of topographically similar stimulus models, but does not occur across sets of topographically different stimulus models (Garcia, Baer & Firestone, 1971).

Other studies of generalized imitation have found similar results (Bandura & Barab, 1971; Poulson, Kyparissos, Andreatos, Kymissis, & Parnes, 2002; Sherman, Clark, & Kelly, 1977; Young, Krantz, McClannahan, & Poulson, 1994). In these studies of generalized imitation, stimulus generalization from the S^{D} models to the S^{Δ} models was observed. Although imitation generalized to S^{Δ} models of the same topography as the S^{D} models, imitation of topographically dissimilar S^{Δ} models was not observed.

<u>Stimulus generalization gradients in generalized imitation</u>

The extent to which imitation generalizes among stimulus models can be measured within a set of stimulus models that can be arrayed along a continuum. In generalized imitation, stimulus generalization can be measured using S^{Δ} models that share some physical features with the S^{D} models but vary along a common physical feature (Guttman & Kalish, 1956; Hanson, 1959; Honig, Boneau, Burnstein & Pennypacker, 1963; Jenkins & Harrison, 1960). Stimulus generalization has only once been studied in generalized imitation using a set of stimulus models that may be arrayed along a continuum (Furnell & Thomas, 1976).

In a study conducted by Furnell and Thomas (1976), imitation of simple motor movements in the presence of a large red ball was reinforced. Following training, tests of generalized imitation were conducted using motor models, vocal models and motor-with-object models, in the presence of the large red ball. The results showed that two of the three participants, three young children with mental retardation, demonstrated generalized imitation to models from all stimulus sets in the presence of the red ball.

After tests of generalized imitation, discrimination training was conducted in which motor models were presented to participants in the presence of one of two stimuli. Motor models were presented in either the presence of a large red ball or a small red ball. In the presence of the large red ball, imitative responding was reinforced and therefore the large red ball functioned as the S^D. In the presence of the small red ball, imitative responding was not reinforced and therefore the small red ball functioned as the S^Δ (Furnell & Thomas, 1976).

Conditional discrimination training was followed by tests of generalization in which the motor models used during training were presented to participants in the presence of four test balls of various sizes, as well as the S^D and S^Δ. All tests of generalization were conducted under extinction conditions, using a successive discrimination procedure. In addition to presenting the motor models used during training, the experimenters presented motor, vocal, and motor-with-object models that never occasioned reinforcement in the presence of the various sized balls (Furnell & Thomas, 1976).

For all participants, imitation of all models was observed in the presence of the S^D. In the presence of the S^Δ, two of the three participants did not imitate any of the stimulus models. For the remaining participant, a low level of imitative responding was observed in the presence of the S^Δ.

Results of tests of generalization showed that the highest percentage of imitative responding occurred in the presence of the S^D and the lowest percentage occurred in the presence of the S^Δ. Responding to the test stimuli was a function of similarity to the S^D. Specifically, as the similarity of the test stimulus to the S^D increased, the percentage of imitative responding in the presence of that test stimulus increased. In addition, imitation in the presence of an S^D (large red ball) generalized across different sets of stimulus models (i.e. motor, vocal, and motor-with-object) (Furnell & Thomas, 1976).

In the Furnell and Thomas study (1976), although the stimulus models controlled the topography of the imitative response, the rate of the imitative response was not controlled by the stimulus models. Rather, the rate of imitative responding was controlled by a higher-order stimulus, the balls of various sizes. Therefore, the level of imitative responding to each stimulus model was controlled by a higher-order stimulus, and not the stimulus models. With the stimulus models controlling the level of imitative responding, the extent to which imitative responding generalizes among a set of stimulus models may be measured.

The purpose of the present study was to examine the extent to which imitation generalizes within a set of stimulus models that can be arrayed along a physical continuum. As discussed earlier in this paper, it has been shown that participants imitate both S^D and S^Δ models when a successive discrimination procedure is used, possibly because of the social discriminative control associated with the adult presentation of stimulus models. Imitation every stimulus model on each trial does not provide the opportunity to measure differences in responding among the models based on the physical similarity to the training stimuli. Therefore, in the present study a simultaneous discrimination procedure was used. A simultaneous discrimination procedure allows participants to imitate on all trials while permitting measurement of differences in responding to the S^D and S^Δ models.

Method

Participants. Four typically-developing children participated in this study. At the start of the study, Sue was 11-years-old, Craig was 5-years-old, Allan was 10-years-old, and Tom was 8-years-old. All participants attended a local public school.

As shown from anecdotal reports and videotape from sessions, a consistent observing response was not demonstrated by Tom. An observing response was defined as the participant's eyes focused on the television, during each trial, throughout the time that the experimenter could be heard saying "do this, or this." To determine the extent to which Tom's observing response differed from that of the other three participants, data were recorded on the observing response demonstrated by Tom and another randomly selected participant, Allan. The percentage of trials in which an observing response occurred for Tom and Allan are shown in Table 1. These data show that an observing response was demonstrated during 79% or less of the trials during each session for Tom. Given this inconsistent attending throughout the trials, it could not be determined whether Tom was fully exposed to the independent variable. Therefore, the data from this participant were not included in the study. These data are available in Appendix A.

Setting. The study was conducted in the Behavior Analysis of Child Development laboratory at Queens College. The room contained two chairs and two rectangular tables. On one rectangular table, positioned against the rear wall, was a 24-inch color television and VCR. A 30 in. by 50 in. grid was hung on the wall opposite the equipment. The grid was divided into seven, white, equally-sized sections, some of which were colored red. The first, third, fifth and seventh sections of the grid were white. The second, fourth, and sixth section of the grid were red. The different colors, either red or white, were used for adjacent sections of the grid to assist the experimenter, data collectors, and participants to quickly determine the arm angle that was imitated or modeled. A video recording camera was mounted on a tripod in the right rear corner of the room to videotape all sessions. The participants were accompanied to the sessions by their mother. The participant's mother remained seated by the video equipment in the laboratory during each session.

Stimulus models. Seven stimulus models were used in this study. These stimulus models consisted of gross motor movements of the arms. That is, each stimulus model consisted of moving the arms to and holding the arms at a specific angle in respect to the body. The arm angles used were 0, 30, 60, 90, 120, 150, and 180 degrees. Figure 1 shows where the participant was required to position his or her arms in order to imitate the various arm angles used in the study. The participant's body is represented by the vertical line located in the middle of the figure.

During each session, participants viewed a videotape on which all trials were presented. Each session began by positioning the participant in front of a large grid, which was divided into 7 equally-sized sections. Each section of the grid represented a different arm angle (i.e. 0, 30, 60, 90, 120, 150, 180). The sections that represented the 0-, 60-, 120- and 180-degree-arm-angles were white. The sections that represented the 30-, 90-, and 150-degree-arm-angles were colored red. The participant was asked to watch a videotape of the experimenter presenting different stimulus models, which were the various arm angles, while standing in front of the grid. The videotape showed the experimenter standing in front of the same large grid that was used for the participant while presenting the different stimulus models. During each trial, the experimenter presented two different stimulus models to the participant.

During training sessions, either the 0- and 30-degree-arm-angles or the 150- and 180-degree-arm-angles were designated as the S+ models. Responses that matched these S+ models were immediately reinforced during training trials. When the 0- and 30-degree-arm-angles were designated as the S+ models, the 180-degree-arm-angle functioned as the S-. When the 150- and 180-degree-arm-angle were designated as the S+, the 0-degree-arm-angle functioned as the S-. The remaining stimulus models were used as probe stimuli, to assess the extent to which imitation generalized to the physically similar stimulus models.

Motivational system. Dimes were used to reinforce imitation of the S+ models during training sessions. When responses matching the S+ models were immediately followed by the experimenter placing one dime into a red cup that was placed on a rectangular table positioned 12 inches from the participant. The dimes were delivered within 3-sec of each matching response. At the end of each of these sessions, participants had the opportunity to exchange their dimes for candy, small toys, trading cards and stickers. Participants were also given the opportunity to keep the dimes they earned during the session. Preferred toys and stickers were identified through informal parent and child interviews.

Dependent Variables. The dependent measure was the percentage of responses matching the stimulus models. Responses matching the stimulus model were defined as movement of the arms to and holding the arms at the same angle as the presented by the stimulus model. A match was scored when the participant's arms were positioned in the same area of the grid as the stimulus model and held in that position for at least for 1 sec. Percentage of responses matching the stimulus models was calculated by dividing the number of matching responses by the total number of opportunities to respond and multiplying by 100%. The percentage of responses matching the models was calculated for each stimulus model.

Independent Measures. The independent measures consisted of the delivery of reinforcement within 3 sec of the participant emitting a response that matched the S+ during training sessions, and the absence of reinforcement during all other trials.

Inter-observer agreement. Data were obtained from videotaped recordings of each session. Three independent observers recorded data on dependent and independent measures on 100% of the trials. Inter-observer agreement was calculated by dividing the number of agreements by the number of agreements plus disagreements multiplied by 100%.

Interobserver agreement was obtained for the dependent and independent measures during all of the trials presented during all sessions of discrimination testing, baseline, training, and generalization testing.

During discrimination testing, reliability data were collected on the participants' verbal response that indicated whether two stimulus models were the "same" or "different." Percentage agreement on the participants' verbal responses during discrimination testing was 100%.

For all independent measures, which included the delivery of reinforcement during training trials and the absence of reinforcement on all other trials, percentage agreement was 100% during baseline, training and generalization sessions. For Sue, the percentage agreement of responses that matched the stimulus model was 94.75% during baseline (range, 100% to 90%), 93% during training (range, 91% to 95%), 97% during generalization testing (range, 95% to 100%). For Carl, during baseline, the percentage agreement of responses that matched the stimulus model was 92.3% (range, 90% to 96%), and 89% during training (range, 87% to 91%), and 89% during generalization testing (range, 87% to 91%). For Allan, the percentage agreement of responses that matched the stimulus model was 95.5% during baseline (range, 90% to 100%), 93% during training (range, 91% to 95%), and 95% during generalization testing (range, 91% to 100%).

General Procedure

Sessions were conducted 4 to 5 times per week. Baseline sessions each included a block of 30 trials. During all other phases of the study, 24 trials were included in each block.

Across all phases of the study, a choice procedure (Steinman, 1970a; 1970b) was used in which the experimenter presented two stimulus models sequentially on each trial and requested that the participant imitate one of the two stimulus models. Immediately prior to presenting the first stimulus model of each trial, the experimenter said "do this." After the first stimulus model was presented for 2 sec, the experimenter said "or this" and presented the second stimulus model for 2 sec. Following the 2 sec interval during which the second stimulus model was presented, the experimenter stood with her arms at her side and waited 3 sec for the participant to respond. The next trial began 2 sec after the participant's response. If the participant did not respond within 3 sec, no consequences were delivered and the next trial began following the 2 sec inter-trial interval.

Two different arm angles were designated as the S+ models. The S+ models were either the 0- and 30- degree arm angles or the 150- and 180- degree arm angles. When the 0- and 30-degree arm angles were designated as the S+, the S- was the 180-degree arm angle. When the 150- and 180-degree arm angles were designated as the S+, the S- was the 0-degree arm angle. Imitation of the S- model did not occasion reinforcement. The remaining stimulus models were presented with every other stimulus model twice. The order of the sequential presentation of the S+, S-, and probe models was counterbalanced. Therefore, each stimulus was presented first and second within the trials equally often. The order of presentation of each pair of stimuli was randomized across sessions.

Discrimination testing. Prior to baseline, a test of discrimination was conducted. To measure the extent to which the stimulus models were discriminable from each other, the experimenter presented every stimulus model with every other stimulus model to the participants. In addition, every stimulus model was also presented with itself during two trials. Participants were asked to verbally respond to whether the two stimulus models were the same or different. Discrimination testing consisted of one block of 56 trials.

Baseline. Four baseline sessions were conducted. Each session consisted of a block of 30 trials. Reinforcement was not available for imitation of any of the stimulus models during baseline sessions. During each baseline session, the 0 and 180 degree stimulus models were presented together on 10 trials. Each of the remaining stimulus models (i.e. 30, 60, 90, 120, 150 degree arm angles) was presented with every other stimulus model twice, resulting in a total of 30 trials.

Training. During each training session, participants were presented with 12 training trials and 12 probe trials. During each of the 12 training trials, one of two S+ models was presented together with an S- model. Reinforcement was delivered for imitation of the S+ models.

