

INCREASING FUNCTIONAL AND SYMBOLIC PLAY SKILLS  
OF CHILDREN WITH AUTISM  
USING ACTIVITY SCHEDULES AND SCRIPT-FADING

by

JENNIFER WOODS

A dissertation submitted to the Graduate Faculty in Psychology in partial fulfillment of the requirements for the degree of Doctor of Psychology, the City University of New York

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## Abstract

INCREASING FUNCTIONAL AND SYMBOLIC PLAY SKILLS  
BY CHILDREN WITH AUTISM  
USING ACTIVITY SCHEDULES WITH SCRIPT FADING

by

Jennifer Woods

Adviser: Professor Claire L. Poulson

Children with autism exhibit play skills deficits. The current study examined the effectiveness of using activity schedules with embedded script-fading on the play skills of four children with autism. A multiple-baseline-across-activities-experimental design demonstrated experimental control. All learners engaged in systematic increases in play responding from baseline to intervention. Three learners engaged in systematic increases in unscripted verbal responding. Three learners engaged in generalized play responding during teaching sessions from play responses with prompts and reinforcers to play responses without prompts and reinforcers. Three learners also engaged in generalized play responding during test sessions without the presence of the intervention package. Finally, three learners engaged in play responding during a 4-6 week follow-up. Results demonstrated that children with autism can be taught to engage in play responding using activity schedules with script-fading.

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Children with autism exhibit delays in the area of play skills. The DSM-IV described the deficits in play skills as failure to use objects appropriately, lack of varied play, and failure to develop make-believe play skills (American Psychiatric Association [APA], 1994). Although behavior analysts have developed training packages that have addressed a wide variety of core deficits of autism, play skills have not been fully addressed. A number of non-behavioral researchers have examined the play skills of children with autism, typically-developing children, and children with Down syndrome (Baron-Cohen, 1987; Gould, 1986; Libby, Powell, Messer, & Jordan, 1997, 1998; Riguet, Taylor, Benaroya, & Klein, 1981; Rutherford & Rogers, 2003; Sigman & Ungerer, 1984; Ungerer & Sigman, 1981, Williams, Reddy, & Costall, 2001). These researchers have provided research protocols that may be used by behavior analysts to define “play skills.” They have also compared groups of children with respect to their play skills and they have consistently found children with autism to be relatively deficient in this area compared to typical peers.

Most of these researchers have differentiated between functional and symbolic play. The authors defined *functional play* responses as using an object as it was designed, for example, pushing a toy car (Baron-Cohen, 1987; Jarrold, Boucher, & Smith, 1993; Libby et al., 1997; Ungerer & Sigman, 1981; Williams, Costall, & Reddy, 1999).

Williams et al. (2001) elaborated on the definition of functional play to demonstrate the progression of play skills in children. Simple functional play responses include the combination of two or more objects that are related (e.g., putting a cup on a saucer) and appropriate use of a single object (e.g., banging with a play hammer). More elaborate functional play responses include using multiple objects appropriately, appropriate vocalizations that supported an appropriate action, and doll-directed acts (e.g., feeding a doll).

Not all play is considered functional play. Researchers have also distinguished *symbolic play* (Baron-Cohen, 1987; Jarrold et al., 1993; Leslie, 1987; Libby et al., 1997; Riguet et al., 1981; Rutherford & Rogers, 2003; Sigman & Ungerer, 1984; Ungerer & Sigman, 1981). Most researchers defined symbolic play as play that involves substituting one object for another (e.g., using a block as a car), attributing false properties to an object (e.g., putting a bandage on a teddy bear's wounded leg), or referring to an imaginary object (e.g., eating pretend food). Objects are not always used as designed; therefore, play is no longer defined by the actual function of the object being used. Baron-Cohen (1987) elaborated on the definition of symbolic play. First, symbolic play involves the child identifying what the actual object is, and what it is being used as (e.g., the banana is not really a telephone). Second, symbolic play responses show variety in responding with a variety of play objects, rather than repetitive responding with a narrow range of play objects. Third, symbolic play often involves the use of dolls as the agents of actions (e.g., a puppet bakes a cake).

Wing, Gould, Yeates, and Brierley (1977) conducted one of the earliest studies comparing the play responses of children with social impairments and typically

developing children. They presented toys and other play materials to the children and categorized levels of play as symbolic play, stereotyped play, or no symbolic play. The authors' definition of symbolic play included some functional play (e.g., the child brushes a doll's hair) and some imaginative, pretend play. Stereotyped play and lack of symbolic play included play responses that involved repetitive use of particular objects. Children with autism engaged in more repetitive, inflexible play responses than children in the non-autism group.

Researchers have compared the extent to which children with autism engage in unstructured symbolic play with similar responding of children with Down syndrome and with typically developing children, matched for mental age (Baron-Cohen, 1987; Gould, 1986; Riguet et al., 1981; Ungerer & Sigman, 1981). Researchers observed children during unstructured, free-play situations in which they presented toys to children, delivered an initial instruction, and did not provide any feedback or reinforcers. Children in the non-autistic groups engaged in more spontaneous symbolic play responses than children with autism. Researchers also examined symbolic play responses in structured situations (Riguet et al., 1981; Sigman & Ungerer, 1984; Ungerer & Sigman, 1981) such as modeling play responses or verbally prompting the child to engage in play responses. Children with autism engaged in more symbolic play responses during structured situations than during spontaneous, free-play situations.

Rutherford and Rogers (2003) compared play responses of children with autism to typically developing peers and children with Down syndrome using the *Fewell Pretend Play Scale, 5<sup>th</sup> Edition* (Rutherford & Rogers, 2003). They placed four different sets of toys, including play people and figures, in front of a child and delivered an initial

question (e.g., “What can you do with these toys?”). If a child did not initiate play responses, the experimenter verbally prompted or modeled play acts. Child responses included symbolic or pretend play which included all responses that involved using an object as if it were another object, attributing false properties to an object, or referring to imaginary objects. Typically developing children engaged in a higher rate and variety of symbolic play responses than children with autism. In addition, children with autism engaged in fewer play responses with dolls than children in non-autistic groups.

Although a number of researchers focused solely on the symbolic play skills of children with autism, others have observed that functional play skills of children with autism are also impaired. Williams et al. (2001) compared functional play skills of children with autism, children with Down syndrome, and typically developing children. Experimenters placed sets of toys in front of the children and observed their play responses throughout a 15-minute interval. Observers coded responses as simple functional play or elaborated functional play. Simple functional play responses included association of two objects that were functionally related (e.g., putting a lid on a pot) or functional use of one object (e.g., pushing a toy car). Elaborated functional play responses included functional use of two or more objects (e.g., flipping something in a pan), functional actions that were accompanied by an appropriate vocalization (e.g., pushing a toy car and saying “vroom”), or doll-directed actions (e.g., feeding a doll). The functional play responses of children with autism were less elaborated and less varied than the play responses of children in non-autistic groups. In addition, the play responses of children with autism were less “integrated.” That is, they involved single responses, rather than multi-step response chains (e.g., flip the burger, put it on the plate, and eat the

burger). Almost all of the responses produced by children with autism involved single objects (e.g., drinking from a cup) and only one child with autism engaged in elaborated functional play responses. The researchers concluded that functional play skills of children with autism were deficient. The researchers did not observe the progression of play responses from use of single objects to more elaborated functional play responses (e.g., drinking from a cup did not progress to drinking from a cup while smacking lips together). In addition, children with autism did not engage in functional play with a doll, while doll-directed acts were the most common elaborated functional play responses of children in non-autistic groups.

Williams et al. (1999) reviewed a number of studies that examined play skills of children with autism. Based upon their review of the related literature, the authors recommend that future researchers consider the exploration of objects and how they are used, in relation to how others use them, when examining functional play responses of children with autism. The authors stated that when the function of an object is unclear, other children identify social cues or imitate others, but children with autism exhibit impaired social skills, including social referencing and imitation, and as a result, object use is impaired. Also, the authors argued that preoccupation with particular features of objects impairs the ability of children with autism to identify the critical features of objects that define their use. Furthermore, the manner in which objects are used affects the way others interact with them. Finally, the authors concluded that object use has a social component and it follows that children with autism demonstrate difficulty with functional play skills because they lack the social components.

In summary, a number of non-behavioral researchers examined play skills of children with autism (Baron-Cohen, 1987; Gould, 1986; Libby, et al., 1997, 1998; Riguet, et al., 1981; Rutherford & Rogers, 2003; Sigman & Ungerer, 1984; Ungerer & Sigman, 1981, Williams, et al., 2001). The researchers defined play and compared the performance of children with autism, children with Down syndrome and typically developing children. The focus of their research was to document the play skill deficits of children with autism. Researchers did not identify procedures to improve play skill performance of these children.

In contrast, a few behavior analytic researchers have designed procedures to improve the play responses of children with autism (D'Ateno, Mangiapanello, & Taylor, 2003; Morrison, Sainato, Benchaban, & Endo, 2002; Stahmer, 1995; Thorp, Stahmer, & Schreibman, 1995). Stahmer (1995) addressed symbolic play skills of children with autism and defined symbolic play in the same way described above. During training, Stahmer presented toys to the learners. The experimenter modeled symbolic play responses and repeated the responses if the learner did not respond. Stahmer reinforced successive approximations of the target response and required responses that were progressively more similar to the modeled response as the experiment proceeded. The experimenter delivered reinforcers related to the play activity (e.g., the learner was given a doctor's play kit after pretending to be a doctor on a telephone). The experimenter included pre-training, post-training, and follow-up probes and measured the percentage of engagement in symbolic play during 30-second intervals. Throughout all probe sessions, the experimenter presented generalization toys, but not teaching toys. Symbolic play

responses of children with autism increased from low frequency during baseline to levels comparable to those of typically developing children (Gardner, 1990).

In another study, D'Ateno et al. (2003) used a video modeling procedure to teach a child with autism to engage in a chain of play responses across tea party, shopping, and baking play. The play responses included actions that would be considered functional play (e.g., putting on a jewelry item). During intervention, the learner watched a video that depicted a play activity. After a minimum of 1 hour from the presentation of the video, the experimenters placed play materials corresponding to the activity depicted in the video in front of her. Observers measured the number of vocal and motor play responses during 5-minute intervals, without prompts or instructions. The number was low during baseline sessions. Upon intervention, the number of vocal and motor play responses increased systematically across all play activities. Whereas modeled play responses increased, the learner did not produce novel play responses. The experimenters only used one video sequence for each play activity, so it is possible that there were insufficient exemplars to generate novel responding (Stokes & Baer, 1977). In addition, the generality of the findings that video modeling increases the play responses of children with autism is limited, because the experiment included only one learner.

The procedures used in the above described studies involved adults or confederate peers modeling play responses on video segments. However, Morrison et al. (2002) examined the effectiveness of activity schedules (MacDuff, Krantz, & McClannahan, 1993) and correspondence training to teach children with autism to engage in a series of play activities. Correspondence training involved delivery of reinforcers to children for correspondence between their non-verbal and their verbal responses (Risley & Hart,

1968). The experimenters measured the number of occurrences of verbal-nonverbal correspondence, the percentage of intervals of on-task responding, and the percentage of intervals of prompts during play with toys across four learners. There were four experimental conditions: (a) baseline, (b) activity-schedule training, (c) reinforcement for labeling of play photographs, and (d) verbal-nonverbal correspondence training. Systematic increases in the frequency of play correspondence and percentage of intervals of on-task responses from baseline to teaching conditions while the percentage of teacher prompts decreased. Morrison et al. (2002) did not directly increase play responses of children with autism, instead, they focused on teaching schedule following and verbal-nonverbal correspondence training.

In summary, the deficit in play skills is a significant problem for children with autism, yet few researchers have designed procedures to address this deficit. One of the goals of the current study, therefore, was to teach symbolic and functional play responses to children with autism, within a behavior-analytic framework. Non-behavioral researchers have described the progression of play skills in typically developing children who first demonstrate functional play skills (Nicolich, 1977; Piaget, 1962; Williams et al., 2001) and then demonstrate symbolic play skills (Nicholich, 1977; Piaget, 1962; Rutherford & Rogers, 2003). In the current study, the experimenter taught children who did not demonstrate functional play skills to engage in functional play responding and children who already demonstrated functional play skills to engage in symbolic play responding. All learners previously demonstrated schedule following skills. The learners responded appropriately to manual prompts delivered from behind by an instructor. The learners also learned to verbally interact about activities with adults using script-fading

procedures (see Krantz & McClannahan (1993) for a full description of script-fading procedures. The current study replicated and extended previous research by using graduated guidance and script-fading procedures to produce play and verbal responding that typically accompanies play. While few researchers examined play responding, researchers have not addressed generalization. Thus, the current study also examined generalization of play responding in two ways. First, researchers assessed generalization in teaching sessions from play responding with prompts and reinforcers to play responding without prompts and reinforcers. Second, the current study examined generalization during separate sessions from play responding with activity schedules to play responding without activity schedules. Finally, the current study assessed the maintenance of the procedures across time by measuring play responses over a 4-6 week follow-up.

### General Method

The experimenter conducted a multiple-baseline experimental design across play activities for each learner. Changes in procedure occurred sequentially across learners. Therefore, to assist the reader, the experimenter discussed the methods used in the current study in different sections corresponding to each learner. First, the experimenter described general methods and procedures for all four learners. The experimenter then included more detailed descriptions of methods and procedures for individual learners. It should be noted that data collection for each learner was conducted at different times (e.g., learner 1—March through September 2005, learner 2—November 2005 through July 2006), and the procedures were slightly modified to meet the individual needs and skill sets of each learner. While the teaching procedures, measurement, and data

collection were the same for all four learners, there were some differences in procedure. For example, for learner 1, the experimenter conducted teaching trials and generalization probes on separate sessions, but for learner 2, conducted teaching trials and generalization probes during the same session.

### *Participants*

Four children with autism, aged four to seven years, diagnosed by an outside agency using the DSM-IV criteria for autistic disorder (APA, 1994), participated. Two children learned functional play responses and two children learned symbolic play responses. Their ages ranged from four to seven years. According to their teachers, learners' exhibited play skill deficits. Teachers did not observe the learners engaging in functional play responses. Teachers observed two other learners engaging in functional play responses, but not in symbolic play responses. The learners mastered the prerequisite skills of (a) schedule following and (b) script-fading programs. The children attended a private school for children with autism for 6 hours per day.

### *Setting*

All sessions occurred in a classroom, five days a week, with only the learners and experimenters present. The experimenter used the same classroom for every session. The size of the classroom was 1.5 m X .93 m. The experimenter placed a rectangular table that was .27 m height X .36 m width X .23 m length at the back of the classroom, alongside two folding tray tables that were .39 m height X .22 width X .16 length and a chair that was .28 m height. Shelves, tables, chairs, bookcases, and cabinets were on the periphery. Two long, vertical windows, .60 m height X .30 m width were on one wall but

the remaining three walls were free of other visual distractions such as signs or pictures. The experimenter used the same classroom for generalization sessions.

### *Materials*

*Apparatus.* The apparatus included recording devices and a kitchen timer. The experimenter recorded the sessions using a JVC® Compact VHS Video Recorder, model # GR-AX75. The experimenter used a kitchen timer to signal the end of each ten-minute session.

*Stimuli.* The stimuli included reinforcers, scripts, and activity schedules. Reinforcers were tokens or behavior contracts that could be exchanged for tangible items or activities that were individualized for each learner. Scripts were textual or pre-recorded on audio recording devices. Schedules were displayed as written checklists or photographic response chains. Scripts and schedules will be fully described below.

### *Dependent Measures*

Table 1 displays examples of play responses that were related to the play materials presented to the learners. Descriptions of nine dependent measures are included below. Observers scored *functional play responses* if the learners used conventional toys according to their function (e.g., the child brings a teacup to her mouth), and/or the learner engaged in doll-directed acts with conventional toys (e.g., the child feeds the doll). Observers scored *symbolic play responses* if a learner used an object as a different object (e.g., using a wooden block as if it were an eraser for a chalkboard), and/or used dolls as agents (e.g., the doll stirs the pot), and/or the learner referred to people or objects that were not there (e.g., the child says, “*okay class, it’s time for reading*”).

Observers scored *prompted play responses, functional or symbolic*, if the experimenter manually prompted the learner to engage in play responses. Observers scored *unprompted play responses, functional or symbolic*, if the experimenter did not manually prompt the learner to engage in play responses.

Observers scored *spontaneous functional or symbolic play responses* if the learner engaged in a higher number of play responses than the criterion, which was 12 (e.g., 13 play responses would be scored as 1 spontaneous play response). Once the experimenter removed all photographs, observers scored all play responses as *spontaneous functional play responses*. The *cumulative number of spontaneous functional play responses* was the cumulative number of spontaneous functional play responses that the learner did not previously engage in.

Observers scored *verbal responses* if utterances accompanied a corresponding gesture or action with objects (e.g., pretending to eat and saying “mmm...this is good”). Observers scored a verbal response that immediately preceded or followed a play response if it was contextually related to that play response (e.g., the learner said “the baby is tired” and then placed the baby in the crib). Verbal responses did not include vocalizations that were non-contextual (e.g., humming or singing) or responses directed to the experimenter (e.g., “I want a cookie please”).

*Scripted verbal responses* were those that matched the script, with the exception of articles, prepositions, or pronouns that were changed or deleted (Krantz & McClannahan, 1993). For example, for the script “I play doctor,” observers scored the response “you play doctor” as a scripted verbal response. *Unscripted verbal responses* were those that were different from the script by more than changes or deletions in

conjunction, pronoun, or preposition use. For example, for the script “I’ll make something good,” the observed scored the responses “I’ll make something great” and “I’ll cook something good” as unscripted verbal responses. Observers also scored an unscripted verbal response if the experimenter removed the script and the learner stated the previously learned script (e.g., “time to play house”). If any word of the script remained, and the learner repeated the previously learned script, the observers scored it as a scripted verbal response.

### *General Procedures and Experimental Design*

*Design.* The experimenter used a within-subject across play activities multiple-baseline design to demonstrate experimental control.

*Baseline.* Throughout all sessions, the teacher served as the experimenter. Two different classroom therapists and one college intern recorded interobserver agreement (IOA), during 30-minute sessions. The experimenter placed play materials on tables directly in front of or next to the learners prior to each session. The experimenter instructed the learners to sit or stand at the table. The experimenter set the timer for ten minutes. The experimenter delivered the instruction, “play [activity] (e.g., play [doctor])” which signified the beginning of the ten-minute interval. The experimenter remained in the room standing behind the learner. The experimenter did not deliver manual and verbal prompts, with the exceptions that the experimenter manually prompted the learner to return to the play area, or if the learner directed a question to the experimenter. The experimenter used a mixed schedule of reinforcement during baseline sessions. That is, the experimenter used an extinction schedule for play responding and delivered reinforcers for attending responses throughout each ten-minute baseline session

using a differential reinforcement schedule that was variable time between sessions but constant time within sessions. So, in session one, tokens were delivered at 1'30", 2'30", 3'30", etc. and during session two, tokens were delivered at 1'15", 2'15", 3'15", etc. The time was variable between sessions so that the time contingency was less discriminable to the learners. If the learner engaged in a self-stimulatory response (e.g, spinning) at the moment a token was to be delivered, the experimenter redirected the learner and waited 5-seconds before delivering the token. Attending responses were defined as looking at things other than play materials or looking at play materials but not engaging in responses with them. The experimenter equated the number of reinforcers delivered during baseline and teaching sessions.

*Intervention.* The experimenter placed the play materials in front of the learners, as during baseline. In addition to the play materials, activity schedules and scripts were placed on the table, in front of the learner. The timer was set for ten minutes and the experimenter delivered the instruction, "play [*activity*]" (e.g., "play *teacher*"). The experimenter stood behind the learner and delivered manual guidance to open the schedule and point to the first picture (Krantz & McClannahan, 1999). If the learner engaged in the play response and repeated the script, the experimenter prompted the learner to turn the page of the schedule. If the learner did not engage in the corresponding play response and/or repeat the script within 5-seconds, the experimenter repeated manual guidance. The experimenter did not deliver verbal instructions. The experimenter delivered reinforcers, when the learner engaged in a play response, according to a continuous reinforcement schedule. The experimenter did not deliver reinforcers for verbal responses.

During intervention, the experimenter used a graduated guidance procedure (cf. Krantz & McClannahan, 1999). The experimenter stood behind the learner and delivered manual guidance to open the primary schedule and point to the first picture (Krantz & McClannahan, 1999). If a script was attached to the page depicting the play response, the instructor used the same manual guidance procedure to press the button of the recorded device. If the learner repeated the script and engaged in the corresponding play response, the experimenter prompted the learner to return to the book, turn the page, and point to the next picture. Initially, the experimenter manually prompted the learner to engage in the depicted play response. The experimenter repeated this procedure for each play response. If the learner did not engage in the corresponding play and verbal response within 5-seconds, the experimenter repeated manual guidance. The experimenter delivered reinforcers, when the learner engaged in a play response, according to a continuous reinforcement schedule. The experimenter did not deliver reinforcers for verbal responses or unrelated responses, such as stereotypy or attending.

*Follow-up.* The follow-up sessions took place approximately four-to-six weeks from the last day of intervention. There was no teaching from the last day of intervention to the first follow-up session. The procedures were identical to those in the final session of intervention. That is, the experimenter did not present secondary schedules. The experimenter did not deliver prompts.

#### *Measurement Procedures*

Measurement recording started at the beginning of each play activity, marked by the experimenter's instruction. Observers recorded data on prepared data sheets. The

experimenter videotaped the play sessions. In addition to measurement of the dependent variables, data were collected on procedural integrity.

Observers scored procedural integrity using a yes or no response checklist. Procedural integrity included that (a) the experimenter manually prompted correct sequence in activity schedules, (b) did not provide manual prompts during baseline or probe sessions, (c) did not give verbal prompts during all trials, (d) delivered the initial instruction, (e) delivered reinforcers for play responses during teaching sessions, (f) delivered reinforcers for attending responses during baseline and probe sessions, and (g) that the learners used the scripts.

Observers used an event recording system to score play and verbal responses. If the learner repeated the previously scored play or verbal response within 5-seconds, observers did not score the second response. If more than 5-seconds elapsed since the previous response, and the learner repeated the same response, the observers scored it as a new response. If the learner engaged in a play response, then engaged in another play response, and then emitted the first play response, observers scored the first response twice. For example, if the learner stirred the bowl, poured flour into the bowl, and then stirred the bowl again, then observers scored the first response (stirred the bowl) twice. So, observers scored three play responses. If the learner engaged in the same play response (e.g., stirred the bowl) with a different object (e.g., stirred with yellow spoon then stirred with white spoon), observers scored two responses.