Within 2-sec of each response that matched the S+ models, the experimenter delivered reinforcement by placing one dime into a blue cup that was placed on a rectangular table positioned 12 inches from the participant. The experimenter did not emit any verbal statements while delivering reinforcement.

Probe trials were interspersed among training trials, all of which were presented in random order. Training sessions were conducted until at least 83% of imitative responding that matched the S+ models was observed for 3 consecutive sessions.

Generalization testing. In three sessions of generalization testing, conducted when training was complete, all trials were presented in the same manner as during training, however, reinforcement was not available for imitation of the S+ models during generalization.

Reversal. Trials were presented in the same manner as during training, however, the stimulus function of the S+ models and the S- model were reversed. For example, if the 0- and 30- degree arm angles were functioning as the S+ models, they would now function as the S- models. If the 180-degree arm angle was functioning as the S- model, it would now function as the S+. Sessions were conducted until responding to the S+ model is observed at 80% or above for 3 consecutive sessions.

Generalization testing. Three sessions of massed tests of generalization were conducted following the reversal.

Results

For all three participants, no significant differences in responding were observed among the stimulus models during the four baseline sessions. With the introduction of reinforcement for responding that matched the S+ models, responding to the S+ models increased in comparison to the other stimulus models for all participants. This increase in responding to the S+ models was accompanied by a decrease in responding to the S- model, in comparison to responding to the S- model during baseline. The results for all participants showed that as the similarity between the probe stimuli and the S+ models increased, the percentage of responding that matched the probe stimuli increased. As the similarity between the probe stimuli and the S+ models decreased, the percentage of responding that matched the probe stimuli decreased. Discrimination testing demonstrated that all stimulus models were discriminable from each other. Sue and Allan responded with 100% accuracy, and Carl with 97% accuracy when asked to indicate whether pairs of stimulus models were the same or different.

Figures 2, 3, and 4 display the results from all the phases of the study for Sue, Carl, and Allan respectively. These figures show the percentage of responding that matched each stimulus model during baseline, training, generalization, reversal and the second test of generalization. Error bars represent the standard error of the mean across sessions for each data point. The data from each individual session are provided in Appendix B. All participants met the training criteria of at least 83% of responding that matched the S+ models within three sessions.

The upper-first panel of Figure 2 shows the baseline data for Sue. A one-way repeated-measures analysis of variance (ANOVA) showed no significant differences in responding across the stimulus models during baseline, $F(6) = 1.140$, $p > .05$. During baseline, there was only one trial during which Sue failed to respond.

The upper-second panel of Figure 2 shows the data obtained during training for Sue. During training, responding that matched the stimulus models with arms at the 0- and 30-degree angle was reinforced. Therefore, the 0- and 30-degree arm angles functioned as the S+ models. The S+ models were presented together with the 180-degree arm angle, which functioned as the S-. With the introduction of reinforcement for responding that matched the S+ models, an immediate increase over baseline responding occurred to the two S+ models; responding that matched both the 0- and 30-degree arm angles increased from 60% and 40%, respectively, during baseline to 94% during training. These differences in responding from baseline to training were significant for the 0-degree arm angle, $t(5) = 3.986$, $p < .01$, and for the 30-degree-arm angle, $t(5) = 3.417$, $p < .05$. The increase in responding that matched the S+ models was accompanied by a decrease in responding that matched the 180-degree-arm-angle stimulus model, the S- model. During baseline, responding that matched the 180-degree arm angle was 60% and decreased to 11% during training. This decrease in responding from baseline to training was significant, $t(5) = 3.644$, $p < .05$.

A one-way repeated-measures ANOVA showed significant differences in responding across the stimulus models during training, $F(6) = 15.65$, $\underline{p} < .0001$. Tukey's multiple-comparison test (see Table 2) revealed significant differences in responding between the S+ models and the S- model, and between the S+ models and all of the probe models (i.e. 60-, 90-, 120-, and 150-degree arm angles). Significant differences in responding between the S- model and all of the probe stimulus models were obtained.

Following training, massed tests of generalization were conducted under extinction conditions. During generalization testing, Sue always matched the S+ models and never matched the S- model. For the probe stimuli, the highest percentage of responding was observed to the 60-degree-arm-angle stimulus model (71%). Therefore, the highest percentage of responding that matched the probe stimuli was observed to the stimulus model that was most similar to the S+ models. The lowest percentage of responding was observed to the 150-degree-arm-angle stimulus model (26%). Therefore, the lowest percentage of responding to the probe stimuli was observed to the stimulus that was most similar to the S-.

A one-way repeated-measures ANOVA revealed significant differences in responding to the stimulus models during generalization testing, $F\ (6) = 67.26$, $p < .0001$. The results of Tukey's multiple-comparison test are shown in Table 3. Tukey's multiple-comparison test revealed significant differences in responding between the S+ models and the S- models, the S+ models and the probe stimulus models (i.e. 60-, 90-, 120-, and 150-degree arm angles), and the S- models and the probe stimulus models (i.e. 60-, 90-, 120-, and 150-degree arm angles). For the probe stimulus models, the level of responding to the 60-degree-arm angle stimulus model was significantly different from the level of responding to the 120- and 150-degree-arm-angle stimulus model. The level of responding to the 90-degree-arm-angle stimulus model was significantly different from the level of responding to the 150-degree-arm-angle stimulus model.

The lower-first panel shows the reversal data for Sue. When the contingency of reinforcement was reversed from responding that matched the 0- and 30-degree-arm-angle stimulus models to the 180-degree-arm-angle stimulus model, the highest level of responding was observed to the 180-degree-arm-angle (94%). The lowest level of responding was observed to the 0-and 30-degree-arm-angle stimulus models (0% and 10%). Sue met the training criteria within 3 sessions (responding to the S+ at or above 83% for three consecutive sessions).

For the probe stimuli, the lowest percentage of responding was observed to the 60-degree-arm-angle stimulus model (27%). As the similarity of the stimulus models to the S+ model increased the level of responding increased, with 38% responding to the 120-degree-arm angle stimulus model and 55% responding to the 150-degree-arm-angle stimulus model. Nonetheless, the highest level of responding was observed to the 90-degree-arm-angle stimulus model (71%).

A one-way repeated-measures ANOVA showed significant differences in responding to the stimulus models during the reversal, $F(6) = 26.71$, $p < .0001$. Tukey's multiple-comparison test revealed significant differences in responding between the S+ model and the S- models, and between the S+ models and most probe models (i.e. 60-, 120-, and 150-degree arm angles). The detailed results of this analysis are presented in Table 4.

The lower-second panel shows the results of the second test of generalization. During the test of generalization, the highest level of responding was observed to S+, the 180-degree-stimulus model (100%). The lowest level of responding remained to the 0- and 30-degree-arm-angle stimulus models (0%).

The highest level of responding observed to the probe stimuli was to the 150-degree-arm-angle stimulus model (71%), which is the stimulus model most similar to the S+ model. Among the remaining probe stimuli, the lowest level of responding was observed to the 60-degree-arm angle stimulus model (33%), which is the stimulus most similar to the 30-degree-arm-angle stimulus model.

A one-way repeated-measures ANOVA showed significant differences in the levels of responding to the stimulus models, $F(6) = 51.06$, $p < .0001$ during generalization testing. Tukey's multiple-comparison test revealed significant differences in responding between the S+ models and the S- models. The results of this analysis are provided in Table 5. In addition, this analysis showed significant differences in responding between the S + model and the probe stimulus models and the S- models and the probe stimulus models.

For the probe stimulus models, significant differences in the level of responding were observed between the 60-degree arm angle and the 120-degree arm angle. The results of this analysis also showed a significant difference between the level of responding to the 90-degree arm angle and the level of responding to the 150-degree arm angle.

The upper-first panel of Figure 3 shows the baseline data for Carl. A one-way repeated-measures ANOVA showed no significant differences in responding to the stimulus models during baseline $F(6) = .6679$, $p = .6767$. During the last session of baseline, Carl did not respond during three trials.

The upper-second panel of Figure 3 shows the mean percentage of responding that matched the stimulus model during training for Carl. With the introduction of reinforcement for responding that matched the 0- and 30-degree-arm-angle stimulus models, an increase over baseline in responding that matched these models was observed. During baseline, the mean percentage of responding was 55% for the 0-degree arm angle and 43% for the 30-degree arm angle. In comparison to baseline, the mean percentage of responding increased to 83% for the 0-degree-arm-angle stimulus model and to 88% for the 30-degree-arm-angle stimulus model during training. These differences were not significant for the 0-degree-arm angle, t (5) = 1.539, p = .1844, or the 30-degree-arm angle, t (5) = 2.020, p = .0994. An immediate decrease was observed to responding that matched the 180-degree-arm-angle stimulus model (S-), from 42% during baseline to 16% during training, however, this difference was not significant, t (5) = 1.618, p = .1660.

Concerning the probe stimuli (i.e. 60-, 90-, 120-, and 150-degree arm angles), an increase in responding that matched the 60-degree-arm-angle stimulus model was observed during training. During training, responding to the 90-, 120-, and 150-degree-arm-angle stimulus models was at a lower level than responding to the S+ models and the 60-degree arm angle. In addition, responding to the 90-, 120-, and 150-degree-arm-angle stimulus models was at a higher level than responding to the S- model.

A one-way repeated-measures ANOVA showed significant differences in responding during training, F (6) = 6.300, p < .0022. The results of Tukey's multiple-comparison test are shown in Table 6. These results revealed significant differences between responding to the S+ models and the S- model. In addition, a significant difference in the level of responding to the 60-degree-arm-angle stimulus model and the S- model was observed. Among the remaining probe stimuli, no significant differences in responding were observed.

The upper-third panel of Figure 3 shows the results from the first test of generalization. During generalization testing, the highest percentage of responding was observed to the 0-degree and 30-degree-arm-angle stimulus models (88% and 100% respectively). The lowest level of responding was observed to the S- model (2%). During generalization testing, as the similarity of the probe stimuli to the S+ models increased, the level of responding that matched the probe stimuli increased.

A one-way repeated-measures ANOVA showed significant differences in the levels of responding to the stimulus models, $F\ (6) = 26.14$, $p < .0001$ during generalization testing. Tukey's multiple-comparison test revealed significant differences in responding between the S+ models and the S- models. The results of this analysis are provided in Table 7. In addition, this analysis showed significant differences in responding between the S+ models and the 120- and 150-degree-arm-angle stimulus models. For the probe stimulus models, significant differences in the level of responding were observed between the 60-degree arm angle and the 120- and 150-degree arm angle. The results of this analysis also showed a significant difference between the level of responding to the 90-degree arm angle and the level of responding to the 150-degree arm angle.

The lower-first panel shows the reversal data for Carl. Carl met the reversal criteria in six sessions. The data shown in this figure reflect the last three sessions in which the criterion was met. The data from all six sessions are shown in Appendix C.

When the reinforcement contingency was reversed for Carl, the highest level of responding was observed to the S+, the 180-degree-arm-angle stimulus model. The lowest level of responding was observed to the 30-degree-arm-angle stimulus model (0%), the S-. Responding that matched the 0-degree-arm-angle stimulus model was 11%. The level of responding to both S- models was lower than the level of responding to the probe stimuli. Responding to the probe stimuli was lower than to the S+ model. A higher level of responding was observed to the 150-degree-arm-angle stimulus model (66%) in comparison to the 120- and 90-degree-arm-angle stimulus models (33% and 38%, respectively).

A one-way repeated-measures ANOVA revealed significant differences in the levels of responding to the stimulus models, $F(6) = 20.35$, $p < .0001$ during the reversal. Tukey's multiple-comparison test revealed significant differences in responding between the S+ model and the S- models. The results of this analysis are provided in Table 8. In addition, this analysis showed significant differences in responding between the S + model and the probe stimulus models and the S- models and the 60-degree-arm-angle probe stimulus model.

Regarding the probe stimulus models, significant differences in the levels of responding were observed between the 30-degree arm angle and the 60- and 90-degree-arm-angle stimulus models.

During generalization testing, the highest level of responding remained to the 180-degree-arm-angle stimulus model, S+ (97%). The lowest level of responding remained to the 0- and 30-degree-arm-angle stimulus models, the S- models (0% and 5%, respectively).

For the probe stimuli, the lower level of responding was observed to the 120-degree-arm-angle stimulus model (27%). Although the highest level of responding was observed to the 150-degree-arm-angle stimulus model (60%) in comparison to the other probe stimuli, a similar level of responding was observed to the 90-degree-arm-angle stimulus model (55%).

A one-way repeated-measures ANOVA showed significant differences in responding to the stimulus models during the second test of generalization, $F(6) = 26.14$, $p < .0001$. Tukey's multiple-comparison test revealed significant differences in responding between the S+ model and the S- models, and between the S+ models and the probe stimulus models. The detailed results of this analysis are presented in Table 9. The level of responding between the 0-degree-arm-angle stimulus model (S- model) and the probe stimulus models was significantly different. For the 30-degree-arm-angle stimulus model (S- model) significant differences were observed when compared with the 60-, 90-, and 150-degree-arm-angle stimulus models. For the probe stimuli, significant differences were observed between the 120-degree-arm-angle stimulus model and the 90- and 150-degree-arm-angle stimulus model.

In the upper-first panel of Figure 4, the abscissa labels are reversed for Allan because the contingencies were reversed. A one-way ANOVA showed no significant differences in responding during baseline, $F(6) = 1.134$, $p = .3825$.

The upper-second panel of Figure 4 shows the percentage of responding that matched each stimulus model during training for Allan. With the introduction of reinforcement for responding that matched the 180- and 150-degree-arm-angle stimulus models, an increase in responding was observed to these stimulus models (88% and 93% respectively), in comparison to responding during baseline (36% and 50%, respectively). These differences were significant, $t(5) = 3.417$, $p < .05$ and $t(5) = 3.482$, $p < .0176$, for the 150- and 180-degree-arm angle stimulus models, respectively. This increase in responding was accompanied by a concomitant decrease in responding that matched the

0-degree-arm-angle stimulus model (16%), the S-, in comparison to responding during baseline (72.5%). This difference was significant, $t(5) = 4.219$, $p < .01$.

Concerning the probe stimuli (i.e. 120-, 90-, 60-, 30-degree arm angles), responding to the 120-degree-arm angle stimulus model increased from 37% during baseline to 77%. The 120-degree-arm-angle stimulus model is the probe stimulus most similar to the S+ models.

A one-way repeated-measures ANOVA revealed significant differences in the levels of responding to the stimulus models during training, $F(6) = 14.37$, $p < .0001$. Tukey's multiple-comparison test showed significant differences between the S+ models and the S- model. The results of this analysis are shown in Table 10. Significant differences were observed between the 120-degree arm angle and the 90-degree arm angle and between the 120-degree arm angle and the S- model. In addition, the level of responding to the 90-degree arm angle was significantly different than the level of responding to the S+ models.

The upper-third panel of Figure 4 shows the data from the generalization phase. During tests of generalization, the highest level of responding remained to the S+ models (100%). A similar level of responding (100%) was also observed to the 120-degree-arm-angle stimulus model, the probe stimulus model most similar to the S+ models.

During generalization testing, the level of responding that matched the 90- and 60-degree-arm-angle stimulus models (27%) was higher than the level of responding to the 30- and 0-degree-arm-angle stimulus models (21% and 0%, respectively). The percentage of responding that matched the 30-degree-arm-angle was higher than the 0-degree-arm-angle and lower than the other stimulus models. These data show that as the similarity of the probe stimuli to the S+ models increased, the level of responses that matched these stimulus models increased.

A one-way repeated-measures ANOVA showed significant differences in the levels of responding to the stimulus models during generalization, $F(6) = 26.14$, $p < .001$. Tukey's multiple-comparison test revealed significant difference between the S+ models and the S- model and all of the probe stimulus models. The results of this analysis are shown in Table 11. Concerning the probe stimuli, significant differences were observed between the 120-arm angle and every other probe stimulus model (i.e. 30-, 60-, and 90-degree arm angles).

The lower-first panel of Figure 4 shows the reversal data for Allan. Allan met the reversal criteria in four sessions. The data shown in this figure reflect the last three sessions in which the criterion was met. The data from all four sessions are shown in Appendix D.

When responding to the 0-degree-arm-angle stimulus model (S+) was reinforced, the level of responding was 100%. The lowest level of responding was observed to the S- models, 180- and 150-degree-arm-angle stimulus models (0%).

As the similarity of the probe stimulus models to the S+ models increased, the level of responding increased. Specifically, the highest level of responding was observed to the 30-degree-arm-angle of stimulus model (72%). A higher level of responding was observe to the 60-degree-arm-angle (55%) in comparison to the 90-degree-arm-angle (44%). The lowest level of responding was observed to the 120-degree-arm angle (27%) in comparison to the probe stimuli.

A one-way repeated-measures ANOVA revealed no significant differences in responding to the stimulus models during the reversal, $F = 1.161$, $p = .3693$.

During generalization testing, the highest level of responding remained to the 0-degree-arm-angle, the S+ model (100%). Responding to the S- models, the 180- and 150-degree-arm-angle stimulus models remained at 0%.

For the probe stimuli, the highest level of responding was to the 30-degree-arm-angle stimulus model (94%), the stimulus model most similar to the S+ model. The lowest level of responding was observed to 120-degree-arm angle stimulus model (5%), the stimulus model most similar to the S- models. Responding that matched the 90- and 60-degree-arm-angle stimulus models was 50%.

Significant differences in responding during the second test of generalization were obtained using a one-way repeated-measures ANOVA, $F = 73.32$, $p < .0001$. Tukey's multiple comparison test revealed significant differences between the S+ model and the S- models and between the S- models and the probe stimulus models. The detailed results of this analysis are presented in Table 12. The level of responding to the S+ model was significantly different than the level of responding to the 90- and 120-degree-arm-angle stimulus models. For the probe stimulus models, significant differences in responding were observed between the 30-degree-arm-angle stimulus model and the 90- and 120-degree-arm-angle stimulus models. In addition, significant differences in responding were also observed between the 60-degree-arm-angle stimulus model and the 90-and 120-degree-arm-angle stimulus models.

Analysis of Response Patterns

In the present study, an analysis of response patterns was conducted to examine which stimulus models the participants imitated when they did not imitate those that were more similar to the S+ models. The results of this analysis showed that during the first test of generalization, in most stimulus pairs, a higher level of responding was observed to the stimulus models most similar to the S+ models. When equivalent levels of responding were observed to both stimulus models in the pair, these stimulus models were more physically similar (i.e. adjacent on the continuum of arm angle) in comparison to the stimulus models presented together in other stimulus pairs.

In comparison to the results obtained from the error analysis for the first test of generalization, similar results were observed for Sue and Alan for the second test of generalization. For Carl, in some stimulus pairs presented during the second test of generalization, a higher level of responding was observed to the stimulus models less physically similar to the S+.

Figures 5, 6, and 7 show the number of responses matching each probe stimulus model when presented together with every other probe stimulus model for Sue, Carl, and Alan, respectively. Overall, the three participants demonstrated similar patterns of responding. A review of the data from one representative participant follows. In addition, a brief review of some differences in imitative responding observed during Carl's second test of generalization is provided.

Figure 5 shows the number of responses matching each probe stimulus model for Sue, under the five successive experimental conditions that she experienced. During baseline (top graph), Sue showed a higher frequency for imitation of the 120-degree arm angle when presented with either the 60-degree arm angle or the 90-degree arm angle. In addition, when the 150-degree arm angle was presented with the 60-degree arm angle, a higher level of imitation of the 150-degree arm angle was observed.

As shown in the second graph, with the introduction of training or reinforcement for imitation of the 0- and 30- degree arm angles, a preference for the 60-degree arm angle in comparison to the 90-degree arm angle was observed. When the 60-degree arm angle was presented with the 120-degree arm angle, a higher level of imitation was observed to the 120-degree arm angle. Equal levels of imitation were observed to the 60- and 150-degree arm angles and the 90- and 120-degree arm angles.

During the first test of generalization (third graph), a higher level of imitation was observed to the stimulus model more similar to the S+ (i.e. 0- and 30-degree arm angles) in most stimulus pairs (i.e. 60/120, 60/150, 90/120, 90/150 and 120/150). For the remaining stimulus pair (60/90), an equal level of imitation was observed.

As shown in the fourth graph, when the contingency of reinforcement was reversed (i.e. S+ = 180, S- = 0 and 30), an increase in imitation of the 150-degree arm angle was observed when Sue was presented with the 60-degree arm angle. An elevated level of imitation was observed to the 90-degree arm angle when Sue was presented with the 60- and 150-degree arm angles. When presented they were presented together, an equal level of imitation was observed to the 90-and 120-degree arm angles and the 120- and 150-degree arm angles.

As shown on the last graph, during the second test of generalization, a higher level of responding was observed to the stimulus models more similar to the S+ (180-degree arm angle) in two of the stimulus pairs (60/150, 90/150). For the remaining stimulus pairs, equal levels of imitation were observed.

Similar patterns of responding were observed for the two remaining participants with the exception of the second test of generalization for Carl. During the second test of generalization, a higher level of responding was observed to the stimulus models more similar to the S+ (180-degree arm angle) in only two of the stimulus pairs (60/150, 120/150). Nonetheless, when presented with the 120-degree and 150-degree arm angles, a higher level of imitation was observed to the 90-degree arm angle. For the remaining stimulus pairs, equal levels of imitation were observed.

Equal levels of imitative responding were observed to some of the stimulus pairs. It should be noted that when equivalent responding to both stimulus models in the pair was observed, a position preference was not observed. That is, the data did not reveal that the participant was consistently imitating the first (or second) stimulus model that was presented during each trial.

Discussion

The results obtained demonstrated stimulus generalization from reinforced training stimuli to non-reinforced testing stimuli. During baseline, no significant differences in imitative responding were observed as a function of stimulus model value for all three participants. With the introduction of reinforcement for imitation of the S+ models, systematic differences in the level of responding to the S+ models in comparison to the S- and probe stimulus models were observed. Following training, tests of generalization produced gradients with the highest level of responding at the S+ model values and the lowest level of responding at the S- model value. For the probe stimulus models, as the physical similarity of the probe stimulus models to the S+ models increased, the level of imitative responding increased. As the similarity of the probe stimulus models to the S+ models decreased, the level of responding that matched these stimulus models decreased.

Similarly, the generalization gradients obtained during the second tests of generalization showed the highest level of imitative responding at the S+ model and the lowest level of responding at the S- models. For Sue and Allan, responding to the probe stimulus models during tests of generalization revealed a similar pattern of responding to that observed during the first tests of generalization. That is, as the physical similarity of the probe stimulus models to the S+ models increased, the level of imitative responding increased. For Carl, responding to the probe stimulus models during the second tests of generalization revealed fewer significant differences in responding to the probe stimulus models in comparison to the first tests. In the second tests of generalization, the contingency of reinforcement was reversed. The history of reinforcement for responding to these stimulus models during the first tests could have influenced responding during second tests of generalization. This history of reinforcement may have contributed to the lower rate at which Carl learned to imitate the S+ model during the reversal (six sessions).

In the present study, an analysis of response patterns was conducted to determine which probe stimulus models the participant's imitated when they did not imitate the stimulus model that was most similar to the S+ model(s). During both tests of generalization, in most stimulus pairs the highest level of responding was observed to the probe stimulus most similar to the S+. To some stimulus pairs, an equivalent level of responding was observed. When an equivalent level of responding was observed to both stimulus models in the pair, these stimulus models were more physically similar (i.e. adjacent on the continuum of arm angle) in comparison to the other remaining stimulus pairs.

An exception to these response patterns was observed in the second test of generalization for Carl. During the second test of generalization, a higher level of responding was observed to some of the stimuli less similar to the S+ model. As discussed above, these results may be because of the history of reinforcement for responding to these stimulus models during the first tests of generalization.

The findings of this study extend the results obtained by Furnell and Thomas (1976). Furnell and Thomas examined stimulus generalization in generalized imitation by first teaching participants to imitate stimulus models in the presence of a large red ball and not to imitate stimulus models in the presence of a small red ball. Similarly to the present study, the authors reported that during tests of stimulus generalization, the level of imitative responding differed as a function of the similarity of the probe stimulus models to the S+. That is, as the size of the probe stimulus models (balls) increased, the level of imitative responding increased.