#### *Interobserver Agreement*

The experimenter scored agreements for play responses, functional and symbolic, and verbal responses, scripted and unscripted, only if both observers recorded the same

response and in the same sequence. The experimenter calculated percentage agreement on each of the dependent variables by dividing the total number of agreements by total number of agreements plus disagreements, and multiplying by 100%. Interobserver agreement data for each learner is discussed in their corresponding sections (e.g., under the heading *Symbolic Play: Mitchell*). The experimenter collected IOA on procedural integrity. Observers recorded procedural integrity in the same manner as the dependent measures, previously described.

### *Social Validity*

The experimenter used video recordings to assess the social validity of play instruction. Nine graduate students, from an applied behavior analysis class, served as judges. The experimenter presented a brief introduction indicating that the judges would be viewing video segments of recently completed research of play skills of children with autism. Judges were presented with multiple pairings of video segments. The experimenter asked judges to indicate in which of the two video segments did play by the child look more typical. The order presentation of the video pairings was counter balanced. The judges were not told which video segments were from which condition. The experimenter did not define the term *play*. The video segments were samples of sessions recorded during baseline and intervention. They were selected randomly from the video recordings, from the final three recorded sessions of baseline and the final three recorded sessions of intervention. There were a total of 20 video segments for each learner, 10 baseline and 10 intervention. The experimenter presented the video pairings for each learner consecutively so that the judges viewed 10 video pairings for Mary, followed by 10 video pairings for Ian, then 10 video pairings for Mitchell, and finally 10

video pairings for Derek. The judges viewed a total of 80 video segments, or 40 baseline-intervention video pairings. This activity was approximately 40 minutes in duration.

## Functional Play

### *Participants*

Two of the learners, previously described, learned functional play responses.

### *Materials*

*Play Materials.* The experimenter presented one set of 25 to 30 conventional toys to the learners during teaching and test sessions. Table 2 displays conventional toys used during baseline, intervention, test, and follow-up sessions.

*Activity Schedules.* There were three primary activity schedules for each learner corresponding to each play activity (house, kitchen, doctor) for a total of three books for a learner. The books were .10 m X .15 m photo books with clear insertable pages. Each primary book contained three photographs (.09 m X .06 m). The photographs depicted secondary activities (e.g., baby in cradle). The secondary activity schedules were play schedules, one for each play activity depicted in the primary schedule for a total of three secondary schedules. The secondary schedules were four photographs on laminated paper depicting play responses related to the play activity (e.g., a picture of the baby in the cradle drinking a bottle). The experimenter placed the photographs on .08 m height X .30 m width plastic strips. The laminated photographs were .08 m width X .06 m height and the experimenter attached the strips using Velcro coin fasteners. There were 3 teaching and 6 probe photographs for each secondary activity. For house, there were 6 secondary activities (e.g., baby in seat). For kitchen and doctor, there were 3 secondary

activities (e.g., prepare food and examine patient, respectively). For each secondary activity, there were two or three sets of photographs corresponding to different sets of materials (e.g., baby #1 in highchair and baby #2 in highchair; cook food—hot dog and vegetables, cook food—steak and eggs, cook food—hamburger and pie; fix hurt patient—yellow bear, fix hurt patient—white bear, fix hurt patient—koala bear). The play responses were identical across the different sets of materials (e.g., stir food in red bowl and stir food in white bowl). The photographs and sets were rotated randomly across sessions using a design matrix so that the learner used a different order each consecutive session. Table 3 displays a sample list of primary and secondary activity schedules for the play activity, house.

*Scripts.* Scripts were pre-recorded phrases or sentences on audio recording devices. The experimenter mounted the audio recording devices on the front cover and inside back cover of the primary schedule, as well as on play objects (e.g., the script “I feed baby” was attached to the highchair using Velcro coin fasteners). The learners used the scripts at the beginning (e.g., “time to play house) and ending of each play activity (“done with house”), as well as at the beginning of each secondary schedule (e.g., “take a bath”). The scripts corresponded to the play activities or responses. The scripts were general so that they can be used with a variety of different play activities or responses. For example, the script “the baby is hungry” could have been attached to the highchair and baby seat. The learners used five scripts each session for a given play activity. The learners used two or three versions of scripts for each beginning, ending, or secondary activity. The experimenter rotated versions of scripts for each play activity across

sessions so that the learner used a different version each consecutive session (Krantz & McClannahan, 1993). Table 4 displays scripts for the play activity, doctor.

### *Dependent Measures*

Observers recorded *prompted* and *unprompted functional play responses*, *cumulative spontaneous functional play responses*, as well as *scripted* and *unscripted verbal responses*, as described in the general procedure section. They also recorded responses during two probe types. First, observers scored *probe functional play responses* during teaching sessions when the learner engaged in play responses that were depicted in the learner's activity schedule, but that the experimenter never manually prompted or reinforced. Second, observers scored *functional play responses* during test sessions if the learner engaged in play responses in the absence of the intervention package. Observers scored *functional play responses* in two ways. First, observers scored the total number of play responses. Second, observers categorized play responses as *teaching*, *probe*, or *other*. *Teaching functional play responses* were those that were depicted (shown as photographs in activity schedules), manually prompted, and reinforced during training sessions. *Probe functional play responses* were those that were depicted, but not manually prompted or reinforced, during teaching sessions. *Other functional play responses* were those responses that were not depicted, prompted, or reinforced during teaching sessions. These responses were not seen before during teaching or probe sessions.

### *Procedure and Experimental Design*

*Design.* The experimenter used the same experimental design, as described in the general procedure section.

*Baseline.* The experimenter used the same general procedures, as previously described in the general procedure section. The experimenter delivered nine tokens for attending responses throughout each baseline session, which was the same as the number of play responses during teaching sessions.

*Intervention.* The experimenter used the same general procedures, as previously described, with a few modifications. First, for Mary, the play activities were house, kitchen, and doctor. For Ian, the experimenter implemented the same activities, but in the different order, kitchen, doctor, and house. Second, the experimenter presented activity schedules as photographic schedules with both learners, instead of written checklists. Third, the experimenter used audio-recorded devices, rather than textual scripts.

The experimenter chose different criteria to begin teaching new activities, to fade play response photographs, and to fade scripts for Mary and Ian. First, for Mary, to begin a new play activity, when Mary engaged in the same number of prompted play responses for at least three consecutive sessions, the experimenter introduced a new play activity. For example, when Mary engaged in three prompted play responses for three sessions during the play activity kitchen, the experimenter introduced the next activity, doctor. Second, the experimenter faded play photographs by cutting away portions of the pictures when the learner engaged in increases in unprompted play responses. The experimenter completely faded photographs when manual guidance was no longer used (0 prompted play responses for house and kitchen) or stable for three sessions (0, 1, and 1 for doctor). The experimenter removed secondary schedules when mean unprompted play responding was at or above criterion (9 play responses). Full photographs were .08 m width X .06 m height, fading step 1 was .07 m width X .05m height, fading step 2 was .06 m width X

.04 m height, fading step 3 was .04 m width X .03 m height, fading step 4 was .03 m width X .01 m height, fading step 5 was no photographs, and fading step 6 was the secondary schedules were removed. Third, once the learner repeated the scripts correctly for two consecutive sessions, the experimenter faded the scripts. The experimenter faded the audio-taped scripts by deleting portions of the script from end to beginning (e.g., full script “the baby is so tired”; fading step 1 “the baby is so       ”; fading step 2 “the baby is       ”, fading step 3 “the baby       ”, fading step 4 “the       ”, and fading step 5 “       ”).

During each play activity for Ian, the experimenter implemented a total of only 10 scripts rather than 15 scripts used by Mary. Both learners used the same criterion number of scripts. That is, during each session there were 5 criterion scripted responses for a given play activity. In addition, the scripts were 3 words, as opposed to 4 words used by Mary. The experimenter used fewer script-fading steps since the phrases were shorter. Also, the experimenter faded the play responses in fewer steps, fading step 1 (F1) to fading step 4 (F4), as opposed to fading step 1 (F1) to fading step 6 (F6) for Mary. As a result, the experimenter chose different criteria for Ian to begin teaching new activities, to fade play response photographs, and to fade scripts. First, to begin a new play activity, when the learner engaged in the same number of prompted play responses for at least two consecutive sessions (e.g., doctor was stable at 3 prompted play responses for two consecutive sessions) the experimenter introduced a new activity (e.g., house). Second, the experimenter faded the play photographs by cutting away portions of the pictures when the learner engaged in systematic increases in unprompted play responses. Fading of play responses for one activity never coincided with (a) fading of play responses for

another activity, (b) the introduction of a new play activity, and (c) never followed a test session. The experimenter implemented F1 when the learner engaged in at least 3 unprompted play responses for 3 consecutive sessions. The experimenter implemented F2 when the learner engaged in at least 5 unprompted play responses for 3 consecutive sessions. The experimenter implemented F3 when the learner engaged in 9 unprompted play responses and 0 prompted play responses for 2 consecutive sessions. For kitchen and house, the experimenter implemented F4 when the learner engaged in more than 9 unprompted play responses for 4 consecutive sessions. For doctor, the experimenter implemented F4 when the learner engaged in 9 unprompted play responses for 1 session. Full photographs were .08 m width X .06 m height, F1 was .06 m width X .04 m height, F2 was .03 m width X .01 m height, F3 was photographs fully faded, and F4 was secondary schedules were removed. Third, the experimenter also faded scripts by systematically removing portions of the scripts from end-to-beginning. When the learner repeated each script correctly, the experimenter implemented F1. For kitchen and house, the experimenter implemented F2 when the learner emitted at least 1 unscripted verbal response. For doctor, the experimenter implemented F2 when the learner repeated at least 4 scripts correctly for 3 consecutive sessions. For kitchen and house, the experimenter implemented F3 when the learner emitted at least 1 unscripted verbal response for 2 consecutive sessions. For doctor, the experimenter implemented F3 when the learner repeated at least 4 scripts correctly for 3 consecutive sessions. The experimenter implemented F4 temporarily for house when the learner emitted at least 5 unscripted responses for 2 consecutive sessions. The experimenter reinstated F3 when the learner emitted 2 unscripted verbal responses for 2 consecutive sessions.

*Probes.* Probe play responses, similar to teaching play responses, were presented as photographs in the activity schedules. Differently from teaching play responses, the experimenter did not manually prompt or reinforce the learner for engagement in probe play responses. The experimenter randomly interspersed one probe photograph among three teaching photographs for each secondary schedule for a total of three probe play responses each session. The experimenter always positioned the probe photograph second or third among the four pictures in the secondary schedule play strip. The experimenter randomly selected the probes from a field of six probe photographs corresponding to a secondary activity (e.g., baby in tub).

*Test Sessions.* The test sessions were identical to the final fading step of teaching. That is, the experimenter presented the primary schedules, but not the secondary schedules. Test sessions were conducted approximately once every ten sessions after the experimenter implemented teaching for a given activity. The experimenter did not provide manual prompts or reinforcers for play or verbal responses. There was a differential reinforcement schedule for play responding in effect. That is, if the learner engaged in a play response, the experimenter waited three-seconds before she delivered the scheduled reinforcer. The experimenter provided reinforcers for attending responses only. Follow-up data for test sessions were not obtained because responding during follow-up teaching sessions was the same as responding during test sessions.

*Follow-up sessions.* Follow-up sessions were conducted, as previously described.

#### *Interobserver agreement*

Observers collected IOA, as previously described. For Mary, observers collected IOA on 60%, 38%, and 35% of baseline sessions for house, kitchen, and doctor,

respectively. The mean agreement for the presence or absence of functional play and verbal responses during baseline sessions was 100%, across all activities. Observers collected IOA during 32%, 33%, and 31% of teaching sessions on the number of play responses for house, kitchen, and doctor, respectively. Mean agreement and ranges of IOA on the number of functional play and unscripted verbal responses were not obtained during a 6-week follow-up. For Ian, observers collected IOA 13%, 29%, and 32% of baseline sessions for kitchen, doctor, and house, respectively. The mean agreement for the presence or absence of functional play and verbal responses during baseline sessions was 100%, across all activities. Observers collected IOA 31%, 28%, and 28% of teaching sessions on the number of play responses for kitchen, doctor, and house, respectively. Table 5 provides mean agreement and ranges for play and verbal responses, across three activities, for Mary and Ian. Measures of IOA were not obtained during a 5-week follow-up.

#### *Procedural integrity*

For Mary, procedural integrity was measured on 40% of baseline sessions and 7% of teaching sessions for house, 12% of baseline sessions and 9% of teaching sessions for kitchen, and 9% of baseline and teaching sessions for doctor. Across all three activities, during baseline and teaching, percentage correct steps of the experimenter's delivery of the procedure was 100%. Mean agreement was 100% for all measures, across all activities. Procedural integrity data were not collected during follow-up sessions.

For Ian, procedural integrity was collected on 13% of baseline sessions and 25% of teaching sessions for kitchen, 6% of baseline and 25% of teaching sessions for doctor, and 9% of baseline and 22% of teaching sessions for house. Procedural integrity was

collected on 50% of follow-up sessions. Percentage correct steps of the experimenter's delivery of the procedure was 100%, across all three play activities, during baseline and teaching. Mean agreement was 100% for all measures, across all activities. Procedural integrity was not collected during follow-up sessions.

### *Social Validity*

As described above, video recordings were used to assess the social validity of play instruction. The same procedures were used.

### Symbolic Play: Mitchell

#### *Participant*

Mitchell learned symbolic play responses. Information regarding Mitchell was previously described.

#### *Materials*

*Play Materials.* Experimenters presented one set of twenty objects including conventional toys and non-conventional objects to the learner during baseline, intervention, and follow-up sessions. Experimenters presented a novel set of twenty objects—combined conventional and non-conventional objects—to the learner during generalization probes. Experimenters also presented one doll to the learner during all sessions. Table 6 displays the toys and non-conventional objects used during baseline, intervention, and follow-up sessions. Table 7 displays the toys and non-conventional objects used during generalization sessions.

*Activity Schedules.* The experimenter displayed schedules as written checklists attached to small clipboards. Each activity had one primary schedule and three secondary schedules. The primary schedules were sets of words or phrases representing play

activities (e.g., “*make eggs*”) that led to a secondary schedule. The experimenter rotated three versions of secondary schedules for a play activity in an alternating fashion across sessions so that the same version was not used by the learner across consecutive sessions. Each secondary play schedule consisted of sets of words or phrases representing specific play responses related to the play activity (e.g., read a story to the class). Table 8 displays a sample primary and secondary activity schedule used for the play activity, chef.

*Scripts.* Scripts were textual phrases or sentences. The experimenter interspersed five scripts across the ten play responses each session. There were two sets of scripts, primary and secondary. There were three versions of scripts, for a total of fifteen scripts. Experimenters rotated the scripts in an alternating fashion so that the same five scripts were not used during consecutive sessions. Scripts were generally related to the play activity so that the same script could be used for a number of different play responses. For example, a script such as *the oven is hot* was followed by different play responses such as putting on oven mitts, putting a pan in the oven, or preparing the dishes for dinner. Table 9 displays scripts used for the play activities, chef and teacher.

#### *Dependent Measures*

For Mitchell, the dependent measures recorded were *prompted* and *unprompted symbolic play responses*, *scripted* and *unscripted verbal responses*, and *cumulative spontaneous symbolic play responses*, as previously described. Observers also measured the number of *symbolic play responses* during generalization sessions. Like the measurement of probe play responses during test sessions for Mary and Ian, observers scored *symbolic play responses* during generalization sessions if the learner engaged in

play responses in the absence of the intervention package. Differently from Mary and Ian, the play materials used during generalization sessions for Mitchell were novel.

### *Procedures and Experimental Design*

*Experimental Design.* The experimenter used the same experimental design, as previously described.

*Baseline.* The experimenter used the same general procedures. The experimenter delivered ten tokens for attending responses throughout all baseline sessions, which was the same as the number of play responses during teaching sessions.

*Intervention.* The experimenter used the manual guidance procedure (cf. Krantz & McClannahan, 1999), previously described, however the procedures were slightly different for textual schedules. The experimenter stood behind the learner and delivered manual guidance to pick up the pencil and follow the pencil along the text (Krantz & McClannahan, 1999). If the learner engaged in the play response and read the script, the experimenter prompted the learner to check a box next to the corresponding play response and script. If the learner did not engage in the corresponding play response and/or read the script within 5-seconds, the experimenter repeated manual guidance. The experimenter did not deliver verbal instructions. The experimenter delivered reinforcers, when the learner engaged in a play response, according to a continuous reinforcement schedule. The experimenter did not deliver reinforcers for verbal responses.

For Mitchell, the experimenter chose different criteria to begin teaching new activities, fade play responses, and fade scripts. First, the experimenter introduced a new play activity (e.g., teacher) when Mitchell engaged in at least two consecutive teaching sessions of 8 unprompted play responses. The introduction of a new play activity did not

follow a generalization session, so, the experimenter implemented the play activity teacher following three, rather than two consecutive teaching sessions.

Second, the experimenter systematically faded scripts indicating play responses. The experimenter faded by removing portions of the text from end-to-beginning (e.g., the full play response, *doll cracks eggs in pan*; F1 *doll cracks eggs in*, F2 *doll cracks eggs*, F3 *doll cracks*, F4 *doll*, and F5 *blank*). The experimenter introduced fading step 1 (F1) when the learner engaged in at least one session of 6 unprompted play responses, across two activities, chef and teacher. For doctor, the experimenter introduced F1 after the first three consecutive teaching sessions, 10 unprompted play responses and 0 prompted play responses. The experimenter introduced fading step 2 (F2) when the learner engaged in at least 3 unprompted play responses, for two consecutive sessions, across all activities. The experimenter introduced fading step 3 (F3) when the learner engaged in at least two consecutive sessions of 8 unprompted play responses, across two activities, chef and teacher. For doctor, the learner proceeded from F2 to F4, without F3. The experimenter introduced fading step 4 (F4) when the learner engaged in at least two consecutive sessions of at least 9 unprompted play responses, across all activities. The experimenter completely faded the scripts indicating the play responses (F5), across all activities, after the learner no longer required prompts to engage in play responses and unprompted play responses were at, or above, criterion.

Third, the experimenter systematically faded scripts by cutting away portions of the scripts from end-to-beginning (e.g., the script “it’s time to eat”, F1 was “it’s time to”, F2 was “it’s time”, F3 “it’s”, and F4 was blank). For all play activities, the experimenter introduced F1 when the learner engaged in at least 1 unscripted verbal response, F2 at

least 2 unscripted verbal responses, and F3 at least 3 unscripted verbal responses. For chef and teacher, the experimenter introduced F4 when the learner engaged in at least 5 unscripted verbal responses. For doctor, the experimenter introduced F4 when the learner engaged in two consecutive sessions of at least 2 unscripted verbal responses. If the learner engaged in fewer than 5 unscripted verbal responses at F4, the experimenter reimplemented the previous fading step.

*Generalization.* The experimenter implemented the same procedures used during generalization as those used during baseline sessions. The play materials were different from the ones used during intervention. For example, the experimenter placed a novel set of conventional toys and non-conventional objects (e.g., chalkboard, chalk, ribbon, shoelaces, aluminum foil, etc.) on the table.

*Follow-up.* The experimenter implemented the same procedures as during the final teaching and generalization sessions.

#### *Interobserver Agreement*

Observers collected IOA on the number of symbolic play responses during 64% of baseline sessions for chef, 48% of baseline sessions for teacher, and 39% of baseline sessions for doctor. IOA was 100% for all activities. Observers collected IOA on the number of prompted and unprompted symbolic play responses during 31% of teaching sessions for chef, 19% of teaching sessions for teachers, and 26% of teaching sessions for doctor. IOA for prompted play responses was 100% for all activities. Mean agreement and ranges of IOA for unprompted play responses were 100%, 100%, and 98% with a range from 88-100%, respectively. Observers collected IOA on the number of symbolic

play responses during 29% of generalization sessions. IOA was 100% across all three play activities.

During baseline, observers collected IOA during 64% of sessions for chef, 48% for teacher, and 39% for doctor. IOA was 100% across all activities. During teaching, observers collected IOA on the number of scripted and unscripted verbal responses during 31% of sessions for chef, 19% for teacher, and 26% for doctor. IOA for scripted responses was 99% (range from 80-100%) for chef, 100% for teacher, and 100% for doctor. IOA for unscripted responses was 99% (range from 83-100%) for chef, 100% for teacher, and 100% for doctor. During generalization, observers collected IOA on the number of verbal responses during 29% of sessions. IOA was 100%, across all three play activities. Observers did not collect IOA during follow-up sessions.

#### *Procedural Integrity*

Observers collected procedural integrity on 2% of baseline sessions and 24% of teaching sessions for chef, 36% of baseline sessions and 13% of teaching sessions for teacher, and 26% of baseline sessions and 16% of teaching sessions for doctor. Mean agreement was 100% for all measures, across all activities. Observers did not collect procedural integrity data during follow-up sessions.

#### Symbolic Play: Derek

#### *Participant*

Derek engaged in symbolic play responding. Information regarding Derek was previously described.

### *Materials*

*Play Materials.* The experimenter presented one set of twenty-five to thirty combined conventional and non-conventional objects to the learner during teaching and generalization trials. Table 10 displays conventional toys and non-conventional objects that were used during baseline, intervention, and test sessions.

*Activity Schedules.* The experimenter presented primary schedules in the same format as used by Mary and Ian, but only one secondary schedule was on a play strip. The experimenter presented the remaining five secondary schedules in 3-ring laminated books. The experimenter depicted one secondary schedule for each play activity in the primary schedule for a total of two secondary schedules. The secondary schedules were six photographs, attached to laminated .10 m X .15 m pages in a book, depicting play responses related to the play activity (e.g., a photograph of a doll stirring food in a pot). The full-size laminated photographs were .08 m width X .06 m height and the experimenter attached them to the pages or strip using Velcro coin fasteners. There were a total of 6 teaching and 12 probe photographs for each secondary activity. For all play activities, there were a total of 2 secondary activities (e.g., car garage and community mat). For each secondary activity, there were one to three sets of photographs corresponding to different sets of materials (e.g., man driving block car, woman driving box, girl driving green foam car; girl doll preparing food, boy doll preparing food; koala examining patient). The play responses were identical across the different sets of materials (e.g., woman driving box down ramp, man driving block down ramp, girl driving green-square down ramp). The experimenter randomly rotated the photographs and sets across sessions using a design matrix so that the learner used a different order

each consecutive session. Table 11 displays a sample list of primary and secondary activity activities for the play activity, cars.

*Scripts.* The scripts used by Derek were the same as those described as used by Mary and Ian. Table 12 displays a list of sample scripts used for the play activity, cars.

#### *Dependent Measures*

Observers recorded the same dependent measures as those recorded for Mary and Ian.