Although Furnell and Thomas (1976) demonstrated stimulus control of generalized imitation as a function of physical similarity to the S+, the stimuli controlling responding were not the stimulus models themselves. Rather, an external arbitrary stimulus (i.e. large red ball) demonstrated discriminative control over imitative responding. Therefore, the extent to which imitation generalized was measured in the presence of various arbitrary stimuli and not to the stimulus models themselves. In the present study, discriminative control of imitative responding was established by the S+ models and not an external stimulus. After establishing control of responding by the S+ models, we measured the extent to which imitation generalized to the probe stimuli by observing which of two stimulus models the participants imitated. Therefore, the present study demonstrated the role of stimulus generalization in generalized imitation by demonstrating discriminative control of imitative responding by the stimulus models themselves.

Social Control Variables

To measure the extent to which imitation generalized within a set of stimulus models in the present study, the participants were presented with a choice to imitate one of two stimulus models. With a few exceptions, the participants imitated one of the two models on each trial when reinforcement was and was not available. These results provide support for the social control hypothesis. According to the social control hypothesis, participants will imitate stimulus models that do not occasion reinforcement because of they have a history of reinforcement for following adult instruction (Steinman, 1970a; 1970b). It has been suggested that although the S^D models control the topography of the imitative response, various other variables control imitative responding in the experimental setting (Poulson, 2003). In the present study, all three participants continued to respond under extinction conditions. It is possible that this continued responding observed under extinction conditions was due to the implicit instructional control exerted by the experimenter.

Discrimination Difficulty

In the present study, although generalization gradients were obtained, some similar levels of responding among the probe stimuli were observed. It could be argued that these similar levels of responding among the probe stimuli were due to a difficulty in discriminating some probe stimulus models from the other probe stimulus models. Nonetheless, in the present study, a pretest of discrimination was conducted to measure the extent to which the participants discriminated each stimulus model from every other stimulus model. During the test of discrimination, Alan and Sue responded with 100% accuracy and Carl responded with 97% accuracy. Based on the results of this pretest, it appears that these similar levels of responding among the probe stimuli could not be explained by a discrimination difficulty. Nonetheless, it is possible that continued tests of discrimination throughout the study could have revealed results that differed from the pretest. We decided not to assess discrimination again during the study because it may have interfered with acquisition and generalization.

Other studies have shown that imitation generalized within a set of stimulus models, but imitation did not generalize across sets of stimulus models (Garcia, Baer, & Firestone, 1971; Poulson, Kyparissos, Andreatos, Kymissis, & Parnes, 2002; Young, Krantz, McClannahan, & Poulson, 1994). These studies demonstrated that imitation generalizes among those models of the same topography, such as vocal models, motor models, or motor-with-object models. Although these studies examined generalized imitation across stimulus models of the same topography (i.e. vocal models, motor models, and motor with objects), there was no single physical dimension along which differences in responding could be measured. Future research may examine the extent to which imitation generalizes within sets of stimulus models of the same topography. For example, after reinforcing imitation of S+ models of motor movement with objects, the extent to which imitation generalizes to other probe stimuli of motor movement with objects could be examined.

Conditioned Reinforcement Hypothesis

In studies of generalized imitation, responding similarly to the stimulus model is immediately followed by reinforcement. Baer and Sherman (1967) proposed that because of the pairing of behavioral similarity with reinforcement, behavioral similarity may become a conditional or automatic reinforcer. Studies that examined the conditioned reinforcement hypothesis found that when imitation of the S+ models was no longer reinforced, a preference for non-reinforced imitation was no longer observed (Baer & Deguchi, 1985; Kymissis & Poulson, 1994). Nonetheless, when the reinforcement contingency for imitation of S+ models was reintroduced, an increase in the preference for non-reinforced imitation was observed.

In the present study, participants were reinforced for imitation of the S+ models during training. With the introduction of reinforcement, we began to observe some preference for imitation of those non-reinforced stimulus models that were more physically similar to the S+ models in comparison to those that were less physically similar. When reinforcement was discontinued for imitation of the S+ models during generalization testing, the preference for imitation of those stimulus models more similar to the S+ models increased. Given the observed increase in responding to those stimulus models more similar to the S+ models in the absence of reinforcement, the results of the present study are different from those results obtained in previous studies (Baer & Deguchi, 1985; Kymissis & Poulson, 1994). In the present study, given that responding to the probe stimuli that were more similar to the S+ models increased during non-reinforced tests of generalization, stimulus generalization provides a more parsimonious description of the results of the present study in comparison to the conditioned reinforcement hypothesis.

The conditioned reinforcement hypothesis has been examined using stimulus models of either motor movement or vocalizations. Interestingly, the behavioral similarity in motor imitation is somewhat different from the behavioral similarity in vocal imitation. For example, in motor imitation, when the participant observes the experimenter raising his arms the visual stimuli are different from what he observes when raising his own arms. During imitation of many motor models the visual stimuli produced by the models behavior and that of the imitator are very different from one another from the visual perspective of the imitator. Therefore, in motor imitation, the participant does not necessarily observe himself emitting a response similar to the stimulus model. Nonetheless, in vocal imitation, the participant hears himself emit a response that is much more similar to the stimulus model. Given the relative absence of observed behavioral similarity in motor imitation, the conditioned reinforcement hypothesis may be more applicable to vocal imitation rather than to motor imitation.

Limitations

In the present study, a large grid was used to assist the experimenter, data collectors, and the participants to quickly discriminate the arm angle that was being modeled and imitated. The grid was divided into seven, white, equally-sized sections, some of which were colored red. Although the different colored sections may have assisted the experimenter, data collectors, and participants to quickly discriminate the various arm angles, the use of the different colors on the grid presents a limitation to the study. That is, using different colors with the various arm angles resulted in a compound stimulus, comprised of both arm angle and color. Given that the stimulus models were compound stimuli, consisting of arm angle and color, imitative responding may have been controlled by color in conjunction with the arm angle. A review of the data from the analysis of response patterns does not show a higher frequency of imitative responding to either color of red or white during any experimental condition. Nonetheless, future research might examine the extent to which arm angle alone controlled the imitative response.

Although the present study did examine the extent to which imitation generalizes among a set of stimulus models that can be arrayed along a continuum, there may have been stimulus dimensions other than arm angle that were controlling responding. For example, in sports such as soccer or basketball, the participants may have been reinforced for moving and holding arms at a 90-degree-angle to the body. It is also possible that some participants had a specific preference for one specific arm angle because of the minimal physical exertion required in comparison to the other arm angles. Future research may attempt to control for these limitations by using different stimulus models.

Table 1

Percentages of Trials with an Observing Response for Tom and Allan

	Tom	Allan
Training	75%	100%
	79%	100%
	75%	96%
Generalization	54%	87.5%
	62%	100%
	58%	100%
Reversal	79%	100%
	62%	100%
	79%	100%
Generalization 2	75%	100%
	75%	100%
	66%	96%

Table 2

Results of Tukey's Multiple Comparison Test of Training Data for Sue

	q						
	S+	S+					S-
Arm Angle	0	30	60	90	120	150	180
0	-	0	5.99*	5.95*	5.23*	6.75**	11.23***
30	-	-	5.99*	5.95*	5.23*	6.75**	11.23***
60	-	-	-	.044	.760	.760	5.23*
90	-	-	-	-	.716	.805	5.28*
120	-	-	-	-	-	1.52	5.99*
150	-	-	-	-	-	-	4.47*

Note: * $p < .05$ ** $p < .01$ *** $p < .001$

Table 3

Results of Tukey's Multiple Comparison Test of Generalization Data for Sue

	q						
	S+	S+					S-
Arm Angle	0	30	60	90	120	150	180
0	-	0	6.21*	8.62***	13.45***	15.94***	21.93***
30	-	-	6.21*	8.62***	13.45***	15.94***	21.93***
60	-	-	-	2.41	7.23**	9.72***	15.72***
90	-	-	-	-	4.82	7.31**	13.30***
120	-	-	-	-	-	2.48	8.48***
150	-	-	-	-	-	-	5.99*

Note: * $p < .05$ ** $p < .01$ *** $p < .001$

Table 4

Results of Tukey's Multiple Comparison Test of Reversal Data for Sue

	q						
	S+	S+					S-
Arm Angle	0	30	60	90	120	150	180
0	-	1.64	4.22	11.06***	5.97*	8.49***	14.51***
30	-	-	2.57	9.41***	4.32	6.84**	12.87***
60	-	-	-	6.84**	1.75	4.27	10.29***
90	-	-	-	-	5..09*	2.57	3.44
120	-	-	-	-	-	2.52	8.54***
150	-	-	-	-	-	-	6.02*

Note: * $p < .05$ ** $p < .01$ *** $p < .001$

Table 5

Results of Tukey's Multiple Comparison Test of Generalization 2 Data for Sue

	q						
	S+	S+					S-
Arm Angle	0	30	60	90	120	150	180
0	-	0	6.49**	8.72***	9.77***	14.1***	19.67***
30	-	-	6.49**	8.72***	9.77***	14.1***	19.67***
60	-	-	-	2.23	3.27	7.60**	13.18***
90	-	-	-	-	1.04	5.37*	10.95***
120	-	-	-	-	-	4.33	9.903***
150	-	-	-	-	-	-	5.57*

Note: * $p < .05$ ** $p < .01$ *** $p < .001$

Table 6

Results of Tukey's Multiple Comparison Test of Training Data for Carl

	q						
	S+	S+					S-
Arm Angle	0	30	60	90	120	150	180
0	-	.467	.027	3.19	4.12	3.65	5.97*
30	-	-	.44	3.65	4.59	4.12	6.43**
60	-	-	-	3.21	4.15	3.68	5.99*
90	-	-	-	-	.935	.467	2.77
120	-	-	-	-	-	.467	1.84
150	-	-	-	-	-	-	2.31

Note: * $p < .05$ ** $p < .01$ *** $p < .001$

Table 7

Results of Tukey's Multiple Comparison Test of Generalization Data for Carl

	q						
Arm Angle	S+ 0	S+ 30	60	90	120	150	S- 180
0	-	.79	3.16	3.91	8.57***	10.15***	12.44***
30	-	-	3.95	4.70	9.36***	10.95***	13.23***
60	-	-	-	.745	5.4*	6.98**	9.26***
90	-	-	-	-	4.65	6.24*	8.52***
120	-	-	-	-	-	1.584	3.86
150	-	-	-	-	-	-	2.28

Note: * $p < .05$ ** $p < .01$ *** $p < .001$

Table 8

Results of Tukey's Multiple Comparison Test of Reversal Data for Carl

	q						
	S+	S+					S-
Arm Angle	0	30	60	90	120	150	180
0	-	1.53	6.16*	3.84	3.06	7.65**	11.59***
30	-	-	7.69**	5.38*	4.59	9.18***	13.13***
60	-	-	-	2.31	3.10	1.48	5.42*
90	-	-	-	-	.788	3.80	7.74**
120	-	-	-	-	-	4.59*	8.53***
150	-	-	-	-	-	-	3.94

Note: * $p < .05$ ** $p < .01$ *** $p < .001$

Table 9

Results of Tukey's Multiple Comparison Test of Generalization 2 Data for Carl

	q						
	S+	S+					S-
Arm Angle	0	30	60	90	120	150	180
0	-	1.04	7.59**	10.48***	5.37*	11.92***	18.53***
30	-	-	6.54**	9.43***	4.32	10.87***	17.48***
60	-	-	-	2.88	2.22	4.32	10.94***
90	-	-	-	-	5.10*	1.44	8.05**
120	-	-	-	-	-	6.54**	13.16***
150	-	-	-	-	-	-	6.61**

Note: * $p < .05$ ** $p < .01$ *** $p < .001$

Table 10

Results of Tukey's Multiple Comparison Test of Training Data for Allan

	q						
	S+	S+					S-
Arm Angle	0	30	60	90	120	150	180
0	-	4.92	3.62	2.95	8.2**	10.21***	9.54***
30	-	-	1.3	1.97	3.27	5.28*	4.61
60	-	-	-	.67	4.57	6.58**	5.91*
90	-	-	-	-	5.24*	7.25**	6.58**
120	-	-	-	-	-	2.01	1.34
150	-	-	-	-	-	-	.67

Note: * $p < .05$ ** $p < .01$ *** $p < .001$

Table 11

Results of Tukey's Multiple Comparison Test of Generalization Data for Allan

	q						
	S+	S+					S-
Arm Angle	0	30	60	90	120	150	180
0	-	3.82	6.82**	6.82**	17.65***	17.65**	17.65***
30	-	-	3.0	3.0	13.82***	13.82***	13.82***
60	-	-	-	0	10.82***	10.82***	10.82***
90	-	-	-	-	10.82***	10.82***	10.82***
120	-	-	-	-	-	0	0
150	-	-	-	-	-	-	0

Note: * $p < .05$ ** $p < .01$ *** $p < .001$

Table 12

Results of Tukey's Multiple Comparison Test of Generalization 2 Data for Allan

	q						
	S+	S+					S-
Arm Angle	0	30	60	90	120	150	180
0	-	0	1.06	9.95**	9.89***	18.78***	19.91***
30	-	-	1.06	9.95**	9.89***	18.78***	19.91***
60	-	-	-	8.89***	8.82***	17.72***	18.85***
90	-	-	-	-	.066	8.83***	9.95***
120	-	-	-	-	-	8.89***	10.02***
150	-	-	-	-	-	-	1.12

Note: * $p < .05$ **$p < .01$ ***$p < .001$

Figure Captions

Figure 1. A representation of the various arm angle positions to which the participant's arms are moved and held when imitating the stimulus models. The participant's body is represented by the vertical line in the center of the figure. The numbers in the figure represent the various arm angles. The position of the numbers corresponds to the position of the participant's right and left arms when imitating each specific arm angle.