#### *Procedures and Experimental Design.*

The experimenter implemented the same baseline and generalization procedures, as well as experimental design, as used by Mary and Ian. The experimenter did not conduct follow-up sessions.

*Baseline.* The experimenter used the same procedures as those described. The experimenter delivered eight tokens for attending responses during baseline sessions, which was the same as the number of play responses during teaching sessions.

*Intervention.* The experimenter implemented the same procedures as those described. The criterion to begin teaching play activities (e.g., kitchen) was the same as used for Mary and Ian. The fading steps for play responses were identical to Ian. Full photographs were the same size, .08 m width X .06 m height. Fading step 1 (F1) was .06 m width X .04 m height, fading step 2 (F2) was .03 m width X .02 m height, fading step 3 (F3) was photographs fully faded, and fading step 4 (F4) was the experimenter removed the secondary schedules. The criteria for fading from full photographs to F1 was 2 consecutive sessions of 4 unprompted play responses, from F1 to F2 was 1 session of 8 unprompted, to F3 was 3 consecutive sessions of 8 unprompted play responses, and to F4

was at least 3 consecutive sessions of 8 or more unprompted play responses. Also, there were four script-fading steps. The steps were similar as those described above, used by Mary. Criteria were similar, with the exception that script-fading never coincided with fading of play responses, so there were occasions when the learner met criterion for implementing script-fading, but the experimenter did not fade the scripts until the following session.

#### *Measurement Procedures*

Observers recorded measures for the dependent and independent variables as previously described.

#### *Interobserver Agreement*

Observers collected IOA on the occurrence and non-occurrence of symbolic play responses during 36%, 33%, and 37% of baseline sessions for cars, kitchen, and doctor, respectively. IOA was 100% across all three activities. Observers collected IOA during 35%, 33%, and 34% of teaching sessions on the number of play responses for cars, kitchen, and doctor, respectively. Table 13 provides mean agreement and ranges for play and verbal responses, across three activities, for Derek.

#### *Procedural Integrity*

For Derek, observers collected procedural integrity on 9% of baseline sessions and 19% of teaching sessions for cars, 9% of baseline sessions and 22% of teaching sessions for chef, and 9% of baseline sessions and 24% of teaching sessions for doctor. Across all three activities, during baseline and teaching, percentage correct steps of the experimenter's delivery of the procedure was 100%. Mean procedural integrity was

100% for all measures, across all activities. Observers did not collect procedural integrity data during follow-up sessions.

### *Social Validity*

As described above, the experimenter used video recordings to assess the social validity of play instruction.

## Results and Discussion

There will be a brief results and discussion section for each dependent measure followed by a general discussion. The experimenter taught functional play responding to Mary and Ian and symbolic play responding to Mitchell and Derek. The experimenter labeled the data in the figures *functional* or *symbolic* to reflect what we were teaching. Both these sets of data are best described simply as *play* data.

### *Play Responding with Activity Schedules*

All learners showed a systematic increase over baseline in the number of unprompted functional or symbolic play responses with the introduction of activity schedules with script-fading. Furthermore, there was a decrease, over time, in prompted functional and symbolic play responses for all learners. To familiarize the reader with the graphs, a detailed description of Figure 1 for Mary, is included.

Figure 1 displays the number of prompted and unprompted functional play responses, for Mary, across three different activities during baseline, activity schedules with script fading, and follow-up sessions. The arrows indicate the fading steps, F1 through F6. The horizontal criterion line indicates the number of teaching photographs presented for a given activity, during teaching. During baseline, the number of functional

play responses was steady at 0 across all three activities, with the exception of 1 unprompted play response during sessions 2 and 3 for the play activity, kitchen.

For the first activity, house, with the introduction of activity schedules with script fading, there was an increasing trend in the number of unprompted functional play responses from 0 in session 10 of baseline to a high of 14 in session 59. At the same time, there was a decreasing trend in prompted functional play responses from 9 in session 11 to 0 in session 59. Once pictures were fully faded (F5) in session 60, unprompted play responding leveled off with a range of scores between 7 and 19. Once play schedules were removed in session 85, the level of unprompted play responding decreased slightly, with a range of scores between 6 and 12, but responding remained higher than baseline levels. For kitchen and doctor, there were similar increasing trends in the number of unprompted functional play responses and decreasing trends in the number of prompted functional play responses. The number of unprompted functional play responses also leveled off when pictures were fully faded and play schedules were removed.

The experimenter conducted 6-week follow-up sessions under the fading step 6 procedure. Responding for the first activity, house, was slightly lower, 8 and 7, in sessions 94 and 95, respectively, but it was above baseline levels. For the second activity house, responding maintained at 11 and 10 in sessions 94 and 95, respectively. For the third activity, doctor, responding was slightly lower, 8 and 7 in sessions 94 and 95, respectively, but it remained above baseline levels.

Figure 2 depicts Ian's responding. Note that Ian received training on play activities in a different order from Mary's—kitchen, doctor, and house. Results similar to those found for Mary were found for Ian. There was a systematic increase in the number

of unprompted play responses with the introduction of the intervention package. There was a decrease over time in the number of prompted play responses. The number of unprompted play responses leveled off when pictures were fully faded and play schedules were removed. During follow-up sessions, the number of unprompted play responses, for each of the three play activities fell within the range of scores obtained at the end of treatment. In all cases they were above baseline levels.

Figure 3 depicts Mitchell's results. Similar results as those for Mary and Ian were found for Mitchell. There was a systematic increase in the number of unprompted symbolic play responses with the introduction of treatment. In addition, there was a decrease, over time, in the number of prompted symbolic play responses, across all three activities. Similar to Mary and Ian, the number of unprompted play responses maintained during follow-up sessions. Responding fell within the range of scores obtained at the end of treatment and was above baseline levels, for all three play activities.

Figure 4 depicts Derek's responding. Similar results to those of Mary, Ian, and Mitchell were found for Derek. There was a systematic increase in the number of unprompted symbolic play responses with the introduction of the intervention package. Also, there was a decrease, over time, in the number of prompted symbolic play responses. Follow-up data were not obtained for Derek.

#### *Play Responding: Conclusions*

Because there was a systematic increase in the number of unprompted functional and symbolic play responses across all learners, with the introduction of activity schedules with embedded script fading, one may conclude that the intervention package caused the increase in play responding. Because the follow-up data obtained 4-6 weeks

after treatment were all within the range of the last treatment sessions and because all were above baseline levels, the effects of the treatment package appeared durable over time.

*Test Sessions: Play Responding without Activity Schedules or Scripts*

Data for the three learners who experienced test sessions are shown in Figures 5, 6, and 7. As previously described, play responses were recorded during test sessions which were conducted in the absence of the intervention package. Data during test sessions were obtained in the same setting and with the same play materials as during treatment, but there were no activity schedules or scripts used during these sessions. All three learners demonstrated a systematic increase in the number of unprompted functional and symbolic play responses over baseline with introduction of the treatment package (activity schedules with script-fading).

Figure 5 displays the number of functional play responses during test sessions in baseline and treatment, for Mary. During baseline, the number of functional play responses was 0 for house and doctor. For kitchen, there was 1 functional play response in sessions 2 and 3, with a return to 0 for the next 30 sessions. For the first activity, house, with the introduction of activity schedules and script fading, there was an increasing trend in the number of functional play responses from 0 in session 10 of baseline to a high of 22 in session 87. Similar results were demonstrated for the second and third activities, kitchen and doctor. Thus, there was a systematic increase in the number of play responses during test sessions with the introduction of the treatment package for responding during training sessions.

Figure 6 and 7 depicts Ian and Derek's responding, respectively. Results similar to those of Mary were demonstrated for Ian and Derek. That is, there was a systematic increase in the number of functional play responses during test sessions with the introduction of the treatment package, across activities.

It should be noted that Mary and Derek engaged in more play responses during test sessions than Ian. This may be because Ian had less experience with play responding because he had fewer sessions (60 as opposed to 79 and 91), and because the activity schedules were faded more quickly for Ian. In addition, all three learners engaged in more probe play responses during test sessions for the first play activities (house, kitchen, and cars for Mary, Ian, and Derek, respectively) than the second or third activities. This may be because all the learners had more sessions with the play responses for the first activities.

#### *Test Sessions: Conclusions*

Because there was a systematic increase in the number of functional and symbolic play responses across all three learners, during test sessions, with the introduction of activity schedules with script-fading for the training sessions, one may conclude that the intervention procedure caused the increase in play responding in the absence of activity schedules and scripts. Activity schedules with embedded script-fading was a successful procedure to increase generalized play responding by children with autism.

#### *Test Sessions: Teaching, Probe, and Other Play Responding*

As previously described, three learners experienced test sessions. The experimenter categorized play responding during test sessions into teaching, probe, and other play responses, as shown in Table 14. Again, teaching responses were those that

were depicted in the photographic activity schedules, manually prompted, and reinforced during training sessions. Probe responses were those that were depicted, but not manually prompted or reinforced during training. Other responses were those that were not depicted, manually prompted, or reinforced. As one would expect, most of the play responding during test sessions consisted of responses that had been directly taught, followed by probe responding, and finally other responding.

*Mitchell: Symbolic Play Responding during Generalization Sessions*

Mitchell emitted symbolic play responding during generalization sessions, shown in Figure 8. Symbolic play responses were recorded during generalization sessions if Mitchell engaged in play responses without the presence of the intervention package. Like Mary, Ian, and Derek, probe play responding for Mitchell was obtained during separate sessions. Unlike Mary, Ian, and Derek, probe play responding was obtained with different play materials and generalization sessions occurred more frequently (after every three teaching sessions as opposed to ten). Mitchell did not demonstrate systematic increases in symbolic play responses, over baseline, with the introduction of the treatment package. Figure 8 displays the number of symbolic play responses, for Mitchell, during generalization sessions. During baseline for all activities, the number of symbolic play responses was stable at 0. With the exception of the first activity, the number of symbolic play responses remained steady at 0 throughout teaching and follow-up sessions.

While procedures were designed to attempt to promote generalization for Mitchell (e.g., using multiple exemplars), he did not demonstrate generalized responding. A possible reason for this failure is that the reinforcement contingencies were discriminable

to Mitchell. First, generalization and teaching sessions occurred separately. During generalization sessions an extinction schedule was occurring and during teaching schedules a 1:1 schedule of reinforcement was occurring. Second, during generalization sessions, different play materials were used. These play materials may have been associated with extinction. Third, generalization sessions were conducted frequently, after every third teaching session. Perhaps this frequency fostered discrimination between training and generalization sessions.

#### *Symbolic Play Responding during Generalization Sessions: Conclusions*

Because there was not a systematic change in the number of symbolic play responses for Mitchell, during generalization sessions, with the introduction of activity schedules with script-fading, one may conclude that the intervention procedure did not cause a change in play responding in the absence of activity schedules and scripts.

#### *Probe Play Responding*

As previously described, because generalized responding was not demonstrated by Mitchell, procedures were changed to attempt to improve the performance of subsequent learners (Mary, Ian, and Derek). Instead of assessing generalization during a separate session (Mitchell), teaching responses and generalization responses were interspersed during the training session (Mary, Ian, and Derek). Three of the four learners experienced probe play responding. Probe play responses were recorded during teaching sessions if the learner engaged in play responses with the presence of activity schedules, but without the delivery of prompts or reinforcers for play responding. Figures 9, 10, and 11 show that all three learners demonstrated systematic increases in the number of probe functional and symbolic play responses, over baseline, with the

introduction of the treatment package. A detailed description of Figure 9 for Mary is included.

Figure 9 displays the number of probe functional play responses, for Mary, during baseline, teaching, and follow-up sessions. During baseline for all activities, the number of probe play responses was steady at 0. There was an increasing trend in the number of probe play responses, for the first activity, from 0 in session 10 of baseline to a high of 4 in session 59. Once pictures were removed (F5) responding leveled off, with a range of scores from 2 to 10 over the next 24 sessions. Once secondary schedules were removed (F6), responding maintained, with a range of scores from 3 to 12 over the next 7 sessions. Similar results were demonstrated for kitchen and doctor. During follow-up sessions 94 and 95, the number of probe play responses for house was 7 and 9, in sessions 94 and 95, respectively. For kitchen, the number of probe play responses was slightly lower, 2 and 3, respectively, but remained above baseline levels. For doctor, the number of probe play responses was slightly lower, 3 and 3, but also remained above baseline levels.

Figure 10 depicts Ian's responding. Results similar to those found for Mary were found for Ian. There was a systematic increase in the number of probe play responses with the introduction of the treatment package. Unlike Mary, when the play responses were fully faded (F4) for kitchen, the number of probe play responses decreased and remained stable at 0. Alternatively, when play responses for doctor and house were fully faded, the number of probe play responses remained within the range of scores obtained prior to F4. During follow-up sessions, probe play responding fell within the range of scores obtained during teaching. In addition, with the exception of the first follow-up session for the play activity, kitchen, all scores remained above baseline levels. Figure

11 displays Derek's results. Similar results as those found for Mary and Ian were demonstrated for Derek. There was a systematic increase in the number of probe play responses, for all activities, with the introduction of the treatment package. Similar to Mary for the first play activity, cars, when the final fading step (F4) was introduced, the number of probe symbolic play responses increased. Unlike Mary, when F4 was introduced for the second and third play activities, responding decreased. Follow-up data were not obtained for Derek.

There were individual differences among learners in the number of probe play responses. Only Mary continued to demonstrate systematic increases in probe responding for all three play activities, after pictures were fully faded (F6). As previously described, there were a total of 12 probe play responses for each secondary activity and only 3 probe play responses were presented each session. Probe pictures were rotated across sessions. As a result, because Mary had the largest number of play sessions (91), she had more opportunities to engage in all of the probe play responses on repeated occasions.

#### *Probe Play Responding: Conclusions*

The same functions as demonstrated with play responding during teaching and test sessions, were observed with probe play responding. Activity schedules with embedded script-fading was also a successful procedure to increase generalized play responding by children with autism.

#### *Cumulative Spontaneous Play Responding*

Spontaneous play responding, scored if the learner engaged in spontaneous play responses that were not previously emitted, is plotted cumulatively for each learner

(Figures 12-15). All four learners showed a systematic increase in the cumulative number of spontaneous functional or symbolic play responses, over baseline, with the introduction of activity schedules with embedded script-fading.

Figure 12 displays the cumulative number of spontaneous functional play responses for Mary during baseline, activity schedules with script fading, and follow-up sessions, for three activities. During baseline, the cumulative number of spontaneous functional play responses was steady at 0, across all activities. For the first activity, house, with the introduction of activity schedules and script fading, there was an increasing trend in the number of cumulative responses from 0 in session 19, to 51 by session 72 when responding remained stable during the next 21 sessions. For the second activity, kitchen, with the introduction of activity schedules and script fading, there was also an increasing trend in the number of cumulative responses from 0 in session 37 to 36 in session 93. For the third activity, doctor, with the introduction of activity schedules and script fading, again there was an increasing trend in the cumulative number of spontaneous functional play responses from 0 in session 51 to 19 in session 93. During follow-up sessions, the cumulative number of spontaneous functional play responses increased slightly to 53 for house, 38 for kitchen, and 20 for doctor.

Figures 13-15 display cumulative responding for Ian, Mitchell, and Derek, respectively. Results, similar to those found for Mary, were found for these learners. There was a systematic increase in the cumulative number of spontaneous functional play responses, over baseline, with the introduction of the treatment package. During follow-up sessions, responding continued to increase.

Similar to the results of probe play responding, all four learners engaged in the highest cumulative number of spontaneous play responses for the first trained play activity. Aside from the fact that learners experienced the greatest number of teaching sessions with the first play activity, differences in spontaneous responding may reflect the differences in the play activities themselves. First, some activities may have taken longer than others. The outcome data would then indicate that the learners engaged in fewer responses for that activity. For example, checking blood pressure with the blood pressure monitor took longer than feeding baby with a bottle. So there would be fewer responses during doctor than during house. Second, a learner may have had prior experience with the activity. For example, Derek's mother reported that he engaged in functional play responses with cars. As a result, Derek may have engaged in more spontaneous play responding during cars than kitchen or doctor.

#### *Cumulative Play Responding: Conclusions*

Activity schedules with embedded script-fading was a successful procedure to increase the cumulative number of spontaneous play responding by children with autism.

#### *Verbal Responding*

Verbal responding was utterances that accompanied play responding. Scripted verbal responses were those that matched the scripts. Unscripted verbal responses were those that were different from the scripts (as previously defined). Figures 16, 17, 18, and 19 show that systematic changes in unscripted verbal responding were demonstrated with the introduction of activity schedules with embedded script-fading for three learners. Mary was the exception, in that she did not demonstrate changes in unscripted verbal responding with the introduction of the treatment package or fading steps.

Figure 18 displays the number of verbal responses, scripted and unscripted, for Mitchell, across three different activities, chef, teacher, and doctor, during baseline, activity schedules with script fading, and follow-up sessions. During baseline across all three activities, the number of unscripted verbal responses was steady at 0, with the exception of 4 unscripted responses in session 34 for the third play activity, doctor. For the first activity, chef, with the introduction of activity schedules and script fading, the number of unscripted verbal responses increased from 0 in session 12 to 6 in session 31, and remained steady throughout intervention. At the same time, the number of scripted verbal responses decreased from 6 in session 10 to 0 in session 29. For the second activity, teacher, with the introduction of activity schedules and script fading, the number of unscripted verbal responses increased from 0 in session 40 to 7 in session 72. At the same time, the number of scripted verbal responses decreased from 6 in session 40 to 1 in session 58. For the third activity, doctor, with the introduction of activity schedules and script fading, the number of unscripted verbal responses increased from 0 in session 55 to 7 in session 74. At the same time, the number of scripted verbal responses decreased from 6 in session 51 to 2 in session 67. During the follow-up sessions, the number of unscripted verbal responses decreased slightly from levels during intervention, but remained above baseline levels, across all three play activities. For sessions 74 and 75, the number of unscripted verbal responses was 6 and 5 for chef, 6 and 5 for teacher, and 5 and 4 for teacher, respectively.

Figure 16 depicts Mary's responding. Mary did not demonstrate systematic increases in unscripted verbal responding with the introduction of the treatment package. Figure 17 depicts Ian's responding. Like Mitchell, Ian demonstrated systematic increases

in unscripted verbal responding with the introduction of the intervention package. During follow-up sessions, unscripted verbal responding fell within the range of scores obtained during the final few teaching sessions at F3. Unscripted verbal responding remained above baseline levels. Figure 19 displays Derek's responding. Similar results to those obtained for Ian, were obtained for Derek. That is, when scripts were fully faded (F4), unscripted verbal responding increased. The experimenter did not obtain follow-up data for Derek.

Mitchell, Ian, and Derek demonstrated systematic increases in unscripted verbal responding over baseline with the introduction of the treatment package. Ian and Derek did not demonstrate increases in unscripted verbal responses until scripts were fully faded (F3 and F4, respectively) because both learners repeated previously scripted statements when scripts were no longer present. Mitchell demonstrated immediate increases in unscripted verbal responding with the introduction of activity schedules with script fading. One possible reason for this immediate increase in unscripted verbal responding may have been that Mitchell was the oldest of the four learners (age 7, compared to 4). As a result, he had more prior experience with script-fading techniques. Also, Mitchell's were the only scripts presented in textual format. Mary, Ian, and Derek's scripts were presented through audio-recording devices.

Unlike the previous learners, Mary did not repeat scripts or unscripted statements when script-fading steps were introduced. As a result, the experimenter reinstated full scripts throughout the study for Mary. It was reported that Mary had also shown difficulty with script-fading techniques in her classroom. That is, once scripts were faded, she did not engage in unscripted verbal responding. Another reason Mary did not

engage in unscripted verbal responding is that the scripts may not have been faded quickly enough, as required by script-fading techniques (Krantz & McClannahan, 1993). As a result, Mary did not engage in response generalization (Keller & Schoenfeld, 1950). Scripts may not have been faded quickly enough because play responses were the primary dependent measure. As a rule, play responses and scripts were never faded on the same day. If play and verbal responding met criteria on the same day, play responding would be faded first. During the following session, scripts would be faded. As a result, scripts were not always faded when verbal responding met criterion.

#### *Verbal responding: Conclusions*

Systematic increases in unscripted statements occurred for three learners, Mitchell, Ian, and Derek, so it can be concluded the script-fading procedure used with them was successful in producing those statements. That was the case even though the script-fading procedures were not used optimally, as described above. That is, criterion for fading activity schedules superceded the criteria for fading scripts.

#### *Social validity*

Figure 20 displays the number of video tape segments during which judges indicated that play look more typical during baseline and intervention for all four learners. As previously described, nine judges viewed 40 pairs of video tape segments, which would allow for 360 total video tape segments. The judges indicated that play looked more typical during intervention video tape segments as opposed to baseline video tape segments, 309 to 51 video tape segments, respectively. Thus, the change in behavior was socially valid.

## General Discussion

Activity schedules with script-fading was an effective intervention to teach children with autism to engage in both functional and symbolic play responses. In addition, the intervention package successfully promoted generalization from teaching play activities with prompts and reinforcers to novel play activities without prompts and reinforcers and in generalized responding from play with activity schedules to play without activity schedules. Activity schedules with script-fading also resulted in verbal responding accompanying play. Finally, because judges found play to be more typical during intervention than during baseline, the change in behavior was socially valid. It is important to note that, as previously described, the experimenter used a within-subject across play activities multiple-baseline design to demonstrate control. The results, then, are robust in that they were repeated not only across response categories, but also across learners. Activity schedules with script-fading can be used to teach a variety of responses to a number of different learners.

The current study extended the related literature on functional and symbolic play in five ways. First, earlier-mentioned researchers compared groups of children with respect to their play skills (Baron-Cohen, 1987; Gould, 1986; Libby et. al., 1997, 1998; Riguet et. al.1981; Rutherford & Rogers, 2003; Sigman & Ungerer, 1984; Ungerer & Sigman, 1981; Williams et. al. 2001). Their results showed that children with autism demonstrated play skills deficits when compared to the skills of typically developing children. By contrast, the current study demonstrated that while the learners with autism demonstrated a deficit in play skills, they could be taught to engage in both functional and symbolic play responses. Second, the current study defined and used functional and

symbolic play as dependent measures within a behavior-analytic framework. Third, although Williams et al. (2001) observed that children with autism engaged in fewer elaborated functional play acts than children in non-autistic groups, learners in the current study engaged in a variety of elaborated responses including actions that involved the functional use of two or more objects, functional actions with appropriate vocalizations, and doll-directed acts. Fourth, Williams et al. (1999) found that object use by children with autism is impaired. In the current study, children with autism were taught to use objects appropriately.

It is important to note that Williams et al. (1999) also found that children with autism lack the social component needed to develop play skills, such as the ability to imitate others during play. The current study did not address social aspects related to play skills. Fifth, these researchers made a distinction between functional and symbolic play, and described the progression of play skills in children from functional use of objects to symbolic, more imaginative play. In the current study, procedures were designed to address both functional and symbolic play skills. Nevertheless, the distinction was important in identifying which play responses to teach the learners. If a learner did not previously engage in functional play skills, then functional play responding was taught. Those learners who already demonstrated functional play skills were taught symbolic play. If the learner did not previously demonstrate functional play skills, one would not want to teach symbolic play responding. For example, if the learner was not observed to play appropriately with a toy telephone, teaching the same learner to talk on a banana telephone might make him or her appear atypical.

### *Related Behavior-Analytic Literature*

The findings of the current study extended and were consistent with the findings of the related literature conducted by behavior analysts. First, the experimenter operationally defined and used the term *symbolic play* to teach play responses to children with autism. Second, similar to D'Ateno et al. (2003), results demonstrated that children with autism can be taught to engage in a series of related functional play responses. Third, the current study supported Morrison et al. (2002) in that children with autism can be taught to engage in play activities using activity schedules. Fourth, the experimenter used activity schedules to teach children with autism to engage in a series of related play responses. Fifth, results supported and extended the findings of Krantz and McClannahan (1993) that script-fading techniques can be used to teach children with autism to engage in unscripted statements. Whereas Krantz and McClannahan examined verbal responding between children with autism and their peers or instructors, the current study examined verbal responding of children with autism during independent play.

### *Practical Implications*

There are practical implications for therapists in applied settings. First, activity schedules with script-fading can be implemented in a classroom. Second, only one instructor is needed to implement the procedures. Third, the procedures can be used with a variety of different-aged children. Fourth, non-readers can be included in this group. If the learner cannot read, photographic schedules can be used. While the easiest way to produce a number of different photographs is by using a digital camera, any camera would be sufficient. This point leads to a weakness of the current study. That is, creating

multiple exemplars for photographic activity schedules can be time consuming and less practical for some instructors.

### *Future Research*

The only measures that the current study examined were play and verbal responding. Future researchers should also measure other related responses, such as stereotypy, to determine whether the procedures might be effective in decreasing inappropriate responding. Moreover, the goal of the current study was to teach children with autism to engage in play skills, and thus, the experimenter did not examine play interactions with peers. In addition to deficits in play skills, children with autism exhibit difficulties interacting with peers during play. Future researchers should examine whether activity schedules with script-fading is a useful procedure to teach children with autism to play with peers at school and at home. It should be noted that Gold (2003) examined peer interaction and play, but the study did not involve script-fading. Furthermore, parents often report that their children with autism do not engage in age-appropriate play activities at home. Future researchers should examine the generality of the treatment package from school to home. Also, the current study involved the use of the same sets of materials during teaching and generalization sessions. Future researchers should examine the generality of play responding from materials presented during teaching to novel play materials. In addition, the current study examined play skills during structured situations. Future researchers should examine the extent to which play skills can be taught to children with autism during less structured, free-play settings. Finally, social validity in the current study was judged by graduate psychology students.

Future researchers should examine the extent to which play is judged to be more typical by parents of typically developing children

Table 1

## Examples of Functional and Symbolic Play Responses

Toys and Materials	Functional Play (always self-initiated)	Symbolic Play Response (self or doll-initiated)
Kitchen set and non-conventional materials (e.g., paper towel roll)	Putting related items together (e.g., placing food item in pan), flipping food item in pan, drinking from cup	Doll as chef puts food item in pan, doll or self stirs bowl with a paper towel roll, feed doll or self pretend food item
Teacher set and non-conventional materials (e.g., popsicle stick)	Writing on dry erase board with marker, pushing buttons on the calculator, writing on paper, ringing bell	Doll as teacher writes, doll or self erases board with block, doll or self speaks to class
Doctor set and non-conventional materials (e.g., straw)	Taking temperature with thermometer, wrapping gauze bandage on doll or self, listening to heart with stethoscope	Doll takes temperature with thermometer, doll or self listens to heart with paper towel roll, wrap doll or self with felt material as bandana

Table 2

Toys that will be used during Baseline, Intervention, Test, and Follow-up Sessions for Mary and Ian

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Play Activity	Toys
House	Two baby dolls, rocking cradle with mobile, infant seat, stroller, blanket, baby books, toy keys, pacifier, mirror toy, teething ring; high chair set with plates, bowls, utensils, cups, jar food, napkin; bath tub set with rubber duck, lotion, shampoo, washcloth, duck sponge, soaps with soap dishes, powder, and hairbrush.
Kitchen	Two stuffed animals, kitchen range set, chef hat, chef apron, cooking set including pot with lid, pan with lid, spatula, 2 slotted spoons, 2 mixing spoons, salt and pepper shakers, large cutting knife, cutlery set, plates, napkins, plastic food items, mixing bowls, cutting board, oven mitt, and baking pan.
Doctor	Four stuffed animals, stethoscopes, plastic band-aids, reflex hammer, thermometer, blood pressure monitor, shot, doctor case, nasal aspirator, ear and eye checker, medicine dropper, medicine syringe, q-tips with container, elastic bandage, liquid dispenser, doctor coat, surgical hat, medicine bottle, doctor headband with magnifier, doctor surgical gloves, examining table.

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Table 3

Sample Teaching and Probe Responses, for Mary and Ian, for Play Activity House

Play Activity	Teaching Responses	Probe Responses
Bathe baby	Shampoo baby's hair. Wipe baby with sponge. Soap baby.	Lotion baby. Play with rubber duck. Powder baby. Sing to baby. Brush baby's hair. Clean baby with washcloth.
Put baby in infant seat	Play with keys. Give baby drink from cup. Rock seat.	Give baby pacifier. Give baby teething ring. Put blanket on baby. Feed baby. Read a book to baby. Give baby bottle.

Table 4

Scripts used by Mary and Ian, for Play Activity, Doctor

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Before Scripts	“I play doctor.”
	“Time for doctor.”
After Scripts	“Doctor was cool.”
	“Finished with doctor.”
Set-up Doctor Scripts	“Ready for bear.”
	“Set-up doctor.”
Examine Patient Scripts	“Hi sick bear.”
	“How are you?”
Fix Hurt Patient Scripts	“What is wrong?”
	“You’ll be okay.”

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Table 5

Interobserver Agreement Percentages and Range of Scores on the Number of Prompted Play Responses, Unprompted Play Responses, Probe Play Responses, Spontaneous Play Responses, and Play Responses during Test Sessions for Mary and Ian

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Play Response by Mary										
	Prompted		Unprompted		Probe		Test Sessions		Spontaneous	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range
House	91%	50-100%	89%	69-100%	98%	67-100%	91%	67-100%	95%	76-100%
Kitchen	97%	80-100%	91%	60-100%	100%	-----	92%	83-100%	95%	67-100%
Doctor	100%	-----	88%	0-100%	95%	67-100%	100%	-----	100%	-----
Play Responses by Ian										
Kitchen	100%	-----	97%	83-100%	96%	67-100%	100%	-----	97%	83-100%
Doctor	100%	-----	97%	80-100%	97%	67-100%	100%	-----	97%	90-100%
House	89%	67-100%	97%	83-100%	100%	-----	100%	-----	99%	94-100%

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Verbal Responses by Mary									
	Non-occurrence		Scripted		Unscripted		Test Sessions		
	Mean	Range	Mean	Range	Mean	Range	Mean	Range	
House	100%	-----	97%	67-100%	100%	-----	100%	-----	
Kitchen	100%	-----	93%	50-100%	100%	-----	100%	-----	
Doctor	100%	-----	95%	75-100%	100%	-----	100%	-----	
Verbal Responses by Ian									
Kitchen	100%	-----	100%	-----	100%	-----	NA	-----	
Doctor	100%	-----	100%	-----	100%	-----	NA	-----	
House	100%	-----	95%	80-100%	100%	-----	NA	-----	

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Table 6

Combined Set of Toys and Non-Conventional Objects used during

Baseline, Intervention, and Follow-up Sessions for Mitchell

Type of object	Activity	Play materials
Conventional toys	Chef	Spatula, pitcher, mixing bowl, wooden spoon, oven mitt, dish set, frying pan, fake foods.
	Teacher	Dry erase board, dry erase markers, eraser, calculator, paper, clipboard, pencil, red pen, scissors, white bell.
	Doctor	Liquid dropper, cotton balls, empty liquid dispenser, stethoscope, bandage, reflex hammer, shot, thermometer, blood pressure monitor, medicine spoon.
Non-conventional materials	Chef, Teacher, and Doctor	Two wooden blocks (small and large rectangles, tissue box, paper towel roll, craft stick, bits of pink sponge, scrap material (blue denim), toilet paper roll holder, white styrofoam.

Table 7

Combined Set of Toys and Non-Conventional Objects used by Mitchell during  
Generalization Sessions (Not Shown in Figures)

Type of Object	Activity	Play Material
Conventional Toys	Chef	Mixing spoon, large cup, pot holder, fake food items, colander, bowl.
	Teacher	Mini-chalkboard, chalk, eraser, silver bell, apple timer, orange highlighter, scotch tape, black pen.
	Doctor	Rolled gauze, pretend medicine bottle, pill tray, cotton swabs.
Non-Conventional Materials	Chef, Teacher, and Doctor	White loofah sponge, green foam, plastic oil can, blue straw, toilet paper roll, purple sponge pieces, paintbrush, blue tupperware top, mechanic's oil funnel.

Table 8

## Sample Primary and Secondary Activity Schedules for Play Activity Chef

Primary Schedule	Secondary Schedule
Make eggs	<ol style="list-style-type: none"> <li>1. Doll cracks eggs in pan.</li> <li>2. Doll mixes eggs with spoon.</li> <li>3. Doll flips eggs.</li> <li>4. Doll puts eggs on plate.</li> <li>5. Doll eats eggs.</li> </ol>
Make sandwich	<ol style="list-style-type: none"> <li>1. Get 2 slices of bread (use bread slice and block).</li> <li>2. Spread peanut butter on bread with paper towel roll (spread from block).</li> <li>3. Spoon jelly on bread with spoon (spoon jelly from tissue box).</li> <li>4. Cut sandwich with craft stick.</li> <li>5. Eat sandwich.</li> </ol>

Table 9

Scripts for Primary and Secondary Schedules, used by Mitchell, for Play Activities Chef and Teacher

Play Activity:	Scripts for Primary Schedules:	Scripts for Secondary Schedules:
Chef	<p>“It’s time to eat.”</p> <p>“I’ll make something good.”</p> <p>“Cooking is so great.”</p> <p>“Making food is fun.”</p> <p>“Let’s prepare a meal.”</p> <p>“I’m getting really hungry.”</p>	<p>“I hope you’re hungry.”</p> <p>“Can’t wait to eat.”</p> <p>“This looks really yummy.”</p> <p>“It will be tasty.”</p> <p>“Everything is almost ready.”</p> <p>“Sure hope it’s good.”</p> <p>“Mmm...it looks great.”</p> <p>“The food is done.”</p>
Teacher	<p>“We’re ready for work.”</p> <p>“It’s time for class.”</p> <p>“Let’s learn something new.”</p> <p>“I’m ready to start.”</p> <p>“Time to do work.”</p> <p>“Get ready to learn.”</p>	<p>“Listen to your teacher.”</p> <p>“Learning is so fun.”</p> <p>“Great working hard class.”</p> <p>“Teaching is really great.”</p> <p>“Please listen up everyone.”</p> <p>“School is the best.”</p> <p>“You are doing well.”</p> <p>“Everyone is working nicely.”</p>

Table 10

Combined Sets of Toys and Non-Conventional Objects, used by Derek, during Baseline, Intervention, and Test Sessions

Play Activity	Conventional Toys	Non-Conventional Objects
Cars	Car garage, community mat and miniature plastic people	Wooden blocks, plastic oil pitcher, matchbox, gift box, shoelace, ribbon, blue cube.
Kitchen	Kitchen range play set and dolls	Yellow foam bottle cleaner, Tupperware lid, sponge pieces, white foam pieces, foam paint brush, ruler, aluminum foil.
Doctor	Doctor's kit and stuffed animals	Tape measure, toilet paper roll holder, paper towel roll, tissue box, blue denim material, popsicle sticks, straw.

Table 11

## Teaching and Probe Symbolic Play Responses, for Derek, for Play Activity Cars

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Teaching Responses	Person drives to gas pump.
	Person walks to store.
	Person drives toward red ramp.
	Person locks car.
	Person drives car into diagnostic center.
	Person washes car at car wash.
Probe Responses	Person pumps gas into car.
	Person talks on pay phone.
	Person drives car down curved, red ramp.
	Person parks gar on garage roof.
	Mechanic fixes car.
	Person presses button on car wash to clean car.
	Person drives car to gate at diagnostic center.
	Person honks horn at gate at diagnostic center.
	Person lifts gate leading to exit ramp.
	Person drives car down blue ramp.
	Person drives car up elevator.
	Person drives car down elevator.

---

Table 12

Scripts, used by Derek, for Play Activity Cars

Before Scripts	After Scripts
Car Garage Scripts	“Cars are so neat.”
	“Playing cars is cool.”
	“I need some gas.”
	“I’ll buy a snack.”
	“Drive to the ramp.”
	“Better lock the car.”
Community Mat Scripts	“This car is broken.”
	“Wash the dirty car.”
	“Oh no, a fire!”
	“I’d like some pizza.”
	“The person is sick.”
	“There’s the school bus.”
	“I’m going to bed.”
	“Here goes the mail.”
	“All done with cars.”
	“Finished playing with cars.”

Table 13

Interobserver Agreement Percentages and Range of Scores on the Number of Prompted Play Responses, Unprompted Play Responses, Probe Play Responses, Spontaneous Play Responses, Test Sessions, Non-occurrence of Verbal Responses, Scripted Verbal Responses, Unscripted Verbal Responses, and Probe Verbal Responses for Derek

	Play Responses									
	Prompted		Unprompted		Probe		Test Sessions		Spontaneous	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Cars	97%	50-100%	94%	71-100%	95%	67-100%	94%	88-100%	87%	0-100%
Kitchen	97%	67-100%	97%	80-100%	92%	50-100%	71%	-----	96%	89-100%
Doctor	100%	-----	98%	88-100%	95%	75-100%	100%	-----	92%	88-100%

	Verbal Responses							
	Non-occurrence		Scripted		Unscripted		Probe	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Cars	100%	-----	96%	75-100%	92%	0-100%	NA	-----
Kitchen	100%	-----	100%	-----	94%	50-100%	100%	-----
Doctor	100%	-----	97%	89-100%	99%	89-100%	100%	-----

Table 14

The total number of teaching, probe, and other functional or symbolic play responses during the *no teaching* condition of test sessions across three play activities for Mary, Ian, and Derek

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Mary			
	Teaching	Probe	Other
	_____	_____	_____
House	52	25	7
Kitchen	39	8	0
Doctor	13	8	0

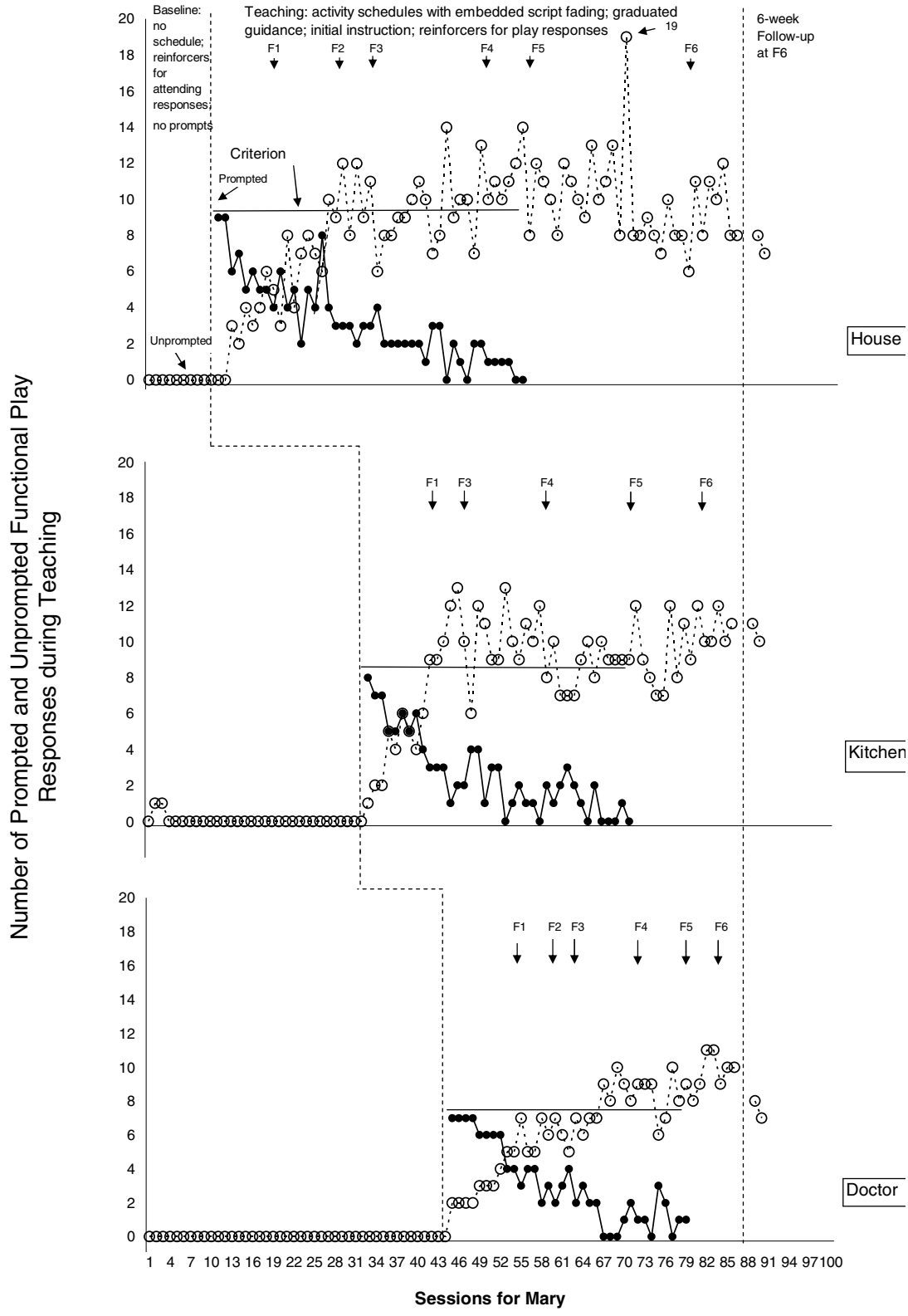
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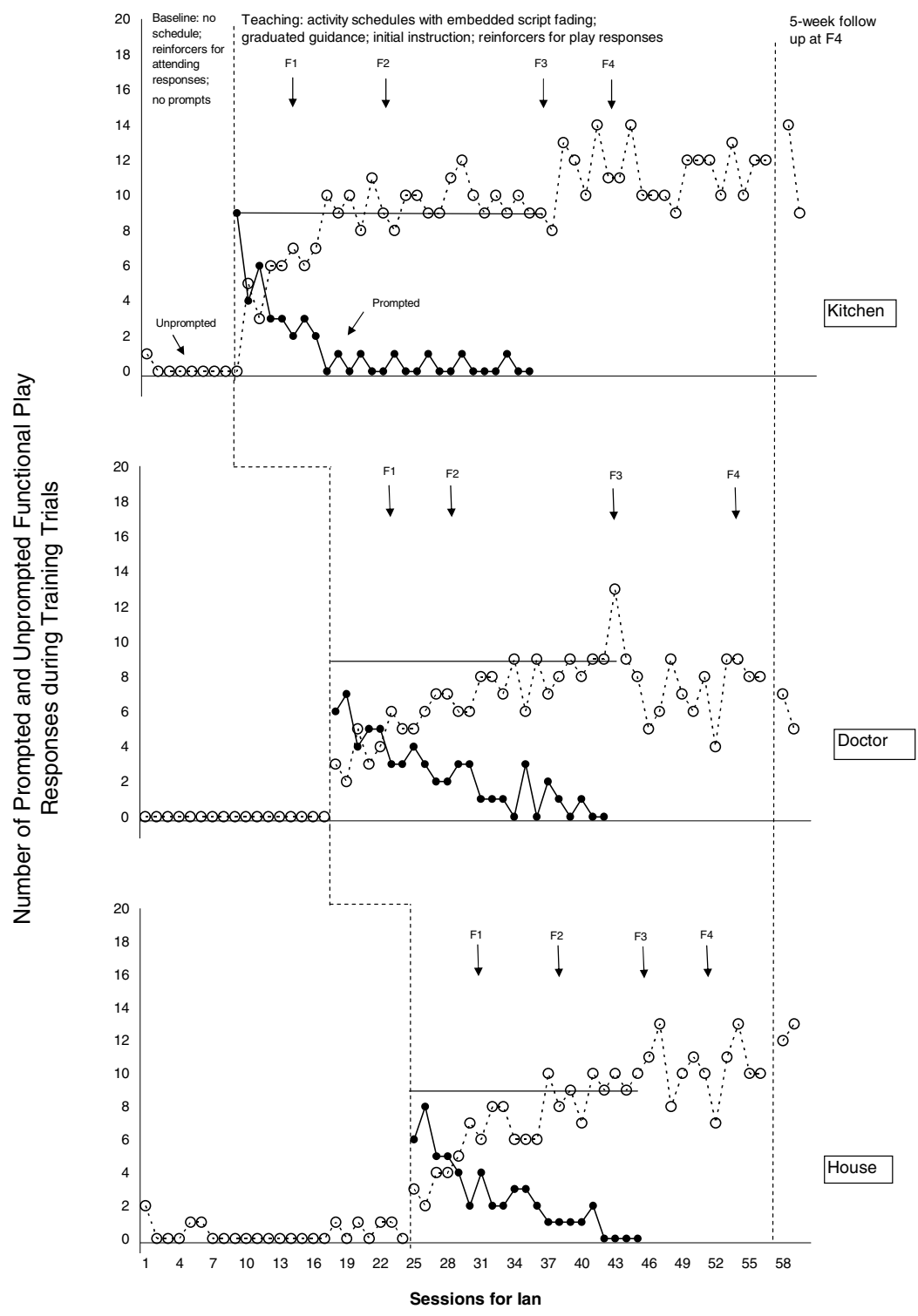
Ian			
	Teaching	Probe	Other
	_____	_____	_____
Kitchen	30	2	0
Doctor	9	3	0
House	12	6	0