Figure 2. Mean percent of responding matching each stimulus model during baseline, training, generalization 1, reversal and generalization 2 for Sue.

Figure 3. Mean percent of responding matching each stimulus model during baseline, training, generalization 1, reversal and generalization 2 for Carl.

Figure 4. Mean percent of responding matching each stimulus model during baseline, training, generalization 1, reversal and generalization 2 for Allan.

Figure 5. Number of responses matching each probe stimulus model when each probe stimulus model is presented together with every probe stimulus model during baseline, training, generalization, reversal, and the second test of generalization for Sue.

Figure 6. Number of responses matching each probe stimulus model when each probe stimulus model is presented together with every probe stimulus model during baseline, training, generalization, reversal, and the second test of generalization for Carl.

Figure 7. Number of responses matching each probe stimulus model when each probe stimulus model is presented together with every probe stimulus model during baseline, training, generalization, reversal, and the second test of generalization for Allan.

Figure A1. Appendix A. Mean percentage of responding matching the stimulus model during baseline, training, generalization, reversal, and the second test of generalization for Tom.

Figure B1. Appendix B. The percentage of responding matching the stimulus model for baseline, training, generalization 1, reversal and generalization 2 for Sue.

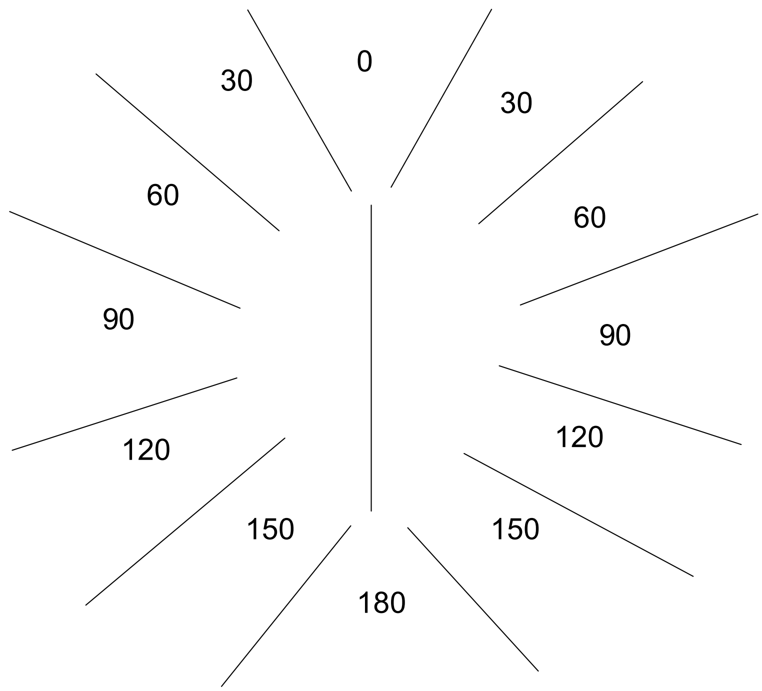
Figure B2. Appendix B. The percentage of responding matching the stimulus model for baseline, training, generalization 1, reversal and generalization 2 for Carl.

Figure B3. Appendix B. The percentage of responding matching the stimulus model for baseline, training, generalization 1, reversal and generalization 2 for Allan.

Figure C1. Appendix C. The mean percent of responding matching the stimulus model for each of six sessions during reversal for Carl.

Figure D1. Appendix D. The mean percent of responding matching the stimulus model for each of four sessions during reversal for Allan.

Figure 1



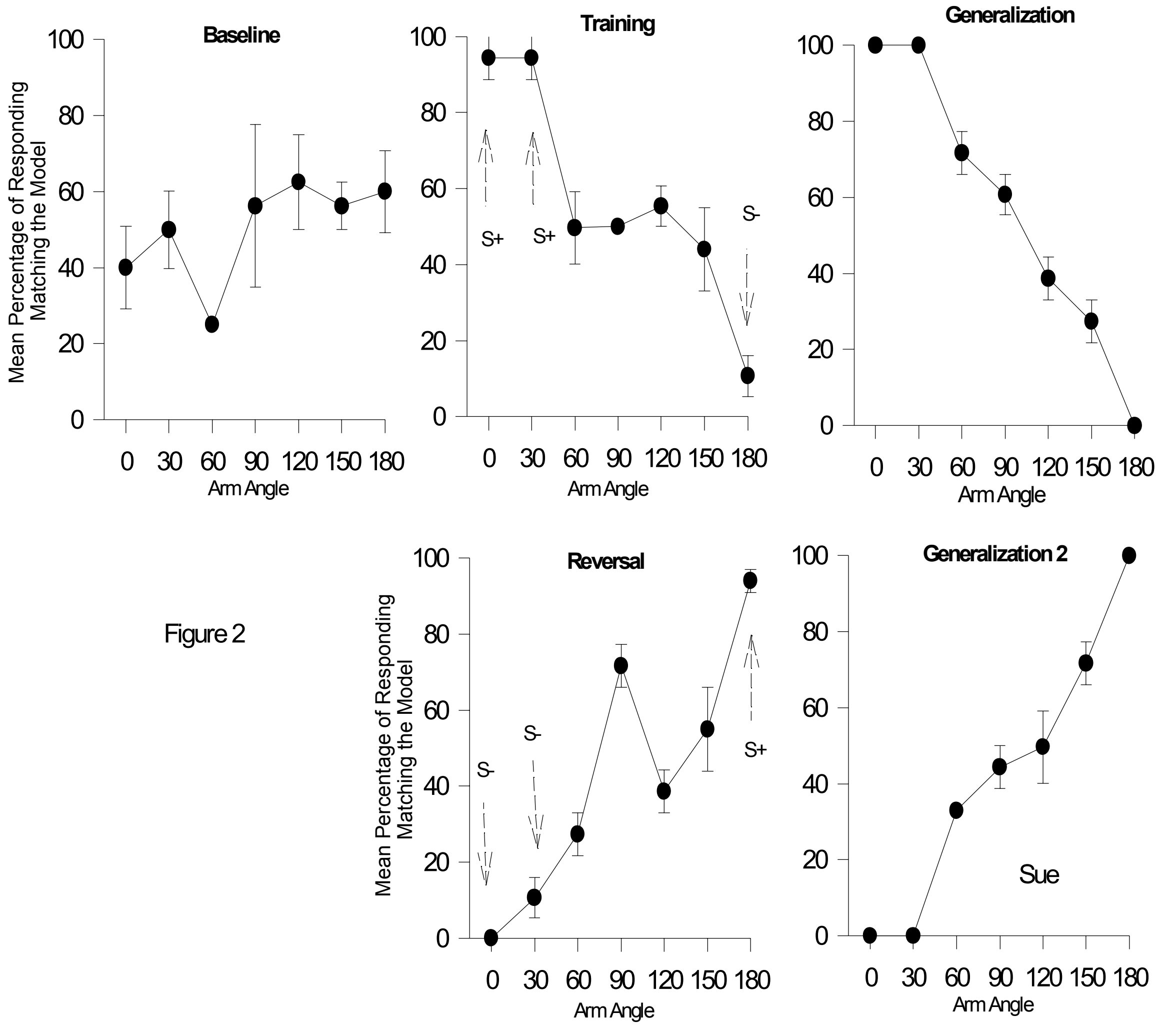

Baseline
Training
Generalization
Reversal
Generalization 2
Mean Percentage of Responding
Matching the Model
Arm Angle
0
20
40
60
80
100
0 30 60 90 120 150 180
S+
S-
Sue

Figure 2

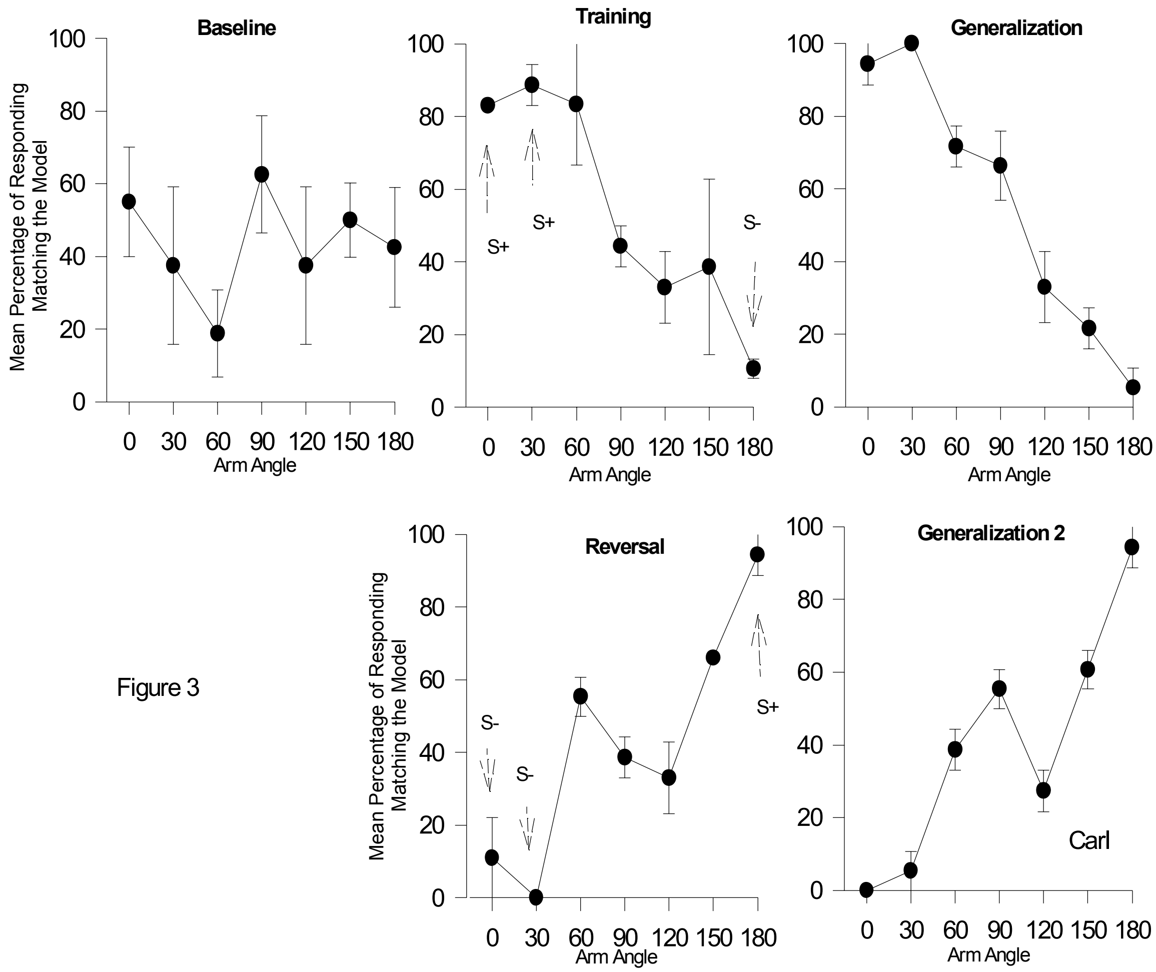

Baseline
Training
Generalization
Reversal
Generalization 2
Mean Percentage of Responding Matching the Model
Arm Angle
0 30 60 90 120 150 180
0 20 40 60 80 100
S+
S-
Carl