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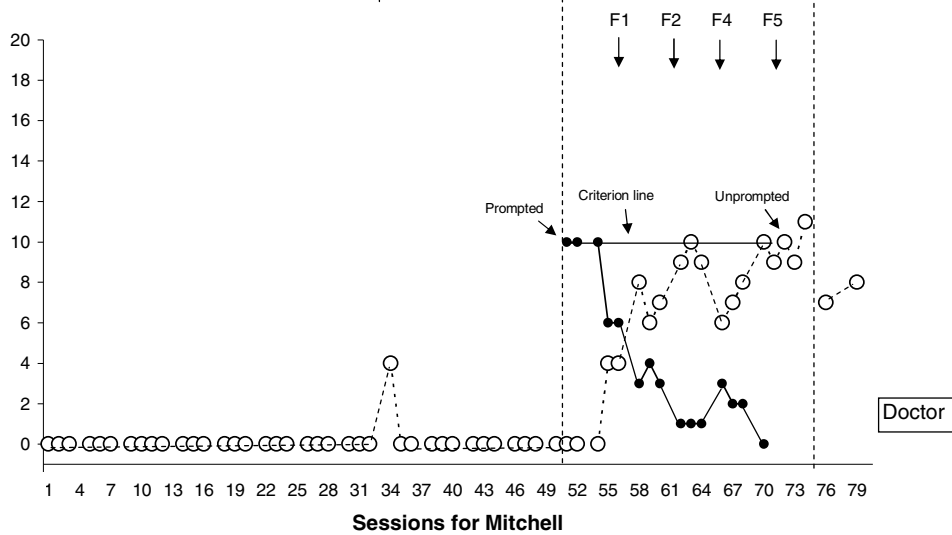
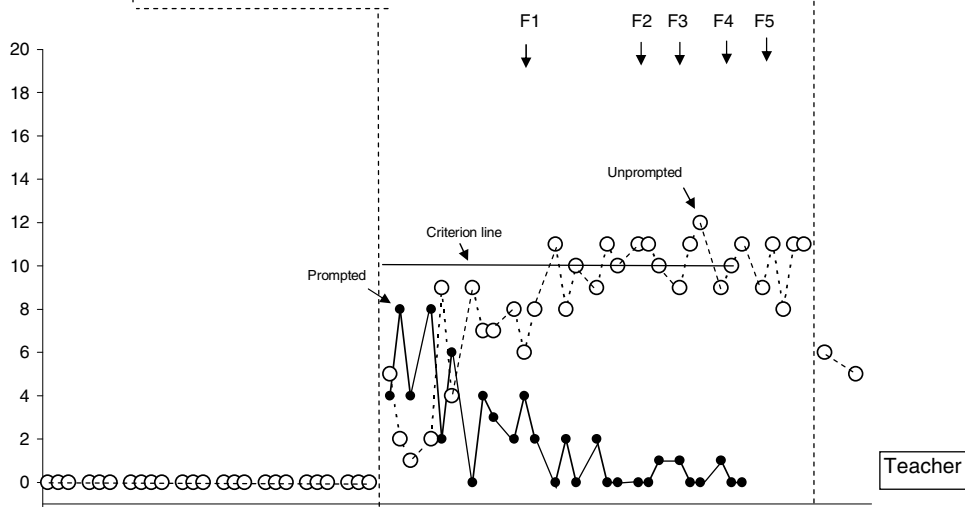
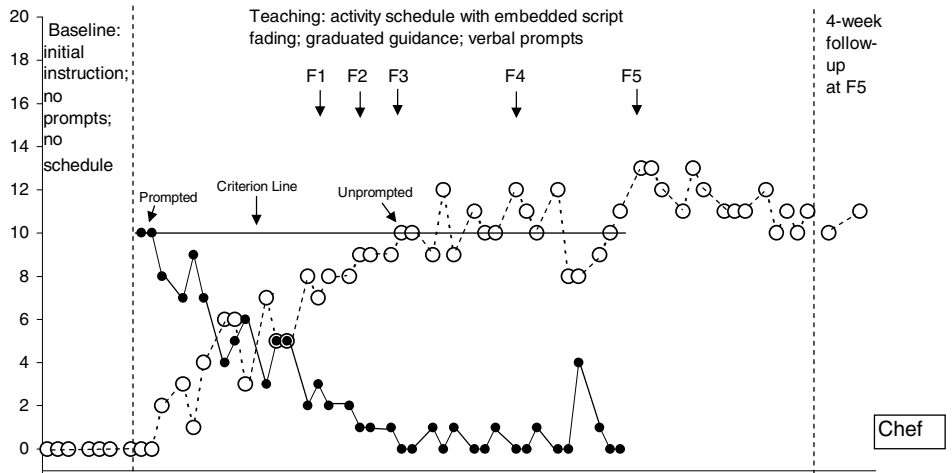
Derek			
	Teaching	Probe	Other
	_____	_____	_____
Cars	0	0	0
Kitchen	32	6	0
Doctor	26	5	0

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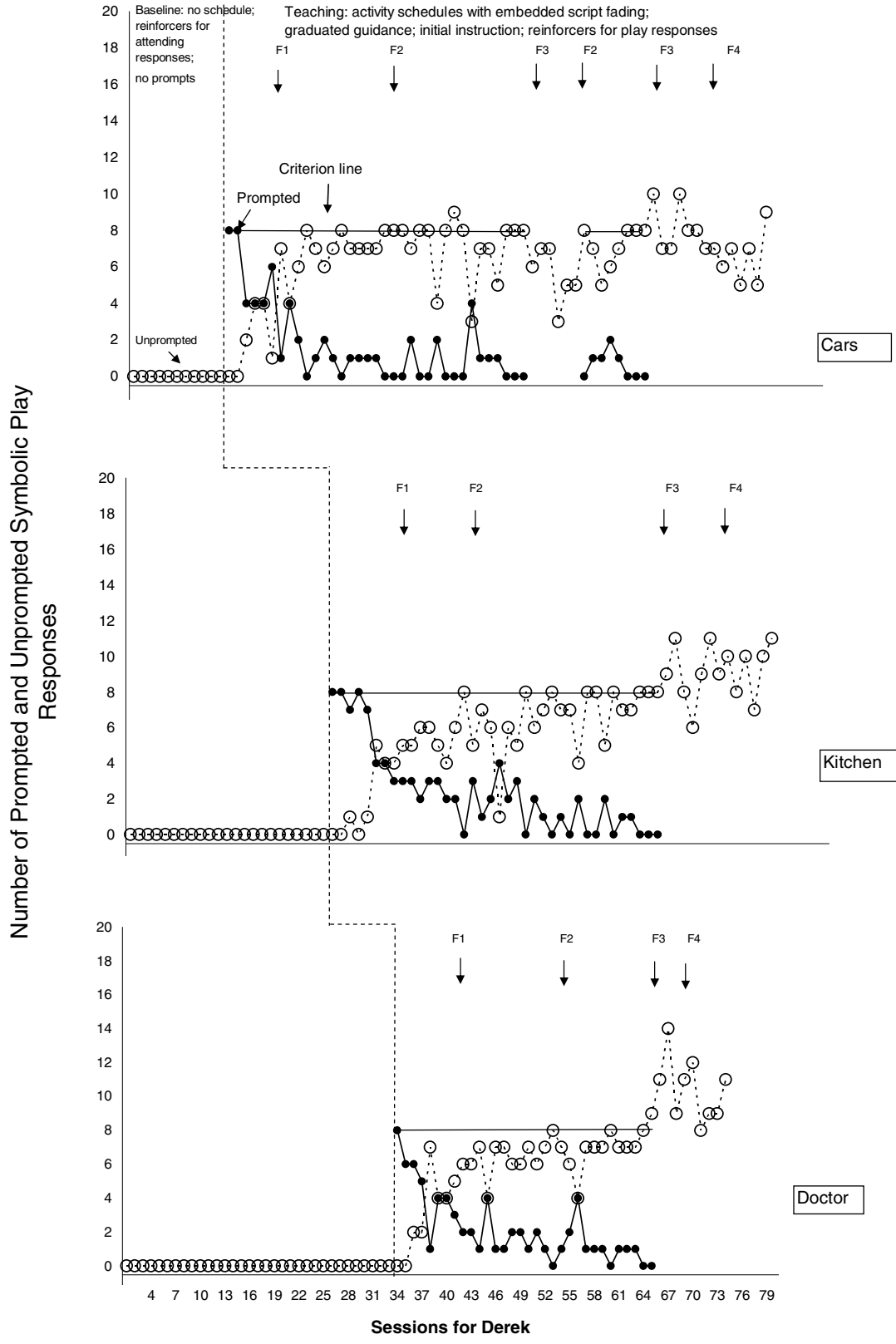


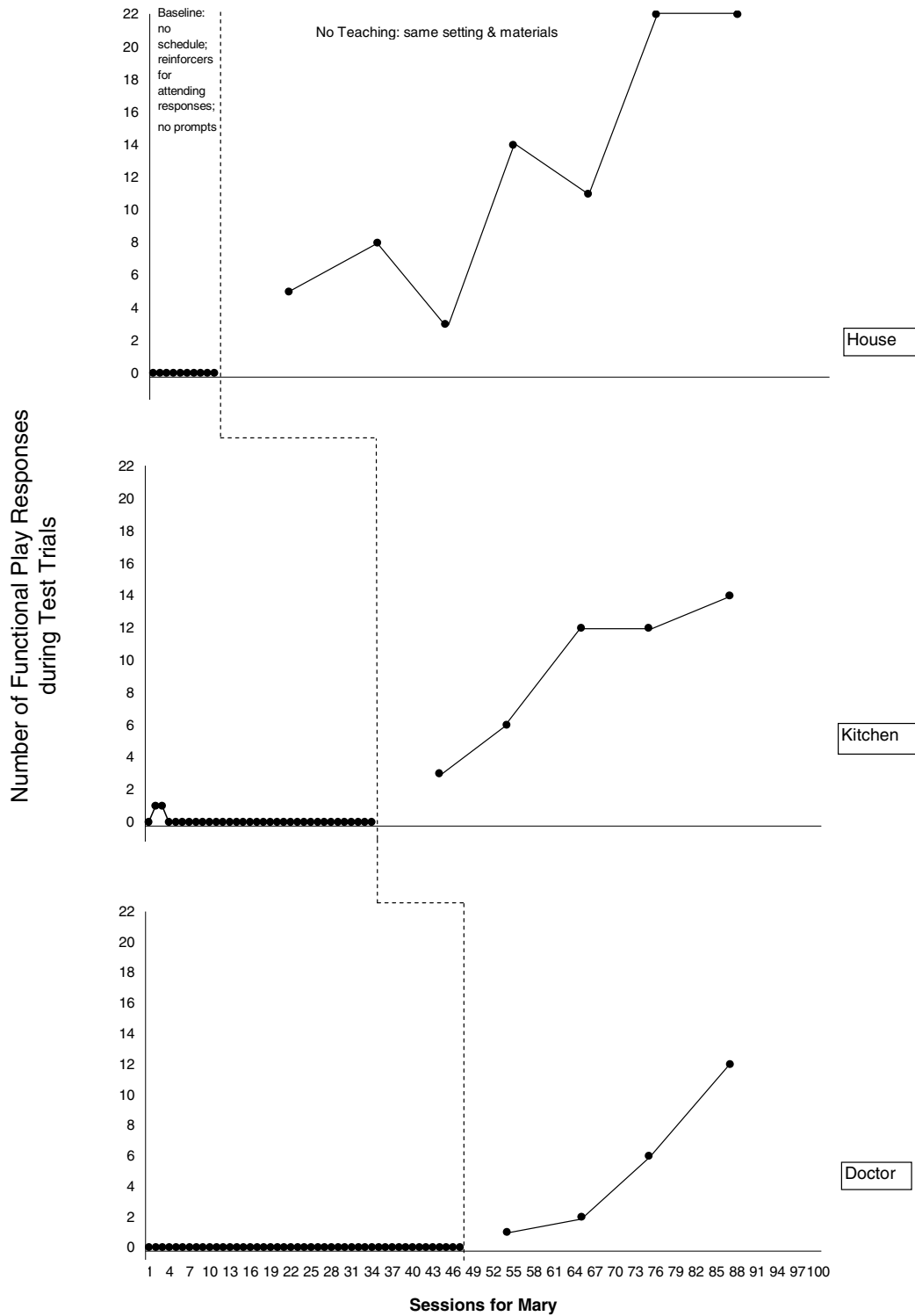
Number of Symbolic Play Responses

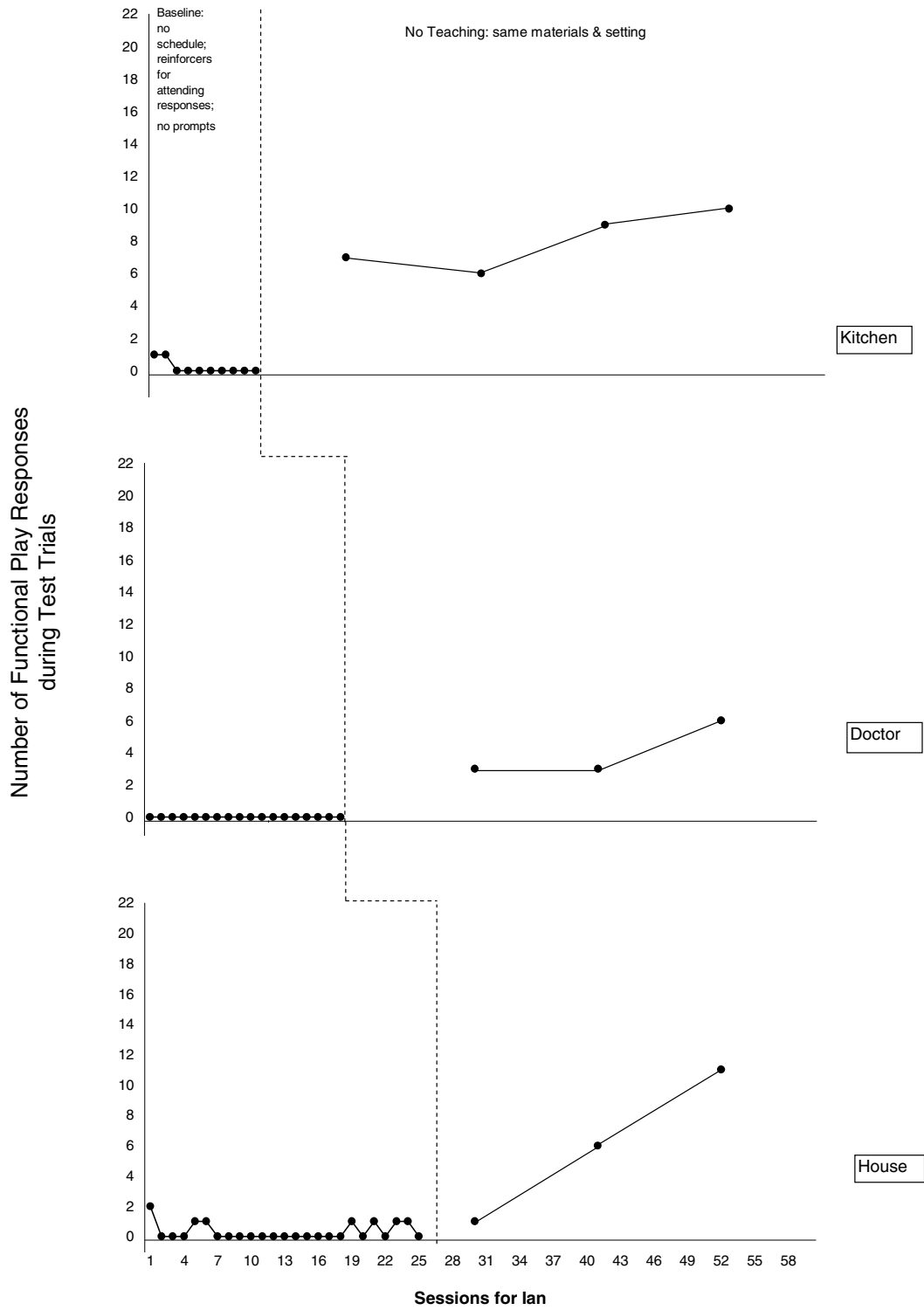


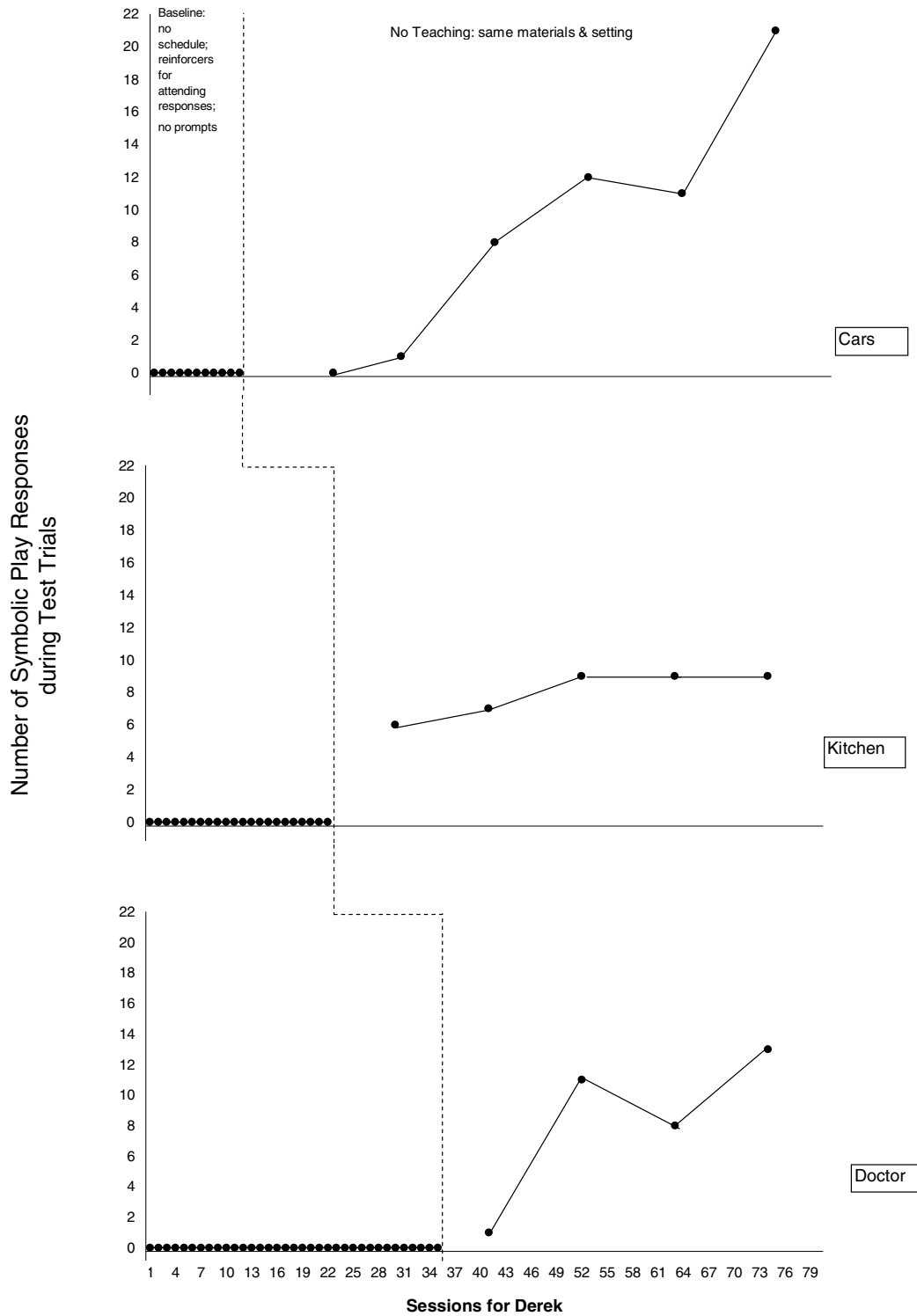
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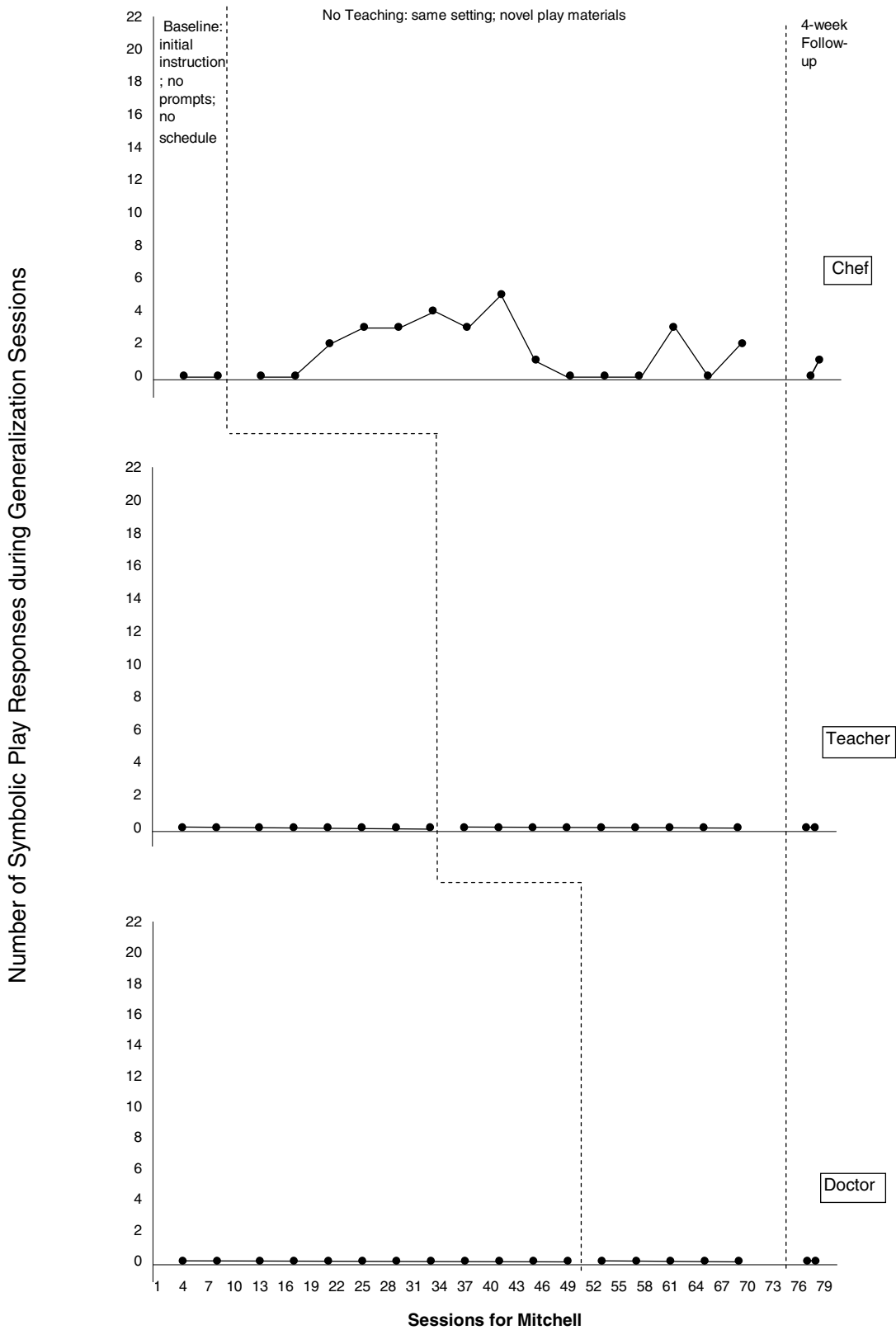
Sessions for Mitchell



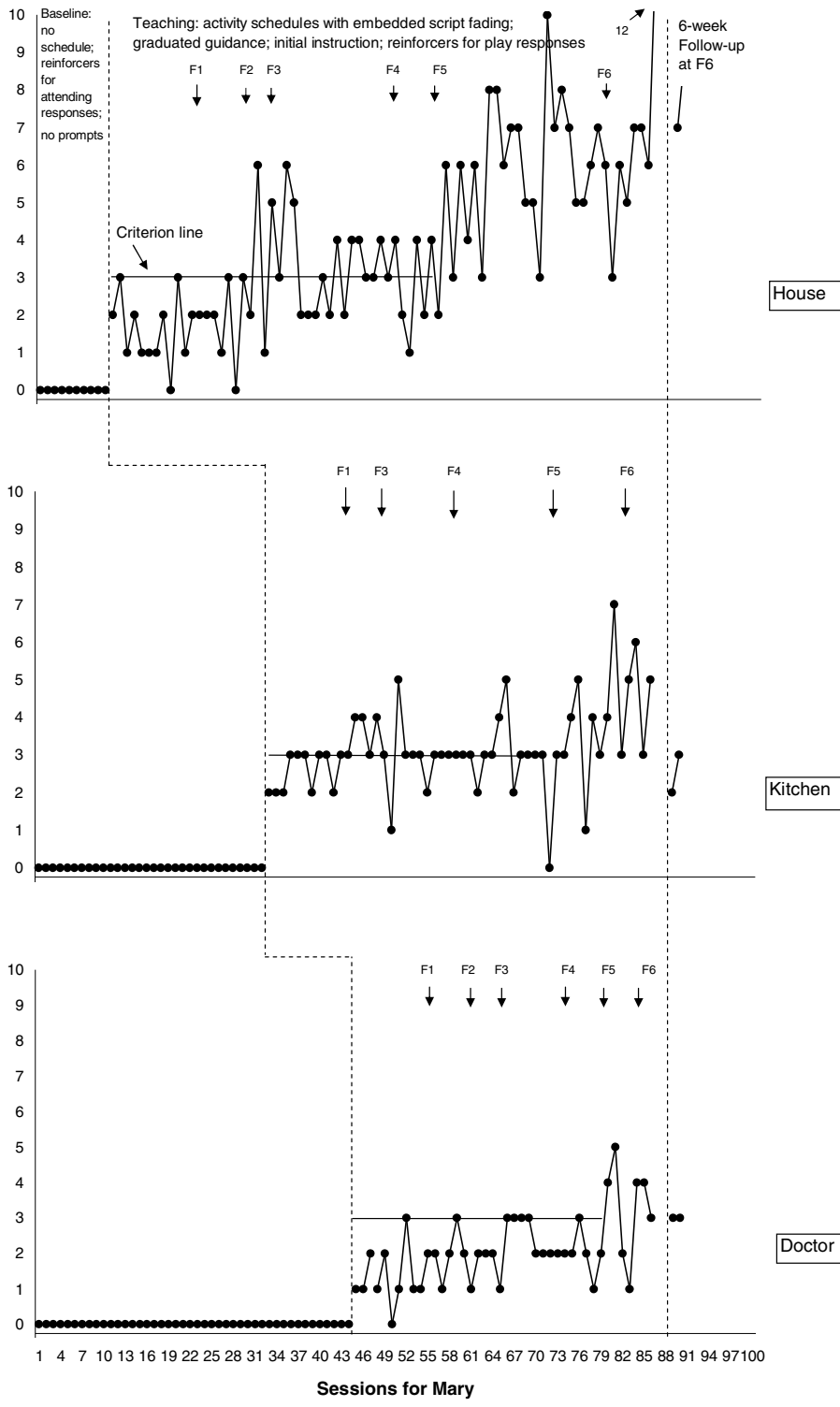




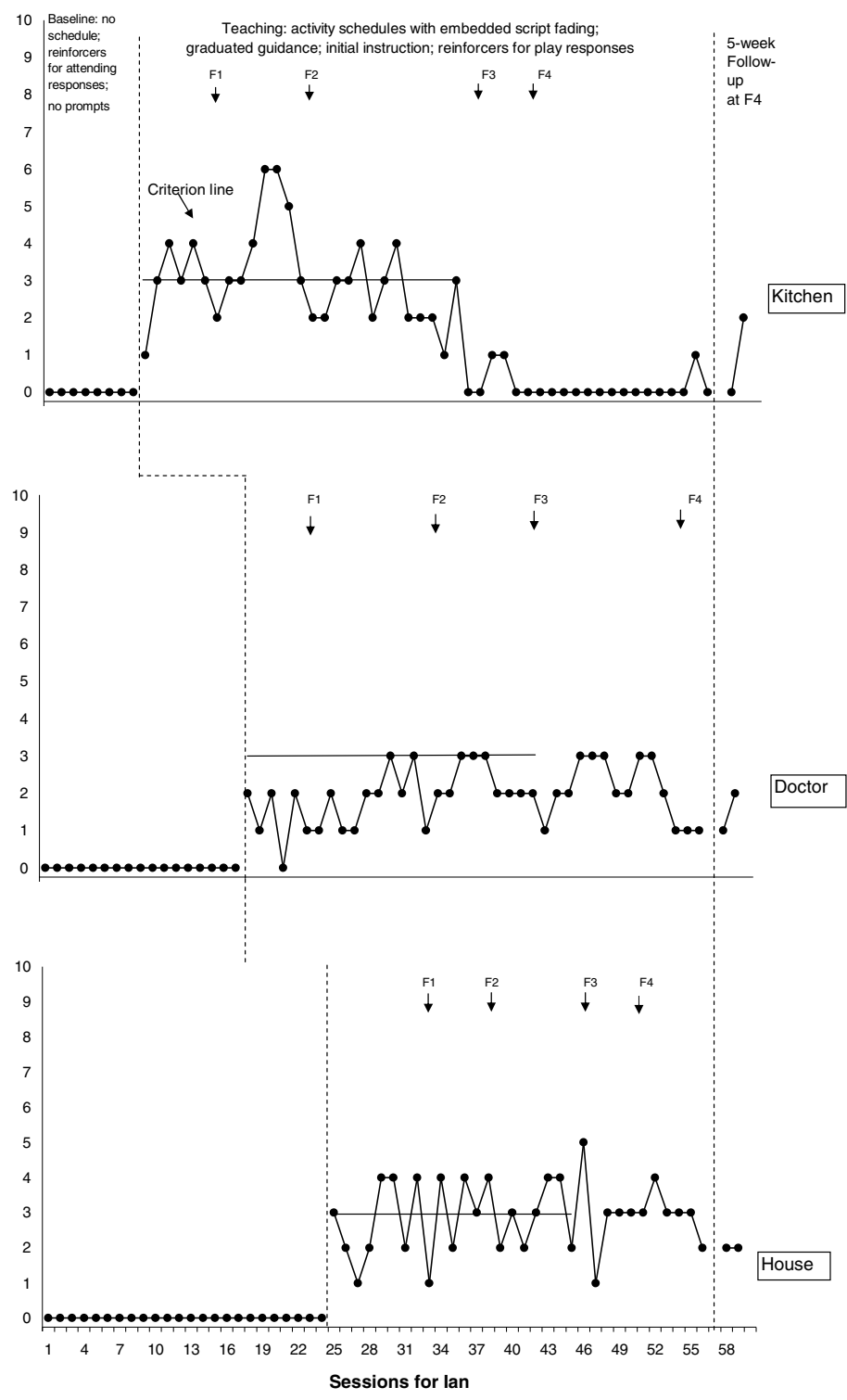




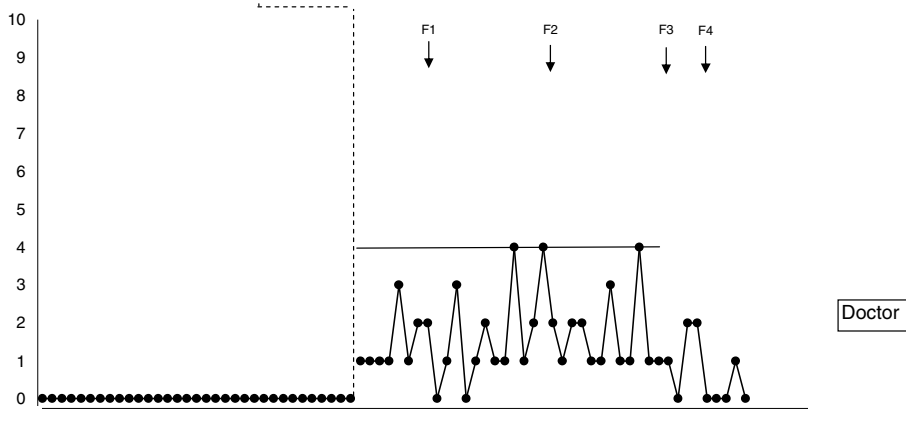
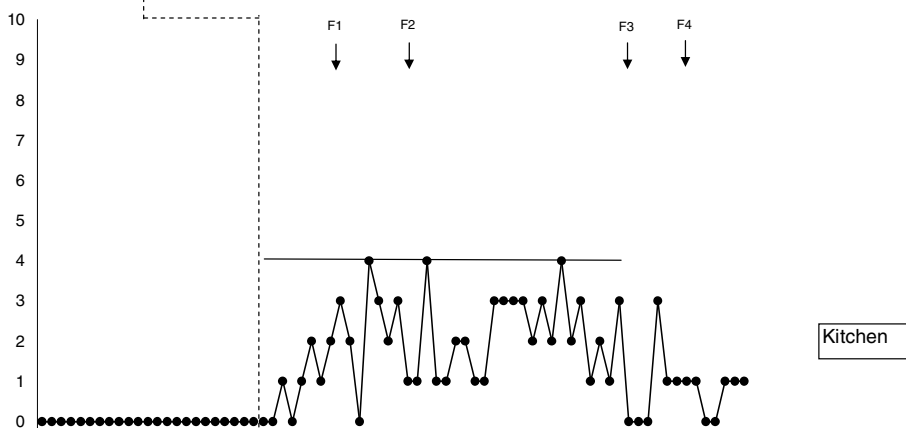
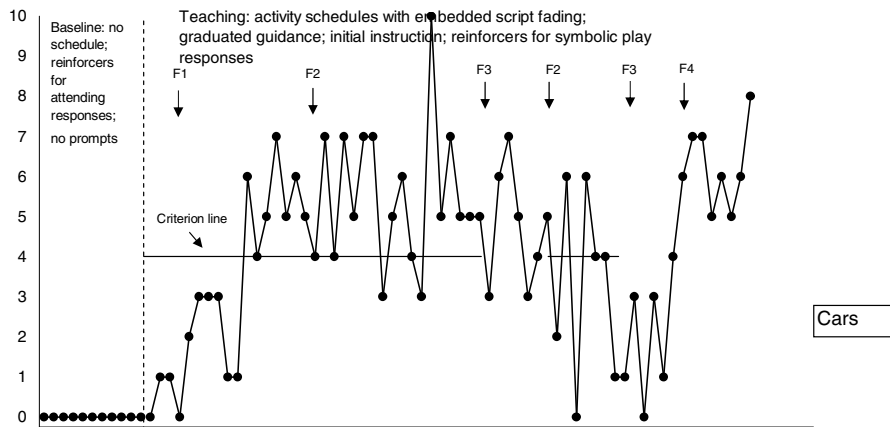
Number of Probe Functional Play Responses



Number of Probe Functional Play Responses



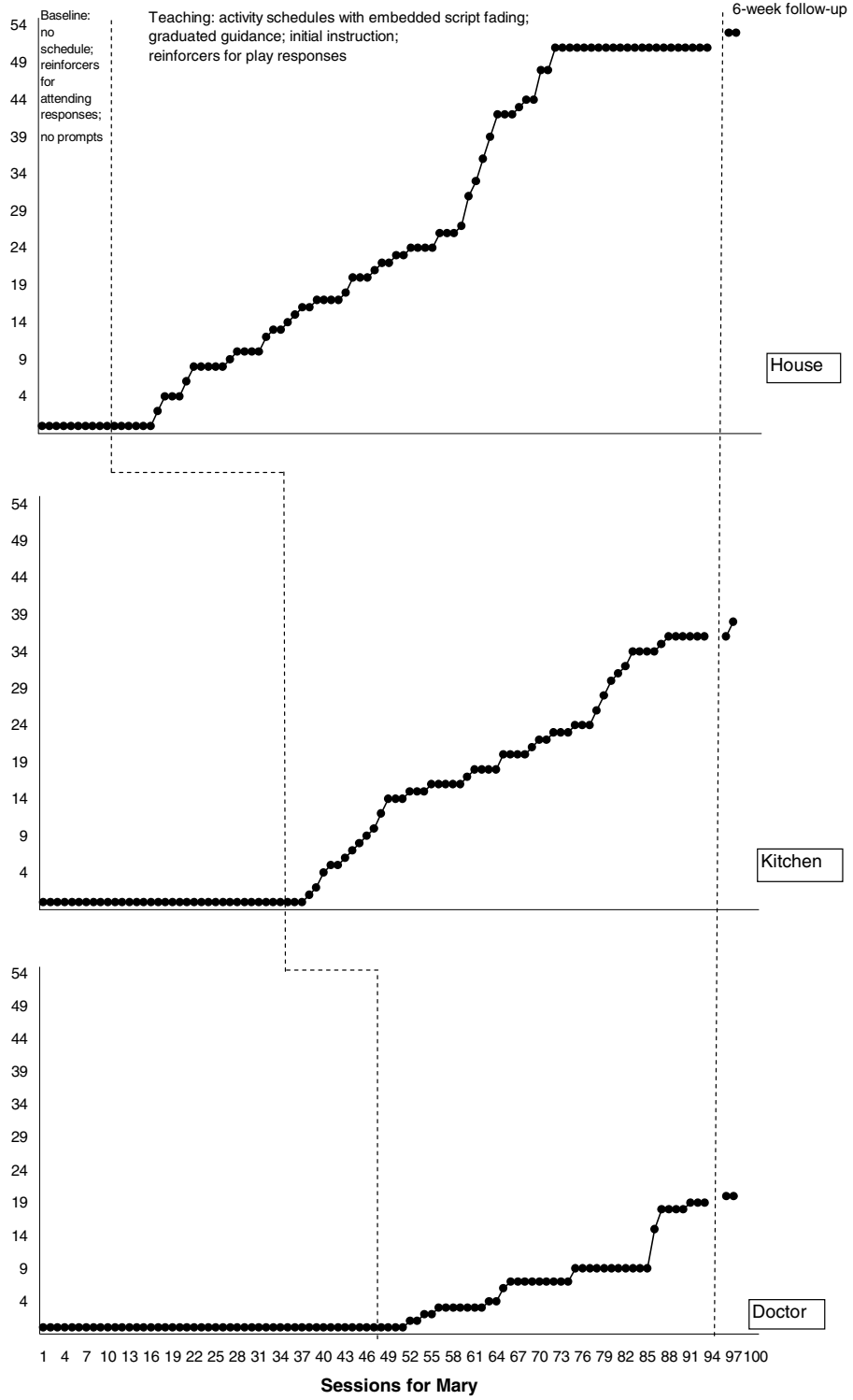
Number of Probe Symbolic Play Responses



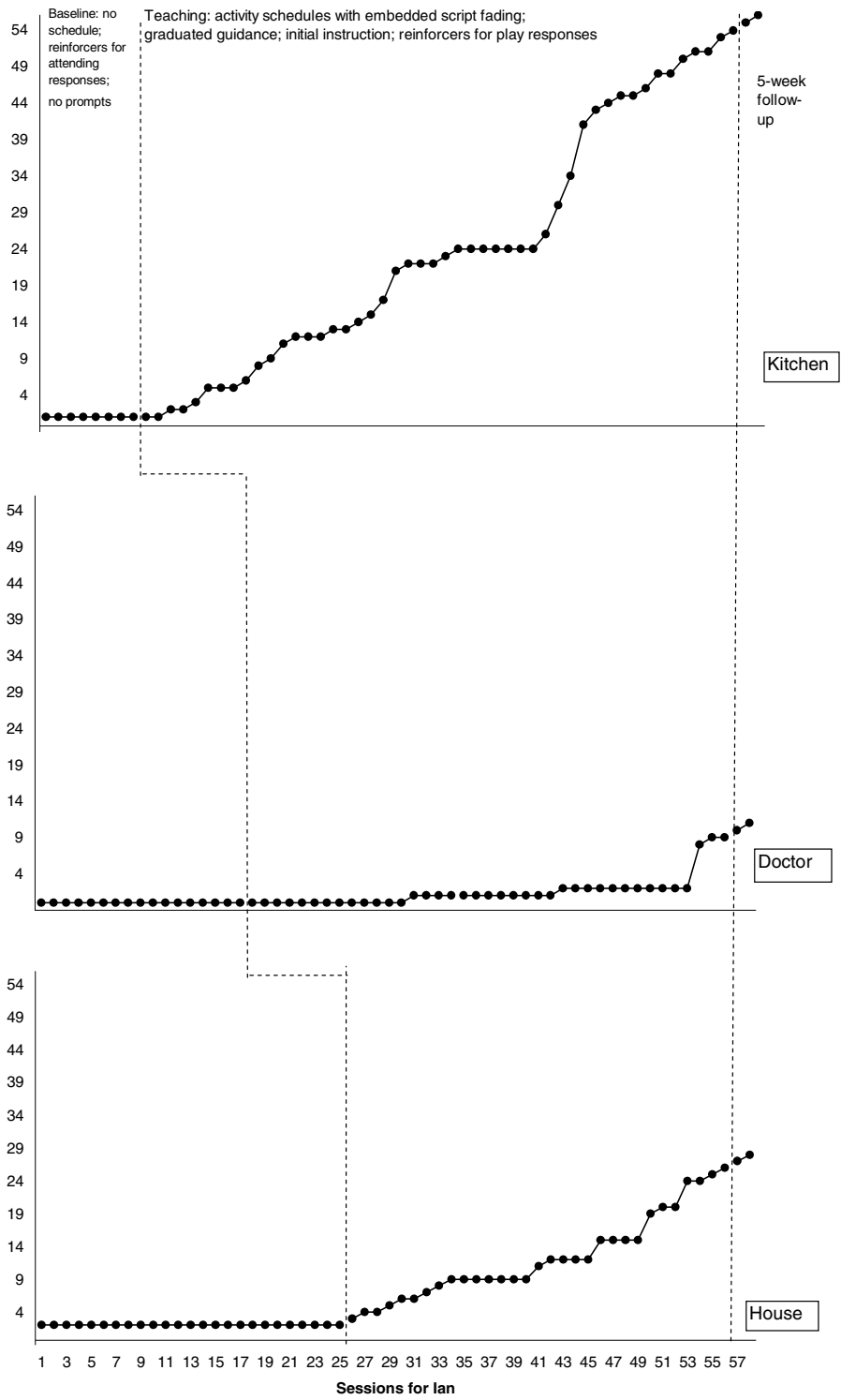
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Sessions for Derek

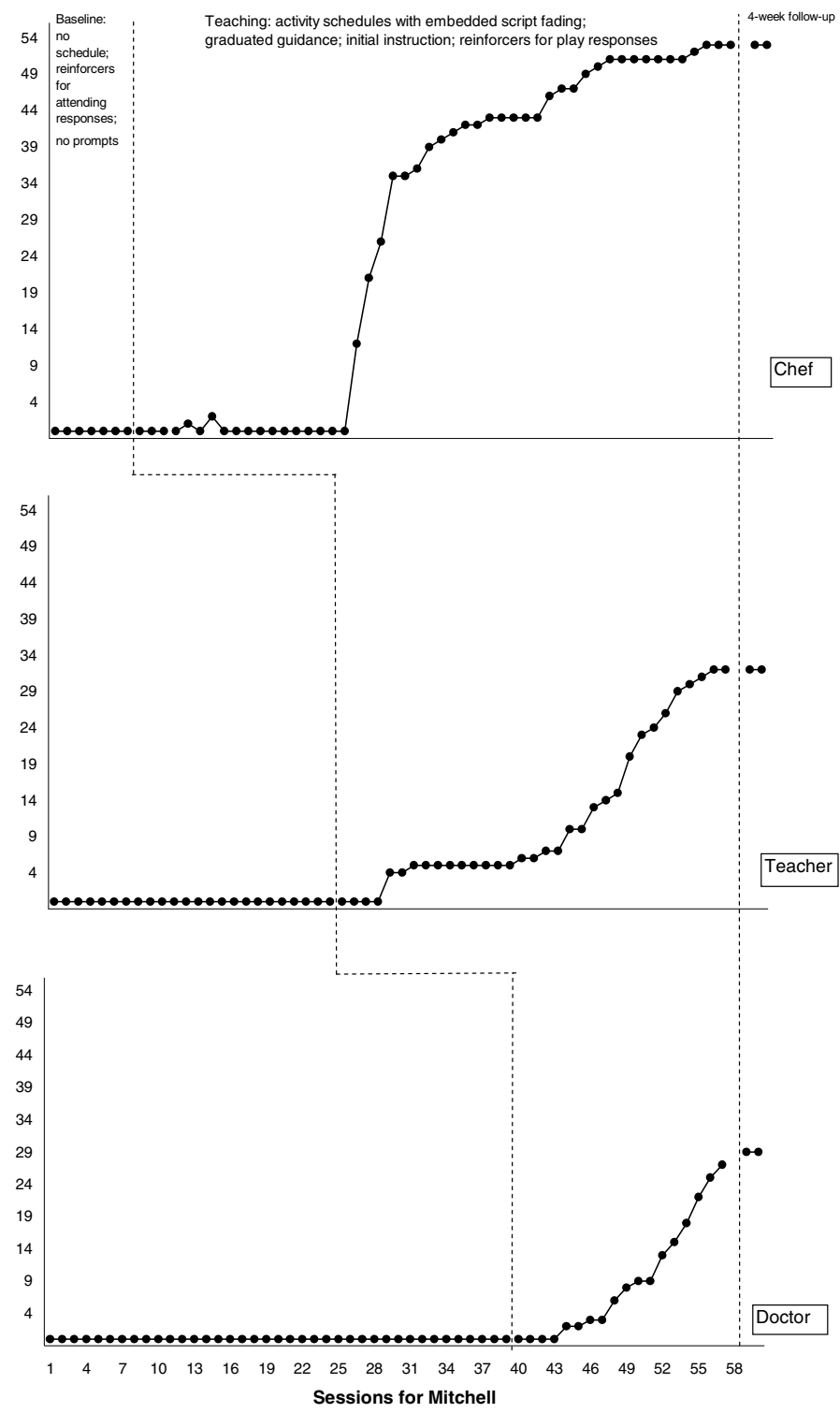
Cumulative Number of Spontaneous Functional Play Responses