Figure 3

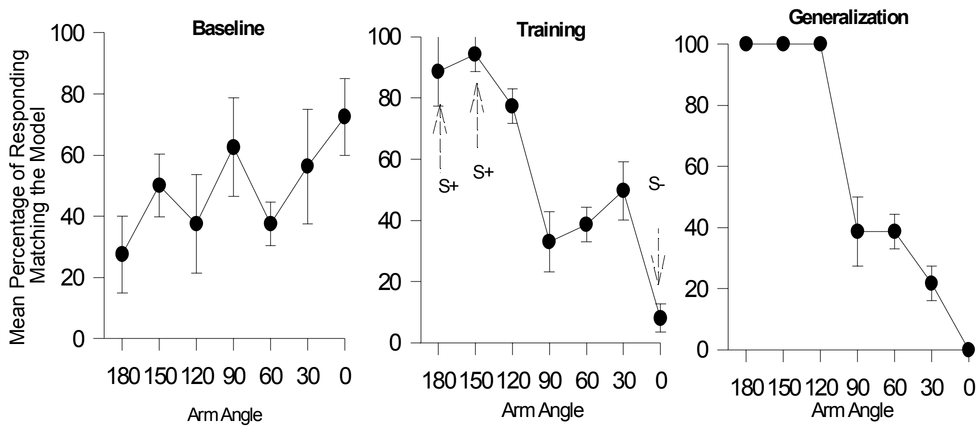

Baseline
Training
Generalization
Mean Percentage of Responding Matching the Model
100
80
60
40
20
0
180 150 120 90 60 30 0
Arm Angle
S+
S+
S-

Figure 4

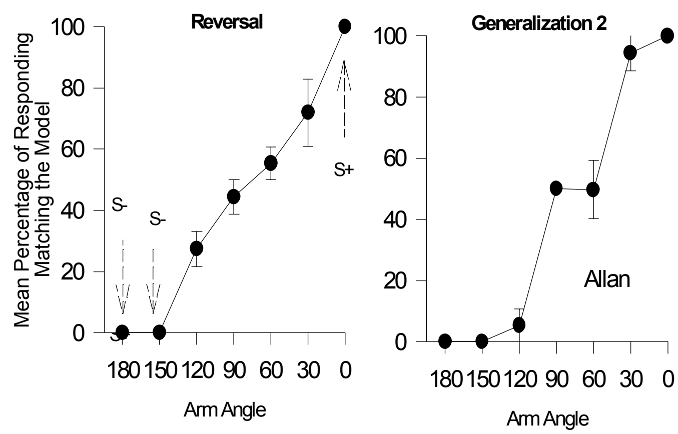

Reversal
Generalization 2
Mean Percentage of Responding Matching the Model
100
80
60
40
20
0
180 150 120 90 60 30 0
Arm Angle
S-
S-
S+
Allan

Figure 5

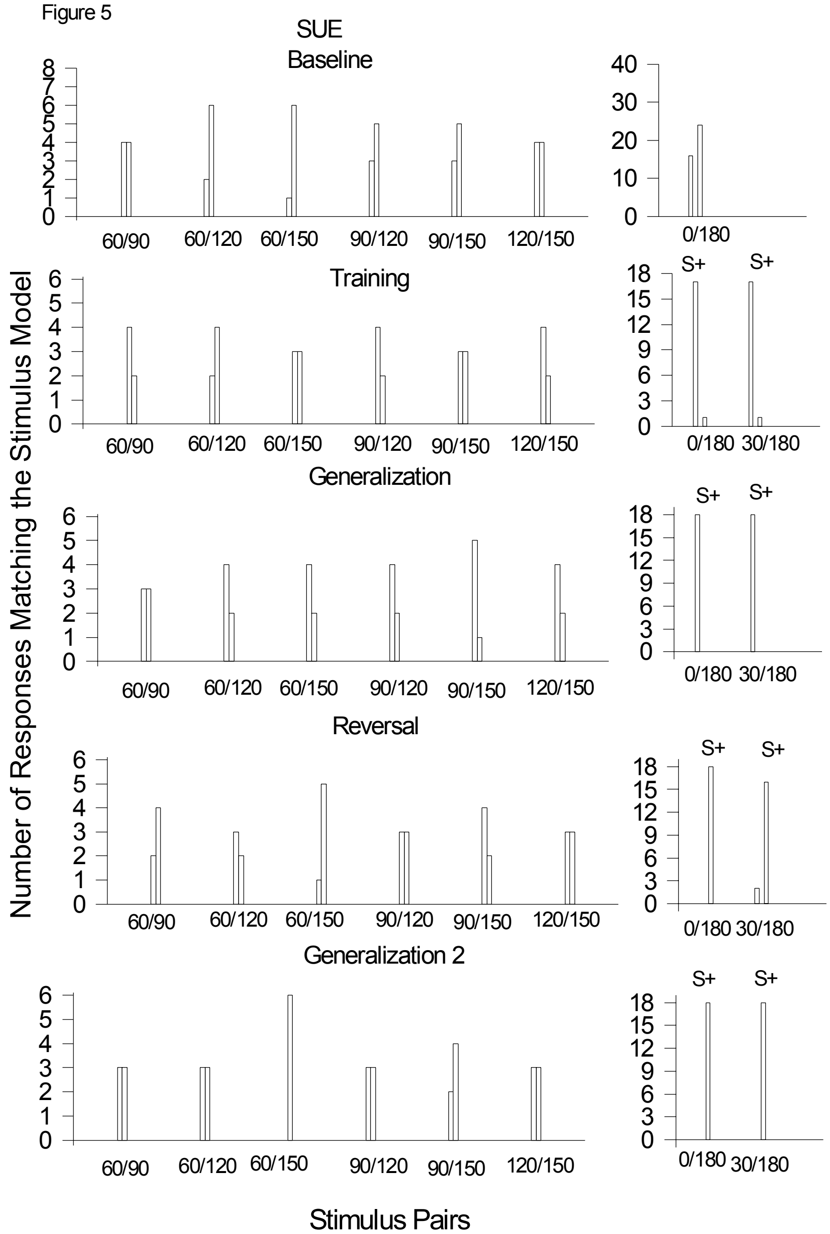

SUE
Baseline
Training
Generalization
Reversal
Generalization 2
Number of Responses Matching the Stimulus Model
Stimulus Pairs
60/90
60/120
60/150
90/120
90/150
120/150
0/180
30/180
S+

Figure 6

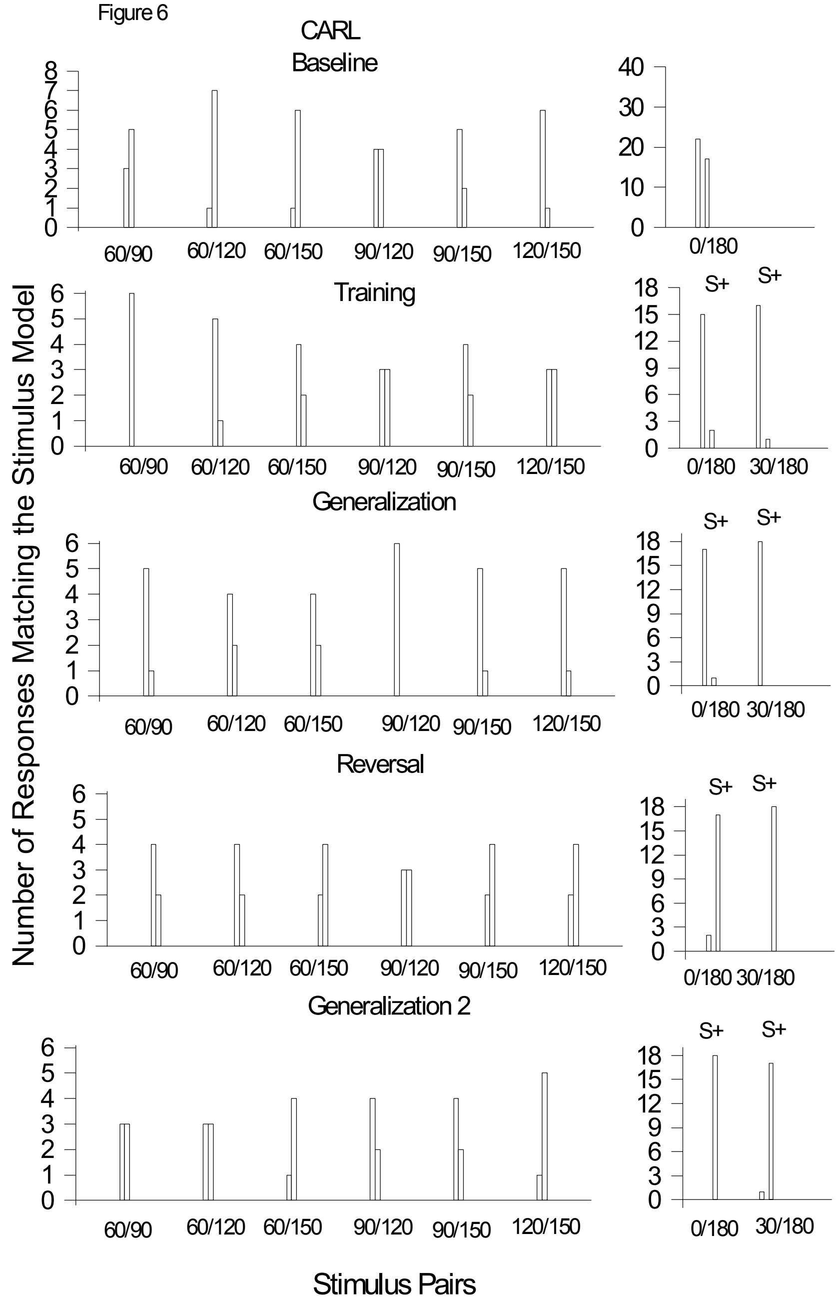
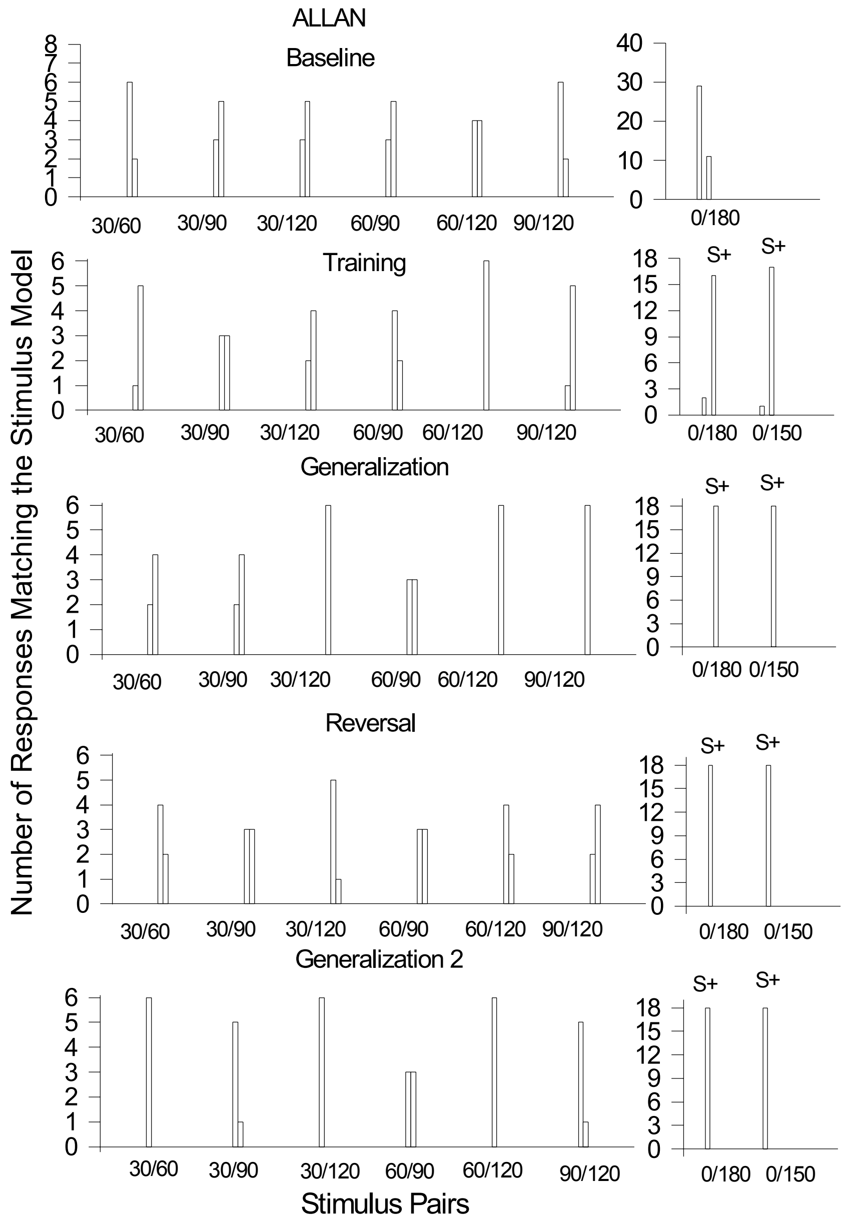

CARL
Baseline
Training
Generalization
Reversal
Generalization 2
Number of Responses Matching the Stimulus Model
Stimulus Pairs
60/90
60/120
60/150
90/120
90/150
120/150
0/180
30/180
S+

Figure 7


ALLAN
Baseline
Training
Generalization
Reversal
Generalization 2
Number of Responses Matching the Stimulus Model
Stimulus Pairs
30/60
30/90
30/120
60/90
60/120
90/120
0/180
0/150
S+

Appendix A

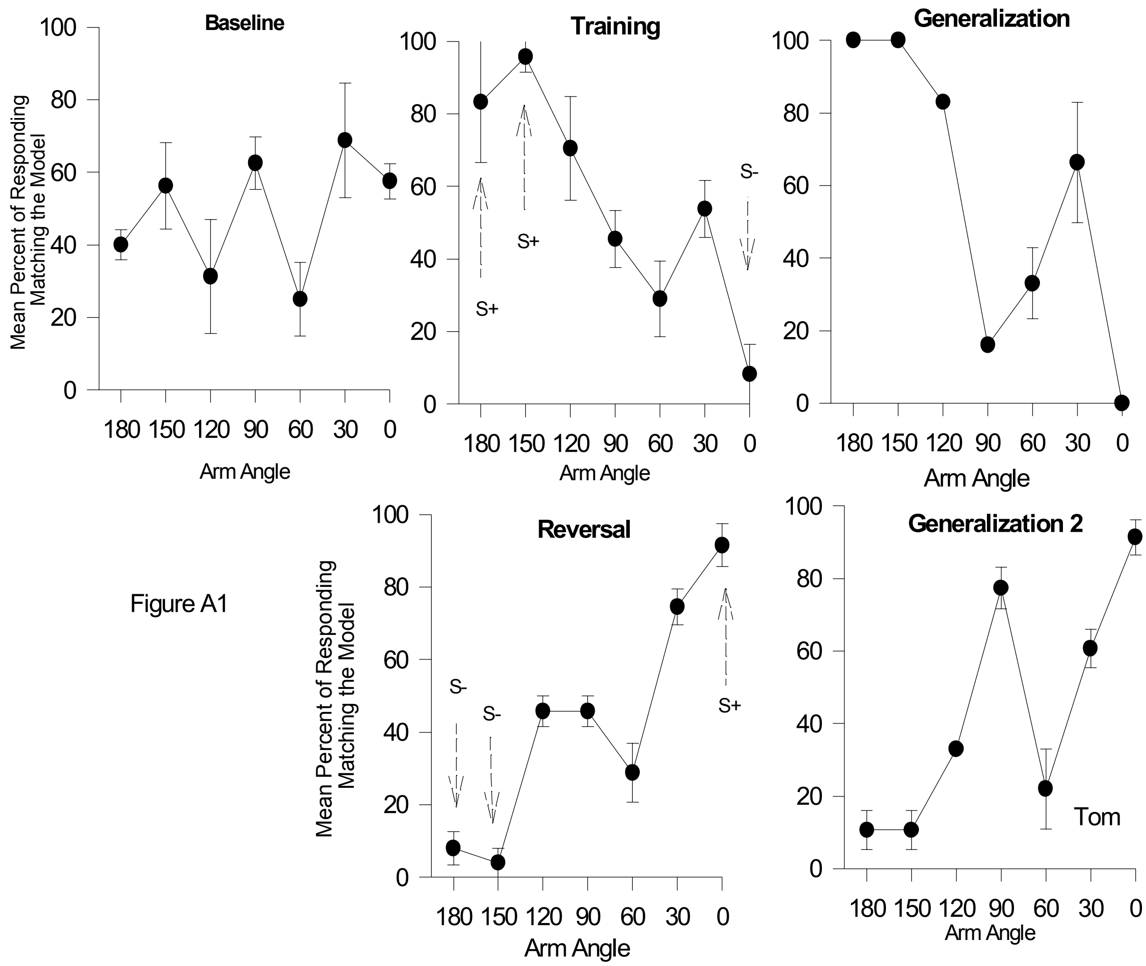


Figure A1

Figure B1

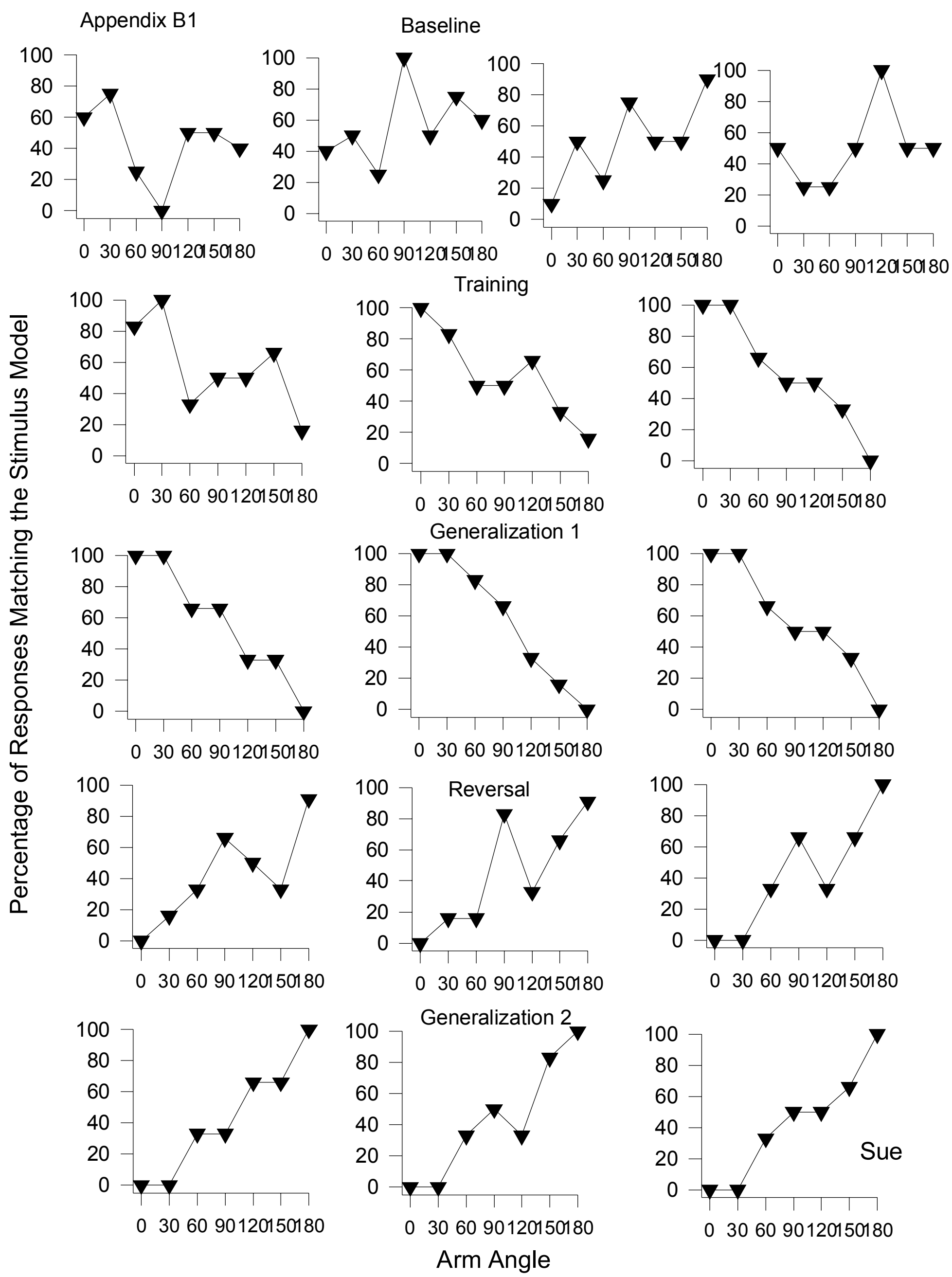

Appendix B1
Baseline
Training
Generalization 1
Reversal
Generalization 2
Sue
Percentage of Responses Matching the Stimulus Model
Arm Angle
0 30 60 90 120 150 180
0 20 40 60 80 100

Figure B2

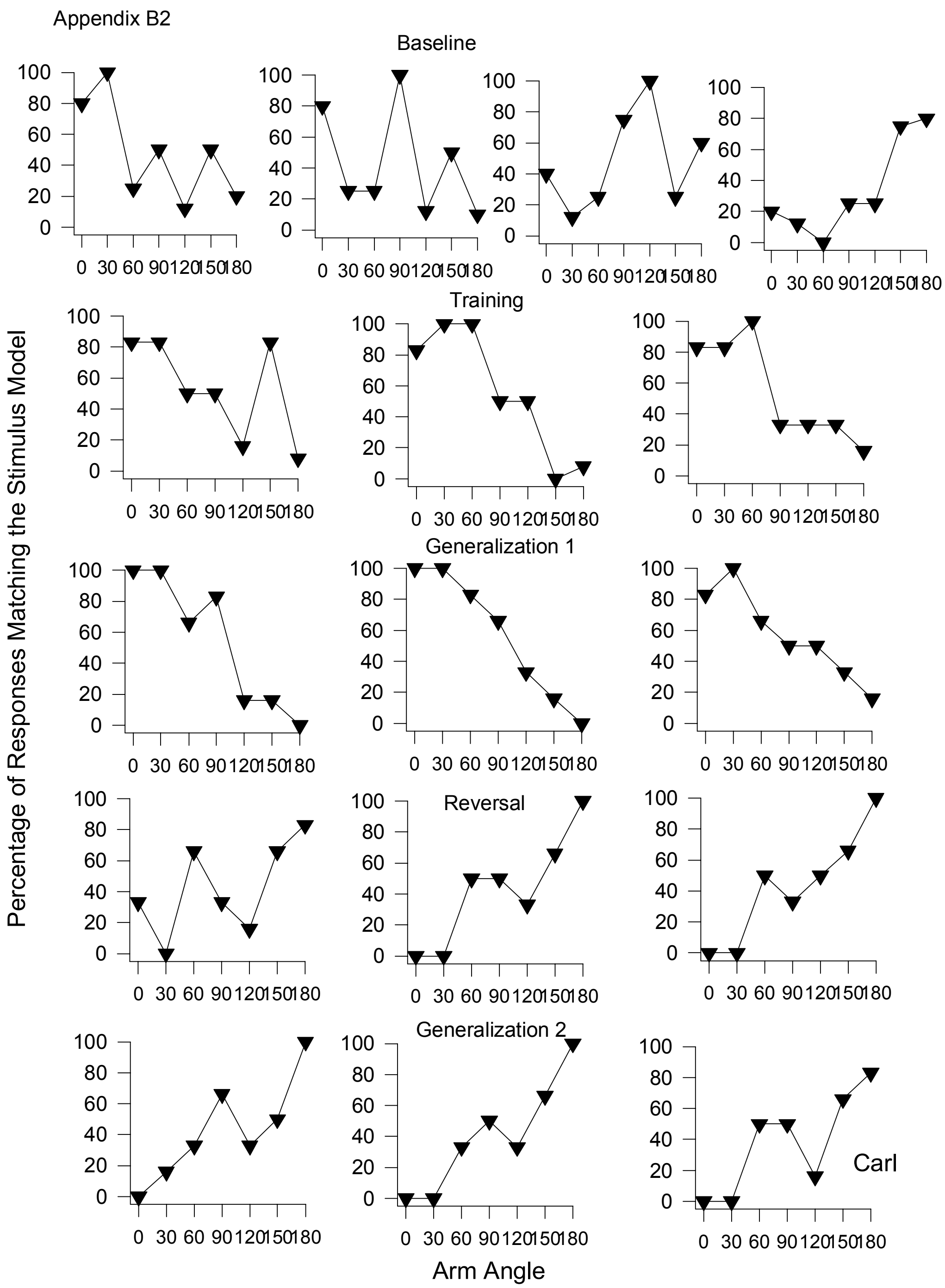

Appendix B2
Baseline
Training
Generalization 1
Reversal
Generalization 2
Carl
Percentage of Responses Matching the Stimulus Model
Arm Angle
0 30 60 90 120 150 180
0 20 40 60 80 100