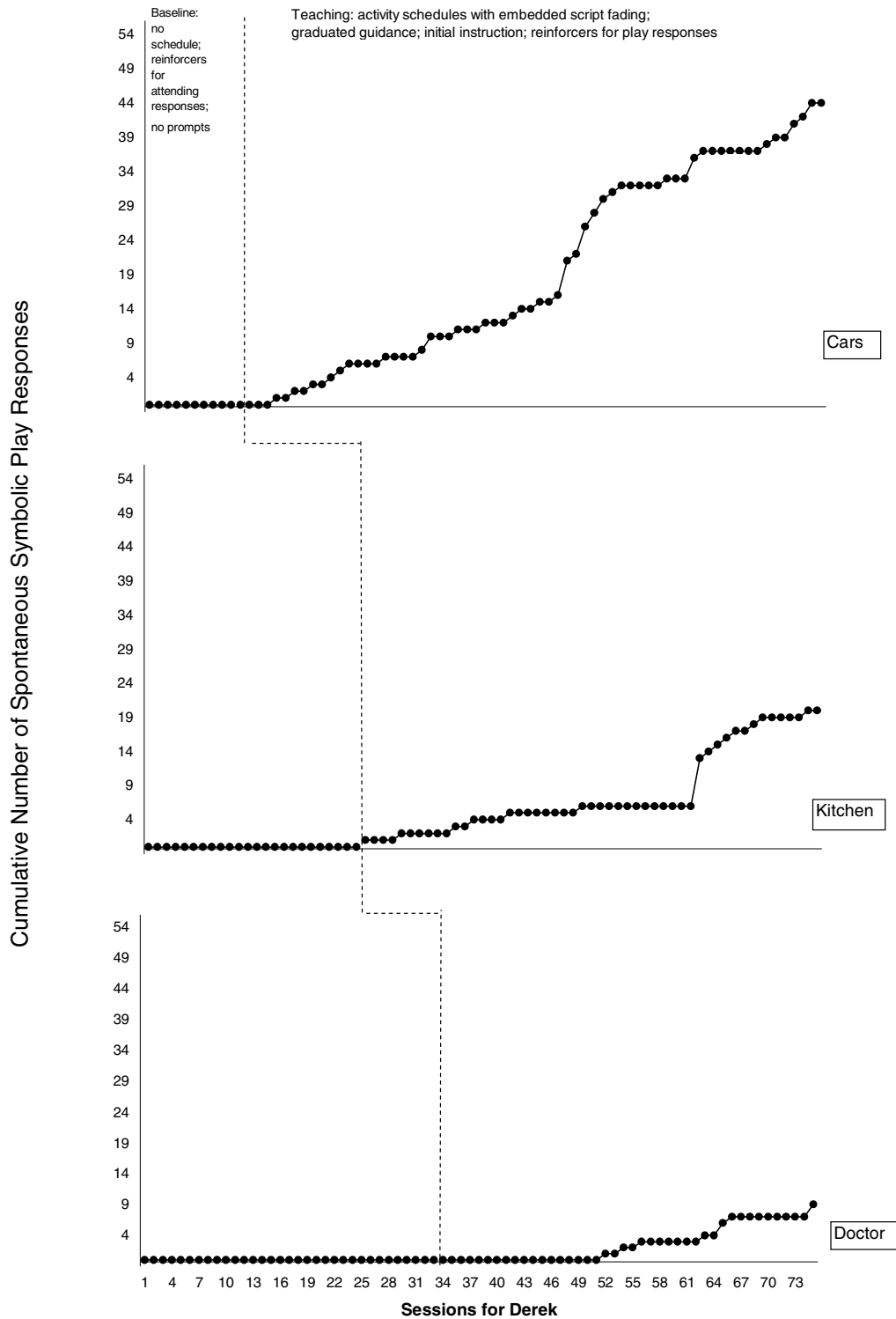


Cumulative Number of Spontaneous Functional Play Responses

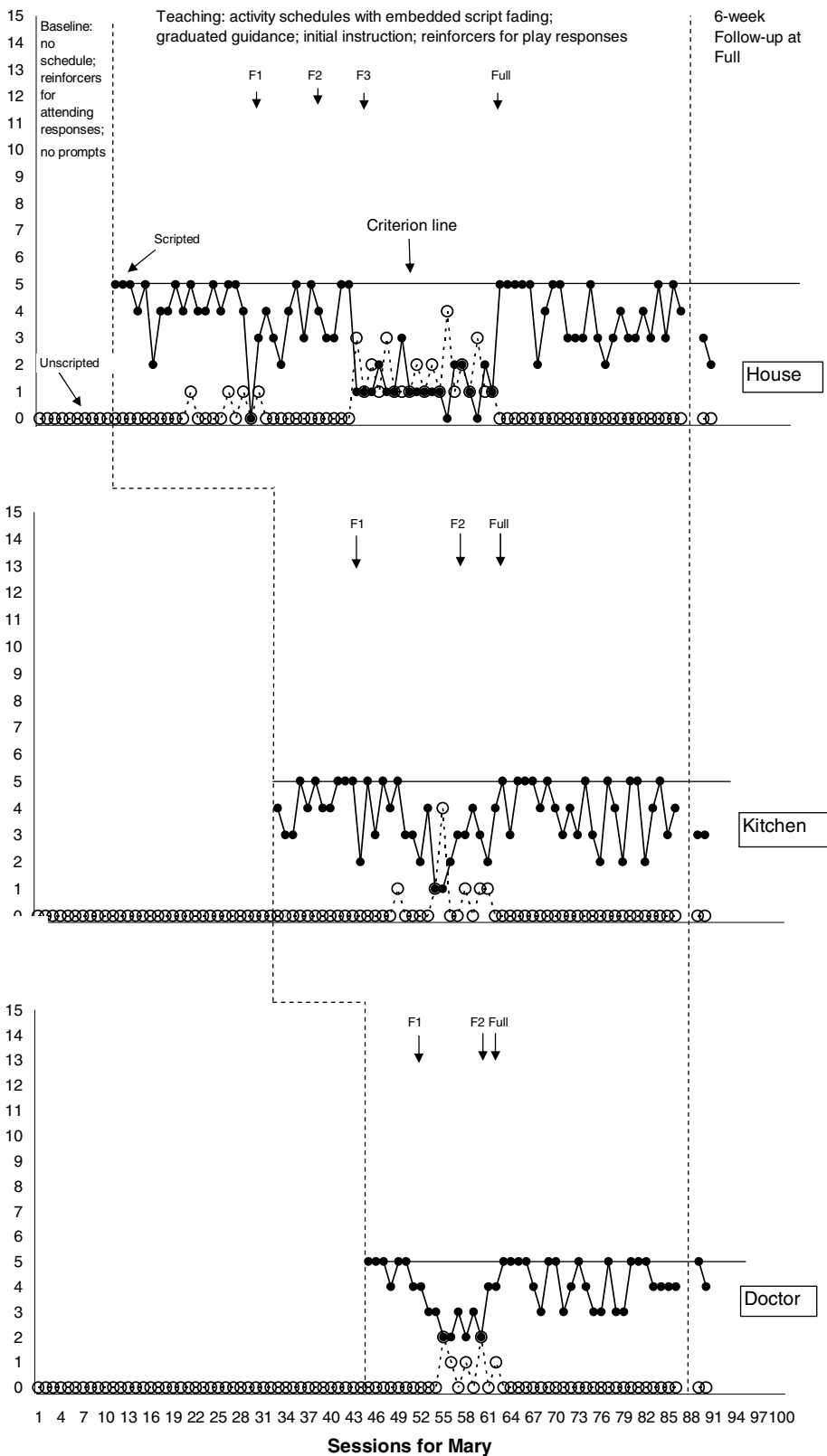


Cumulative Number of Spontaneous Symbolic Play Responses

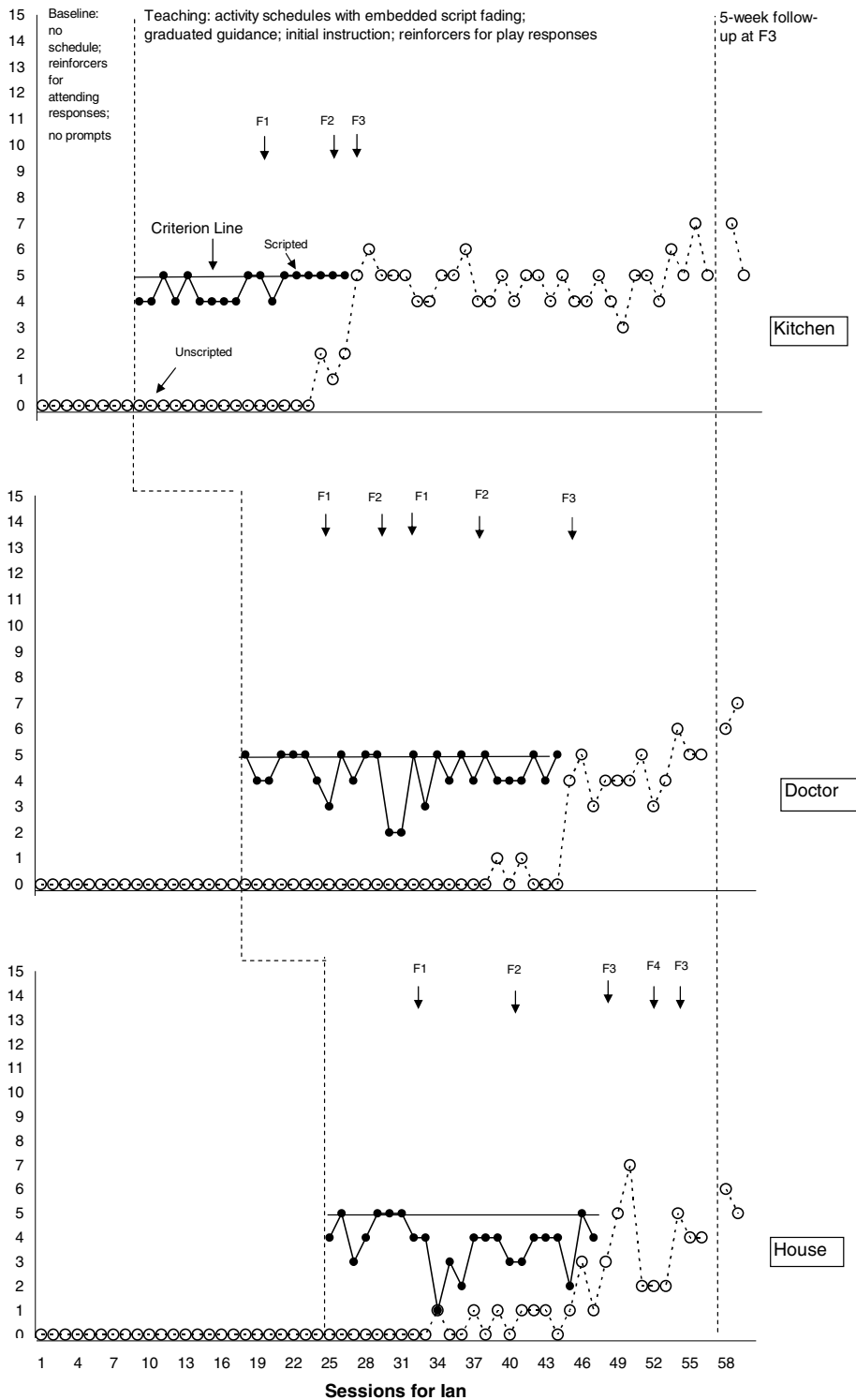




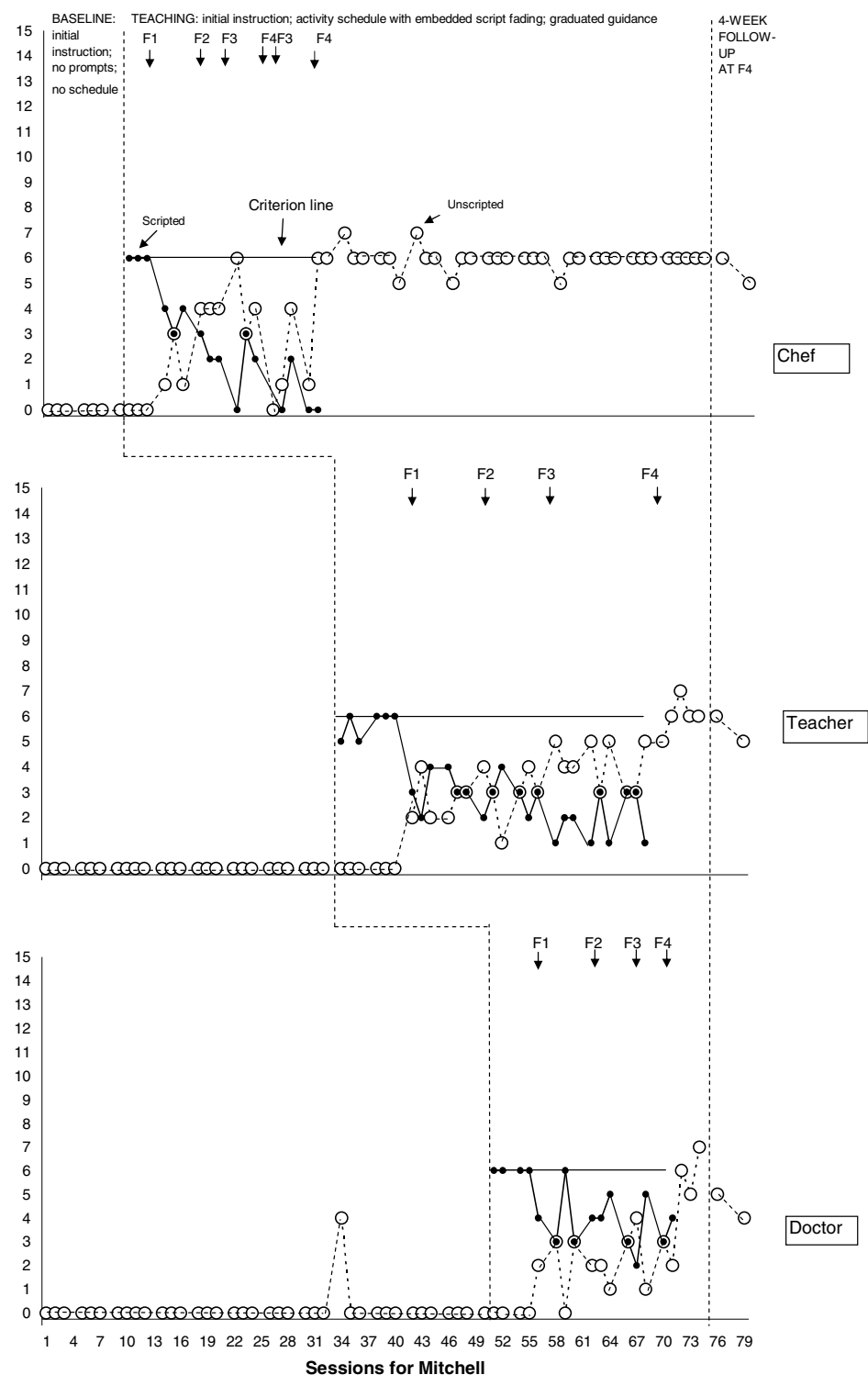
Number of Scripted and Unscripted Verbal Responses



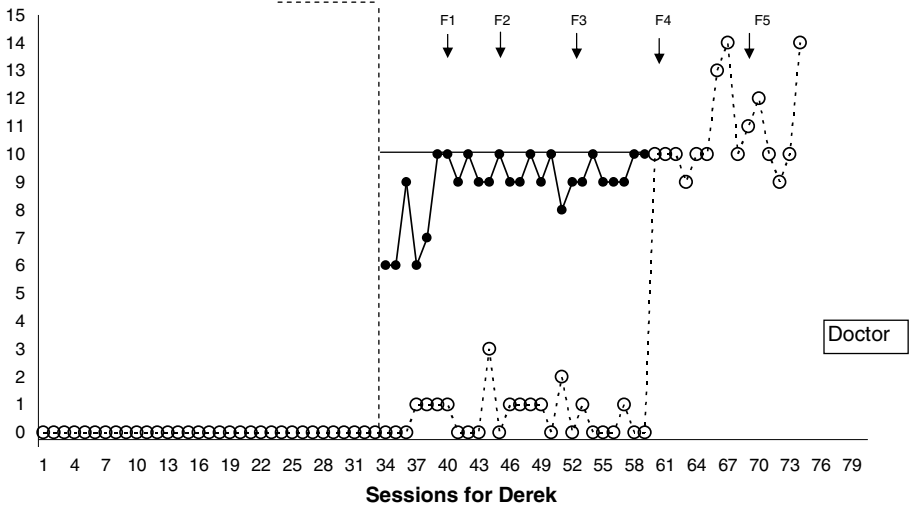
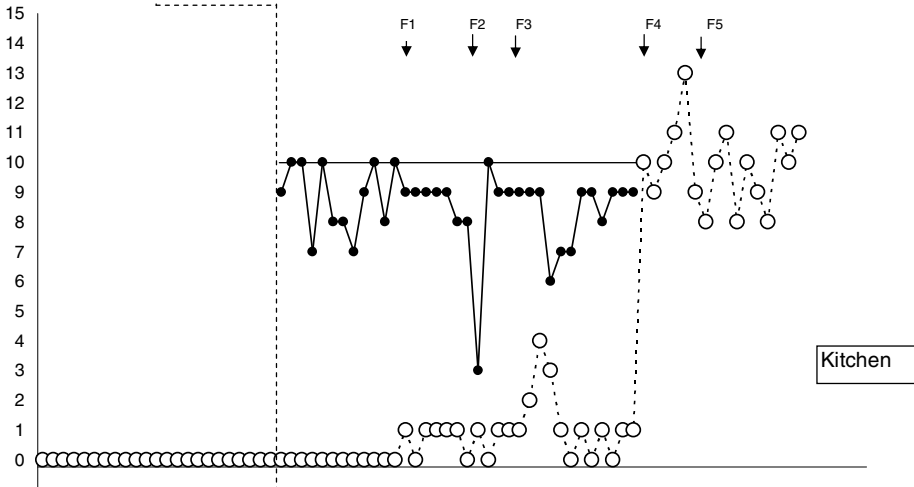
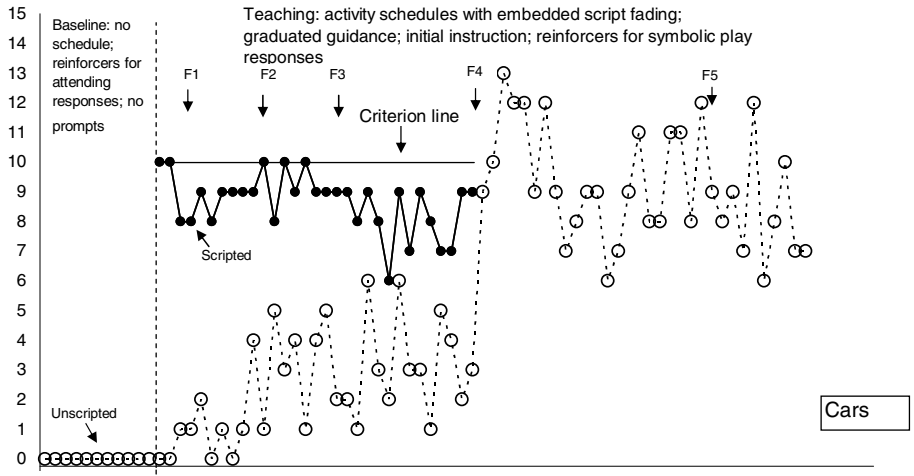
Number of Scripted and Unscripted Verbal Responses during Training Trials

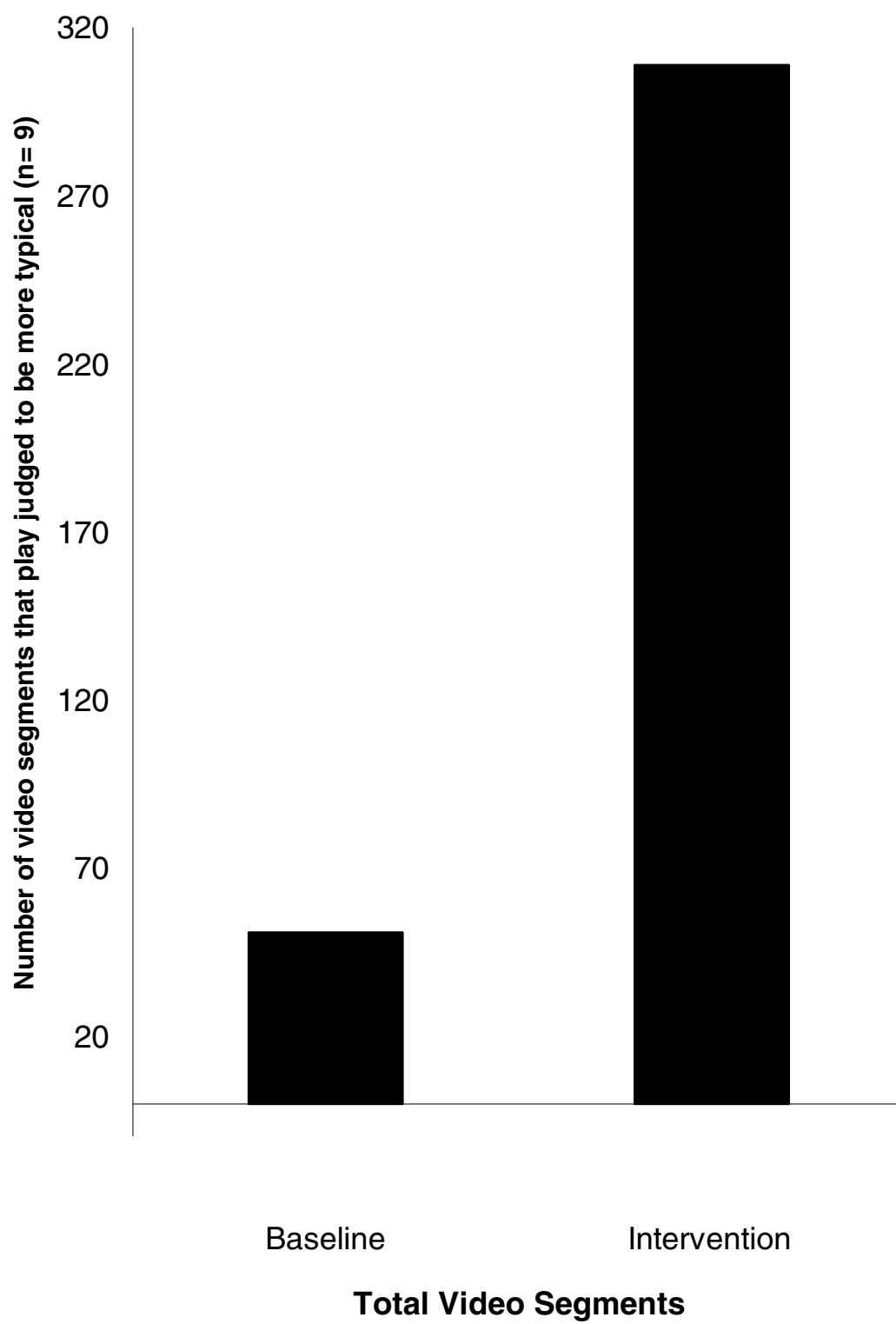


Number of Scripted and Unscripted Verbal Responses



Number of Scripted and Unscripted Verbal Responses





Appendix

A Review of the Literature on Errorless Learning Procedures and  
Implications for Teaching

Errorless Learning Procedures:

A Review of the Literature and Implications for Teaching

by

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City University of New York

### Abstract

The present article examines errorless learning procedures and provides implications for their use in applied settings. Errorless learning procedures involve teaching a discrimination with a very low error rate from the beginning of instruction. Different errorless learning procedures described in the research literature include a) stimulus fading, b) stimulus shaping, c) stimulus superimposition and fading, d) stimulus superimposition and shaping, e) time-delay, f) stimulus equalization, and g) exclusion. Choosing an errorless learning procedure will depend on the nature of the stimuli. When the stimuli differ along some physical dimension, fading should be used. When the stimuli are more complex, stimulus shaping procedures should be used. One of the most critical factors in designing errorless learning procedures is manipulating criterion-related stimulus elements.