Figure B3

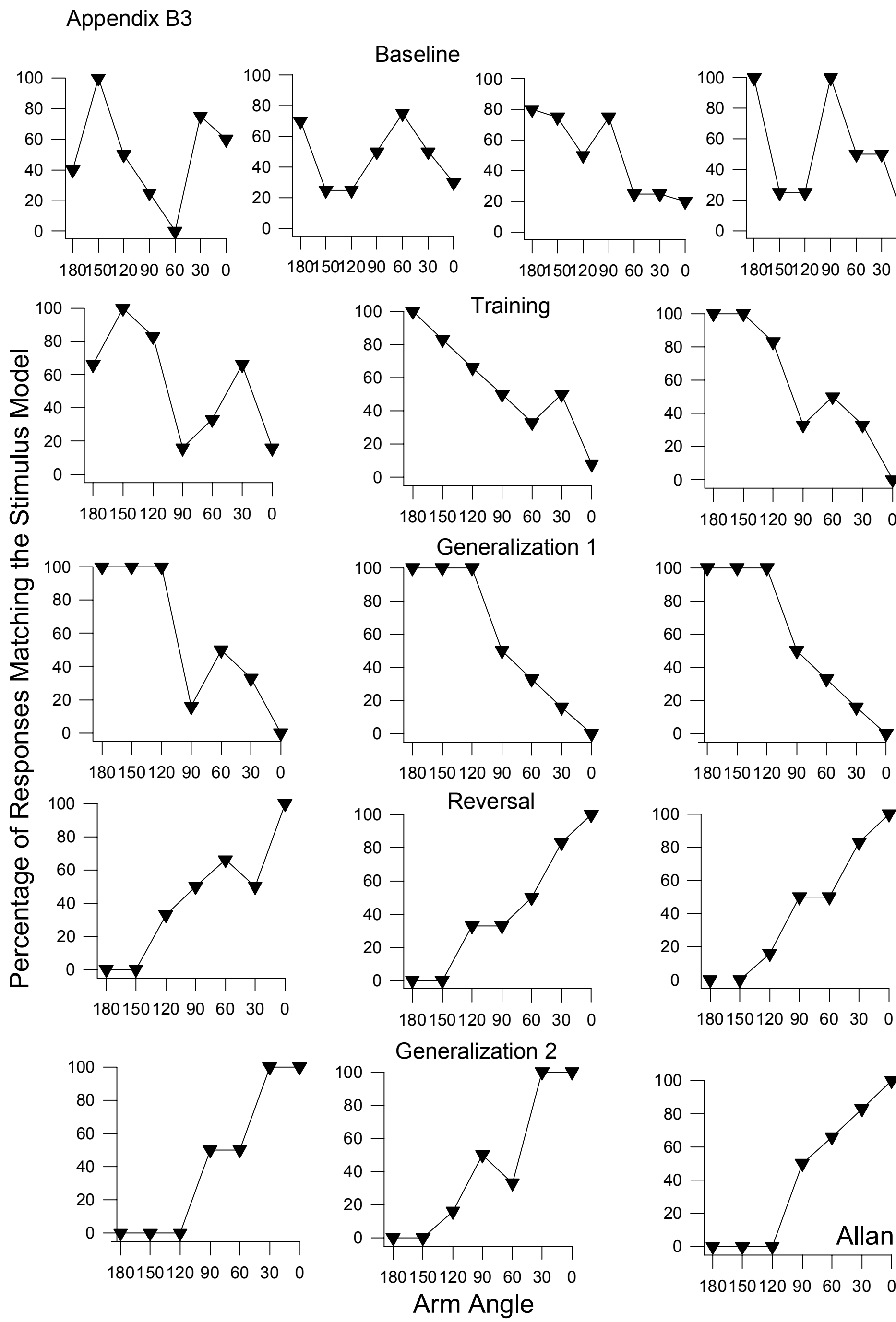

Appendix B3
Baseline
Training
Generalization 1
Reversal
Generalization 2
Percentage of Responses Matching the Stimulus Model
Arm Angle
180 150 120 90 60 30 0
0 20 40 60 80 100
Allan

Figure C1

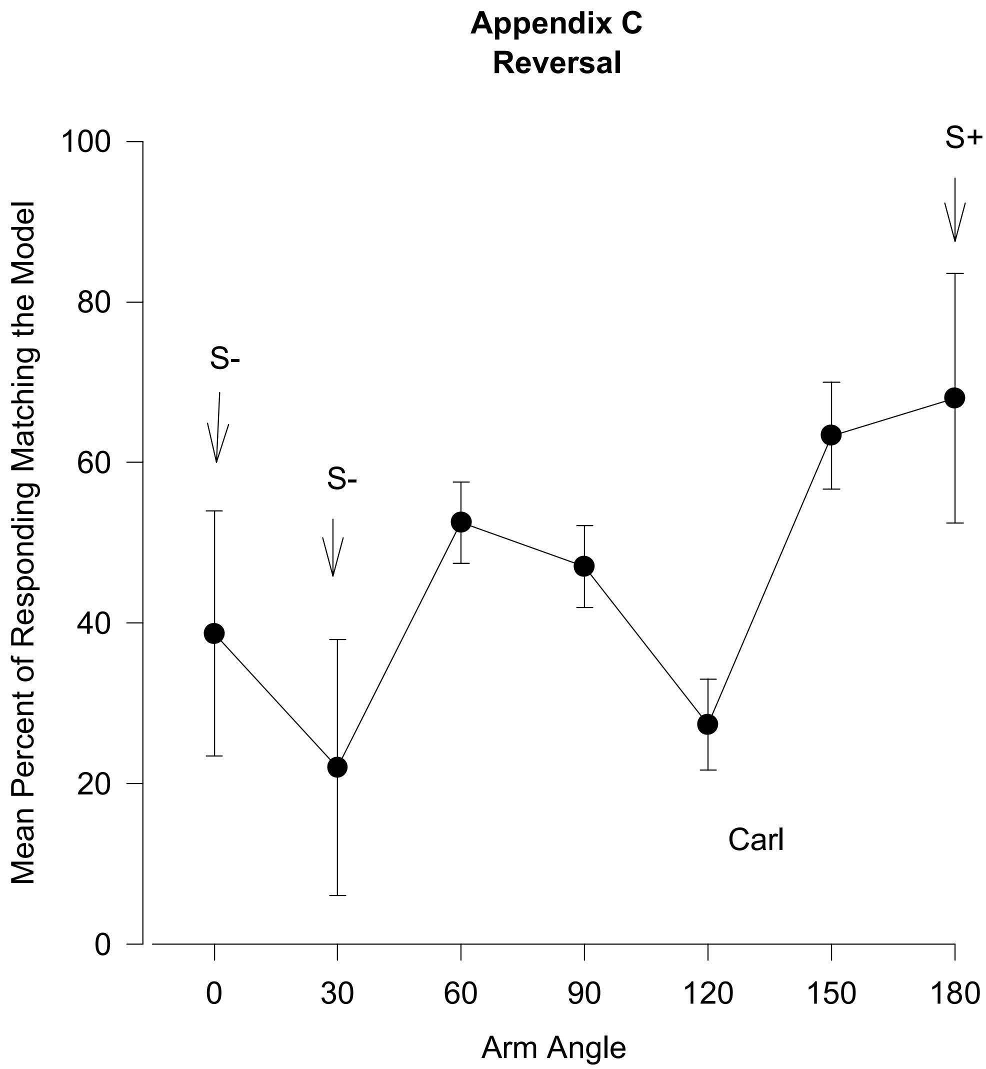
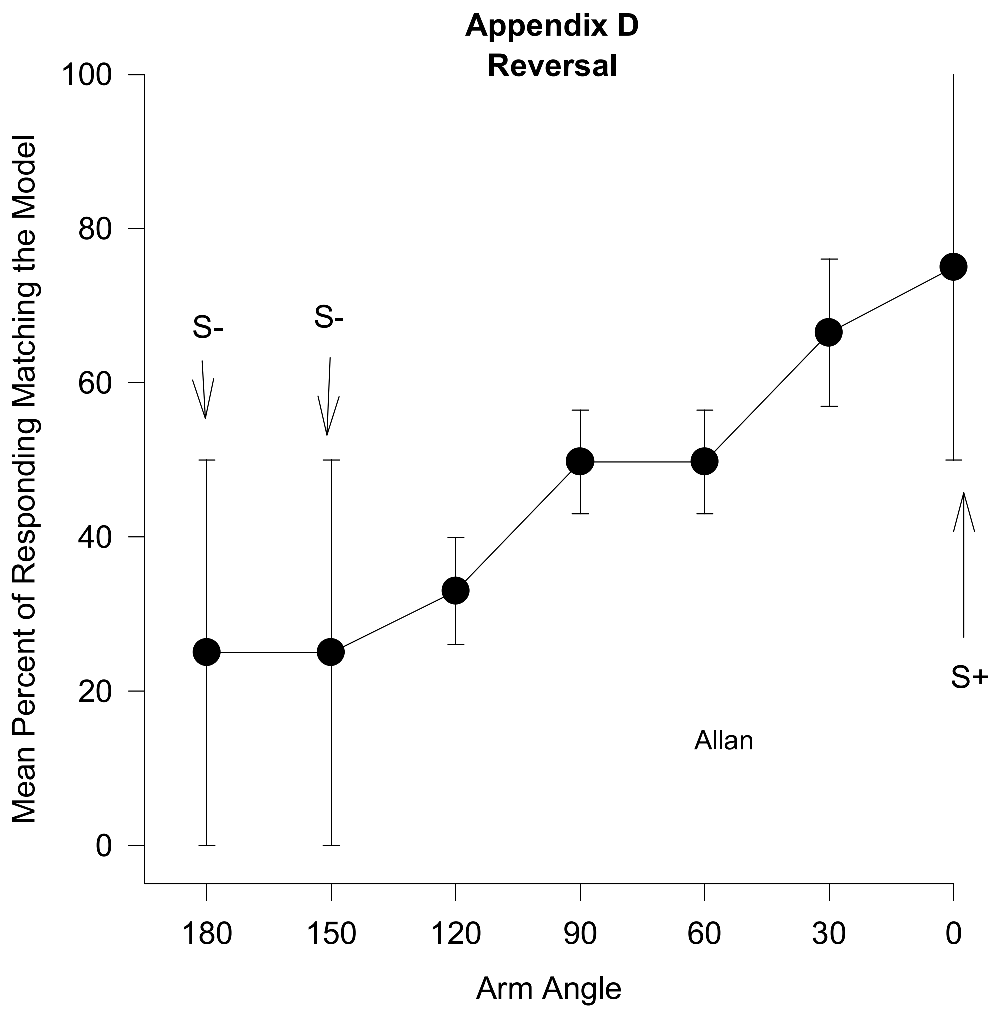

Appendix C
Reversal
Mean Percent of Responding Matching the Model
100
80
60
40
20
0
S-
S-
S+
Carl
0
30
60
90
120
150
180
Arm Angle

Figure D1


Appendix D
Reversal
Mean Percent of Responding Matching the Model
100
80
60
40
20
0
S-
S-
S+
Allan
180
150
120
90
60
30
0
Arm Angle

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