Errorless learning procedures:

A review of the literature and implications for teaching

In studies involving discrimination learning, researchers attempt to establish stimulus control. Stimulus control has been defined as the “...extent to which the value of an antecedent stimulus determines the probability of occurrence of a conditioned response” (Terrace, 1966, p. 271). A greater degree of stimulus control is demonstrated when the probability of a response increases. Throughout the first half of the 20<sup>th</sup> century, it was believed that a differential reinforcement procedure was needed to establish stimulus control (Hull, 1950; Spence, 1937). That is, a discrimination was established, only after responding to both the S+ and S- was demonstrated. Typically, trial-and-error learning procedures were implemented (Keller & Schoenfeld, 1950). Both stimuli were presented at criterion from the start of training. Correct responding to the S+ was followed by the presentation of a reinforcer, whereas incorrect responding to the S- was not followed by the presentation of a reinforcer. When using trial-and-error procedures, the researchers assumed that the organism would eventually acquire the discrimination, although the degree of control by the experimenter was limited (Terrace, 1966). That is, the stimuli were always presented in their final form; and therefore, the experimenter was unable to manipulate the stimuli to increase the likelihood that the organism would differentially respond to the stimuli.

Alternatively, it has been demonstrated that stimulus control can be enhanced by attempting to increase the probability of responding to S+ and to decrease the probability of responding to S- (Terrace, 1966). This element is done by directly manipulating the stimuli involved in the discrimination. Initially, two stimuli that are discriminable to the organism are presented. Reinforcers are presented to the organism for correct responding to a series of gradually changing stimuli, along some dimension (e.g. intensity), until the

final discrimination is established. Responding to S- is absent, or at a low rate.

Procedures involving discrimination learning without errors have been referred to as errorless learning procedures (Terrace 1963a). In the current article, both trial-and-error and errorless learning procedures will be examined and compared. A review of the different types of errorless learning procedures and the critical factors that promote enhanced stimulus control in errorless learning procedures will also be discussed.

### Trial-and-Error Learning Procedures

Trial-and-error learning was described in a series of landmark experiments conducted by Thorndike toward the end of the 19<sup>th</sup> century (cf. Keller & Schoenfeld, 1950, pp. 36-39). An animal, typically a cat, was placed inside a problem box. Food was placed in view, just outside the box. To escape from the box and obtain the food, the cat had to pull a string that operated the latch. When the cat was first placed in the box, it engaged in a number of different responses until it eventually pulled the string, escaped from the box, and immediately consumed the food. At first, it took the cat approximately one-hundred-sixty seconds to escape. The latency to escape the box gradually decreased over successive trials, until the cat consistently began to escape in ten-seconds. The latency data were plotted and the resulting graphic display was called a learning curve. The learning curve is illustrative of the type of learning involved when using trial-and-error procedures.

In later years, new apparatus was developed to study trial-and-error learning with a variety of animals and in a variety of situations (cf. Catania, 1998, pp. 60-65). For example, a food-deprived rat was placed in an experimental chamber equipped with a lever and a food cup. Pressing the lever resulted in the delivery of a pellet into the food

cup. Experimenters recorded the rate of lever pressing and results demonstrated that the response rate of the rats gradually increased over time.

### *The function of errors*

Classic theories of discrimination learning were based on trial-and-error learning (Hull, 1950; Spence, 1937). Responding to both S+ and S- was thought to be necessary for a discrimination to be formed. Hull (cf. Spence, 1937) postulated two types of trial-and-error learning. One is the complex-type illustrated by maze learning, where the completion of the maze that includes a series of correct responses, gets reinforced. In the second, simple type of learning, the subject is reinforced immediately for correct responding, but incorrect responding is followed by no reinforcement or punishment. The experiments involving the cat in the problem-box is an example of this type of learning. Another example is discrimination learning, where reinforcers are delivered contingently for correct responding, while incorrect responding is not reinforced. Discrimination learning is different from problem-box learning in that in the latter, the same correct response is reinforced on each trial.

Conversely, in discrimination learning, whether a response will be followed by a reinforcer is dependent on the conditions of the stimuli at the moment of responding. To illustrate, a rat is placed in a chamber with a lever, in a successive discrimination paradigm (cf. Keller & Schoenfeld, 1950, pp. 118-119). The experiment is arranged so that two-different stimuli a bright, as opposed to a dim, light alternate within the chamber. Instead of delivering reinforcers for all lever presses, responding depends upon the presence of the bright light. That is, when the chamber is dim, lever pressing does not produce reinforcers whereas when the chamber is bright, lever pressing produces

reinforcers. The bright light is a discriminative stimulus ( $S^+$  or  $S^D$ ), in that it sets the occasion for the delivery of a reinforcer if a response is made. The dim light is also a discriminative stimulus ( $S^-$  or  $S^\Delta$ ), in that it sets the occasion that a response will not be followed by a reinforcer.

Furthermore, reinforcers, delivered contingent on responding to  $S^+$ , strengthen that response, and therefore increase the probability of responding to the  $S^+$ . Likewise, non-reinforced responses to  $S^-$  weaken that response, and therefore decrease the probability of responding to the  $S^-$  (Spence, 1937). As the alternation between  $S^+$  and  $S^-$  continues, differential responding to these stimuli gradually increases. Keller and Schoenfeld (1950, p. 119) provide a detailed account of this process:

“...extinction is the hallmark of discrimination—responding to  $S^\Delta$  extinguishes while responding to  $S^D$  is maintained. A cumulative response curve should therefore reveal, by its shape, the formation of the discrimination. That is, it should resemble a curve of extinction. It is because extinction, as opposed to conditioning, is the important process in discrimination that our experiment provided such relatively long periods of  $S^\Delta$ .”

It is clear from this excerpt that responding to  $S^-$  was believed to be a necessary condition in the process of discrimination learning.

Terrace (1963a) challenged these findings after demonstrating that a discrimination can be acquired with relatively few, or no errors. Pigeons were taught a simultaneous visual discrimination between a red key ( $S^+$ ) and a green key ( $S^-$ ). The pigeons were taught to peck the key in the presence of the  $S^+$  and not in the presence of the  $S^-$ . The  $S^+$  remained constant while presentations of the  $S^-$  varied. Terrace examined the differences in performance as a result of when and how the  $S^-$  was introduced. First, the  $S^-$  varied in when it was presented during training, early or late. Second, the  $S^-$  varied in how it was presented during training, with differences in both duration and

intensity of the stimulus. Initially, the S- was presented for brief periods and was dark. Gradually, the duration and intensity of the S- was increased until, at criterion, these features were the same as the S+. Results from the experiment demonstrated that when the S- was introduced early in training and was successively and progressively altered in both duration and intensity, pigeons responded without errors. As a result, Terrace concluded that responding to S- was not needed for a visual discrimination to be formed by pigeons. The conclusion was in direct conflict with the prevailing assumption at the time that responding to S- was required for learning to occur. An important implication of this research was the possibility of using procedures other than trial-and-error training to teach new skills to animals. The experimenter is able to produce behavior changes as a result of procedural manipulations in errorless learning procedures, rather than placing the organism inside a chamber and waiting for the desired response to occur (Terrace, 1966).

Terrace (1963a) characterized the responding of four groups of pigeons that acquired the discrimination with or without errors. First, the performance during acquisition and post-acquisition sessions by the pigeons that acquired the discrimination without errors was more accurate than the performance by the pigeons that acquired the discrimination with errors. That is, responding to S- occurred at a low rate or was absent for the early-progressive group, while responding to S- occurred at a high rate for the early-constant, late-progressive, and late-constant groups. Terrace also outlined two characteristics that were observed only in the performance of pigeons that acquired the discrimination with errors. Although responding to S- had become low and stable, occasional bursts of responding to S- were recorded when S+ and S- were presented in

succession. In addition, in the first trial that S+ and S- were presented simultaneously immediately following a series of trials where S+ was presented alone, occasional bursts of responding to S- were also observed. Terrace concluded that a major effect of responding to S- was the development of “permanently faulty discrimination performance” (p. 23).

The second characteristic described by Terrace (1963a) was that responding to S- was followed by immediate changes in responding to S+, the phenomenon of behavioral contrast (Reynolds, 1961). Behavioral contrast is a change in responding when presented with a particular stimulus, in a different direction from the responding that occurred during the original stimulus. In the first part of the experiment, responding to S- was immediately followed by an increase in the rate of responding to S+. Similarly, in part two of the experiment, responding to S- was immediately followed by decreased latency of responding to S+. Conversely, for the pigeons that responded with few or no errors, there was no behavioral contrast. Terrace (1963b) replicated these findings in another study where he again demonstrated the above. The pigeons that learned the discrimination with errors, the latency of responding to S+ decreased permanently, while the latency of responding to S+ was unaffected for the pigeons that acquired the discrimination without errors. Terrace concluded that “...a necessary and sufficient condition for contrast is the occurrence of responses to S- during the formation of a discrimination” (p. 231).

Third, Terrace concluded that the S- had acquired aversive properties. When the S- was presented, pigeons that had acquired the discrimination with errors would usually either turn away from the key or exhibit a fright reaction. Alternatively, the pigeons that

acquired the discrimination without errors would lower their heads from the pecking position, but continue to face the key, while remaining quiet. This behavior was different from that of the pigeons that had acquired the discrimination with errors.

Stoddard and Sidman (1967) demonstrated similar results in a study that examined the function of errors on performance by children on a simultaneous form discrimination. Experimenters first taught children with mental retardation to discriminate a circle and an ellipse. The subjects then proceeded through a series of circle-ellipse stimuli involving increasingly difficult form discriminations. The control condition involved stimuli that were gradually reduced in size, beginning with stimuli that the subjects could discriminate. The experimental condition involved stimuli from the latter portion of the circle-ellipse series that the subjects could not discriminate. The subjects in the control group responded correctly through the circle-ellipse series in a steady, consistent fashion. The subjects in the experimental group produced errors and experimenters identified inappropriate error patterns, such as circling the nine-key matrix. The subjects in the experimental group repeated earlier steps in the circle-ellipse series until correct responses were made, and then proceeded forward through the series more gradually than during initial training. Two of the subjects in the experimental group did not respond correctly and the circle-ellipse discrimination had to be taught again. The experimenters concluded that successful transfer of discrimination, from forms that are easily discriminated, to more difficult form discriminations, will not occur when errors are produced. In addition, subjects who learn inappropriate error patterns for a given discrimination may permanently respond incorrectly on the basis of that discrimination.

Everett (1977) analyzed the function of errors during the acquisition of a discrimination on the post-discrimination generalization gradients of typically developing children. He also investigated whether S- acquired inhibitory control in children who acquired the discrimination with, as opposed to without, errors. The simultaneous discrimination involved two types of tasks: intradimensional discriminations (line tilts of different degrees) and interdimensional discriminations (line tilts and dots). The children acquired the discrimination using trial-and-error or errorless fading procedures, and the procedures were successful in producing errorful or errorless learners, respectively. After the discrimination was acquired, Everett (1977) examined generalization from training stimuli to testing stimuli (various line tilts). Following interdimensional training, the generalization gradients were flat for both the errorful and errorless learners, revealing no difference in responding. Similarly, the gradients for the intradimensional task were not different with regard to the errorful or errorless learners. Everett (1977) concluded that S+ had acquired control, whereas S- had not. These findings were consistent with Terrace (1963a, b), that reduced the importance of S- and placed greater emphasis on the S+ in discrimination learning.

In summary, results from these and other studies challenged the prevailing assumption that responding to S- was needed for a discrimination to be established (Hull, 1950; Keller & Schoenfeld, 1950; and Spence, 1937). The function of errors, as a result of trial-and-error procedures, was examined (Everett, 1977; Stoddard & Sidman, 1967; and Terrace 1963a,b). A previous history with trial-and-error procedures had a detrimental affect on subsequent performance (Touchette, 1968). Consequently, evidence supporting the use of errorless learning procedures was demonstrated.

### Errorless learning procedures

Although most typically developing children are able to acquire new skills using trial-and-error procedures, children with serious learning deficits often have difficulty acquiring new skills using these methods. When traditional trial-and-error procedures are unsuccessful, other procedures should be tried (Bijou, 1968). One procedure that has been effective in teaching complex skills to children with serious learning deficits, even after traditional trial-and-error teaching procedures have failed, is errorless learning (Bijou, 1968; Dixon, Spradlin, Girardeau, & Etzel, 1974; Schreibman, 1975; Sidman & Stoddard, 1966; and Touchette, 1968).

There are two common features of errorless learning procedures. (a) The beginning discrimination is relatively easy. The stimuli are initially presented in a format that the subjects can easily discriminate, although the final discrimination required by the organism is difficult. In trial-and-error procedures, the stimuli are presented in their final, criterion form from the outset of training. (b) By contrast, in errorless learning procedures, stimulus changes occur gradually. Progressive changes are made to the stimuli until the final, criterion discrimination is established. Control of responding is either maintained through this transformation or is transferred from one or more stimulus dimensions to another.

Errorless learning procedures have been used to teach many different skills, across different populations, and in different settings (Lancioni & Smeets, 1986). Since the study conducted by Terrace (1963a), demonstrations of errorless learning have been shown in children with severe learning deficits (Bijou, 1968; Dixon et al., 1974; Mosk & Bucher, 1984; and Sidman & Stoddard, 1966), typically developing children (Moore &

Goldiamond, 1964; Schilmoeller, Schilmoeller, Etzel, & LeBlanc, 1979), training United States Air Force Pilots (Prather, 1971), and in the neuropsychological rehabilitation of memory-impaired individuals (Baddeley & Wilson, 1994).

A number of studies have been conducted to analyze the effect of using errorless learning procedures as opposed to traditional trial-and-error training to teach discrimination skills (Dixon et al., 1974; Duffy & Wishart, 1987; Richmond & Bell, 1986; Schilmoeller et al., 1979; and Touchette, 1968). In addition, some of these studies have examined the extent to which a previous history with one type of teaching method affects the other.

#### Comparison of trial-and-error and errorless learning procedures

Touchette (1968) compared errorless learning procedures with trial-and-error procedures, to teach a simple, simultaneous discrimination to boys with severe retardation. A black square was presented on a screen and the subjects pressed the response key located closest to it. Only one out of seven subjects acquired the discrimination using trial-and-error procedures alone. The six subjects that did not acquire the discrimination were then taught using an errorless learning procedure. Although five of the six boys acquired the discrimination, previous history with trial-and-error procedures interfered with subsequent learning and maintenance of a discrimination using errorless learning procedures. In contrast, all six boys who were taught using errorless learning procedures alone acquired and maintained the discrimination.

Schilmoeller et al. (1979) also compared an errorless learning procedure with trial-and-error procedures to teach a conditional discrimination to typically developing children. Additional training, using errorless learning procedures, was given to those

subjects who did not acquire the conditional discrimination with the initial use of trial-and-error procedures. Again, previous history with trial-and-error procedures interfered with subsequent learning of the discrimination using the stimulus shaping procedure. Likewise, Dixon et al. (1974) found that errorless learning procedures were superior to trial-and-error procedures to teach an in-front spatial discrimination to adolescents with mental retardation. All nine subjects in the experimental group acquired the discrimination using errorless learning procedures, whereas none of the eight control subjects acquired the discrimination using trial-and-error procedures. In another study (Duffy & Wishart, 1987), typically developing children and children with Down's Syndrome were taught two simultaneous discrimination tasks. Results demonstrated that the children performed better on training and test trials after errorless learning as opposed to trial-and-error procedures.

In the studies previously discussed, the experimenters used different variations of errorless learning procedures. For example, in the Schilmoeller et al. (1979) study, two variations of errorless learning procedures were used, called stimulus fading and stimulus shaping. The next section is a comprehensive review of the variations of errorless learning procedures.

#### Different errorless learning procedures

Several variations in errorless learning procedures have been described in the literature. Most of the procedures involved fading of stimulus elements, but those procedures were further distinguished in the research literature based on how the stimulus elements were faded. Procedures identified include a) stimulus fading (Dixon et al., 1974; Moore & Goldiamond, 1964; Sidman & Stoddard, 1966; and Terrace, 1963a), b)

stimulus shaping (Bijou, 1968; Schilmoeller & Etzel, 1977; and Sidman & Stoddard, 1966;), c) stimulus superimposition and stimulus fading (Terrace, 1963b Touchette, 1968), d) stimulus superimposition and stimulus shaping (Etzel et al., 1981), e) time-delay (Touchette, 1971; Touchette & Howard, 1984), f) stimulus equalization (Dixon, 1977), and g) exclusion (Hoko & LeBlanc, 1988).

### *Stimulus Fading*

Stimulus fading involves manipulations along one or more physical dimensions of a stimulus. Gradual shifting of control from the stimulus elements that are being faded to the final, criterion stimulus required for the discrimination is demonstrated. When a stimulus is faded, its intensity, but not overall topography is changed.

Moore and Goldiamond (1964) examined the effects of a stimulus fading procedure on the performance of a visual discrimination task by typically developing preschool children. In a delayed matching-to-sample, simultaneous discrimination paradigm, children were required to match triangles based on their rotation. Incorrect matches differed only slightly in their orientation to the sample. When presented with the triangles in their final form, the children had difficulty discriminating the correct match. To increase responding to the correct triangle, it was illuminated, while the brightness of the incorrect matches was progressively increased. The correct triangle was initially presented at full intensity, while the incorrect triangles were dull. Correct responding by the subjects might have been enhanced by a phi phenomenon effect. That is, the phi phenomenon effect might have occurred while moving one's eyes from the sample to the correct match. When the correct match was bright and the incorrect matches were dull, it appeared as though the sample "jumped" to the correct match (due to the timing of their

appearances). When the S+ and S- matching stimuli no longer differed in intensity, correct responding was maintained. The authors concluded that stimulus fading could be used to teach conditional discriminations to typically developing children using matching-to-sample procedures.

Sidman and Stoddard (1966) used a stimulus fading technique, in a simultaneous discrimination paradigm, to teach people with mental retardation to discriminate between a circle and an ellipse. Initially, the subjects were not able to discriminate between these two forms; therefore, training began with stimuli that the subjects could easily discriminate, a bright key as opposed to a dark key. One of the stimuli was gradually transformed, by altering the shape of the stimulus, until the final stimuli to be discriminated differed only in form. Presentations of the S+ (circle) stimulus remained constant while the S- (ellipse) stimulus was gradually faded in both form and intensity. Initially, the incorrect key was dark. The first step was to increase the intensity of this key in successive presentations. Next, once the brightness was faded in completely, the form of the stimulus was then faded in. At first, the ellipses were barely visible. With each successive presentation, they became progressively darker. Finally, the only remaining difference between the keys was their form, circle or ellipse. The gradual-stimulus fading technique resulted in the successful transfer of responding from the easier discrimination of stimulus intensity, to the more difficult discrimination of stimulus form. The authors concluded that people with mental retardation can be taught a form discrimination using a stimulus fading technique.

Fading techniques have been used to train more complex discriminations to children with severe learning deficits. Dixon et al. (1974) taught a spatial discrimination

to children with mental retardation. Children were presented with drawings of persons or animals positioned in their profile view and had to touch the front of the figures, or referent objects. Next, the referent objects appeared with other relational objects. A relational object was a drawing presented in various locations around the referent object. One relational object was placed directly in front of the referent object. Gradually, the relational object was positioned further from the referent object. At the same time, other relational objects in three different locations (under, on top of, and behind) were progressively faded in. These positions comprised the S- locations. For the final fading steps, the picture was broken up into four quadrants with an identical referent object placed in all four positions. The experimenters compared the performance of an experimental group trained using this fading technique to a control group taught using a traditional trial-and-error procedure. All nine subjects in the experimental group, whereas none of the eight control subjects, acquired the discrimination.

Researchers have differentiated between fading elements presented within, as opposed to outside, the stimulus complex. The procedures have been referred to as within-stimulus prompting and extra-stimulus prompting respectively (Rincover, 1978; Schreibman, 1975; and Wolfe & Cuvo, 1978). Within-stimulus prompting involves the selection of known stimuli as prompts that are within the stimulus-complex. Extra-stimulus prompting involves the selection of known stimuli as prompts that are outside of the stimulus complex, along non-manipulated dimensions. Within-stimulus and extra-stimulus prompting are both stimulus fading procedures. Within-stimulus prompts include exaggerated elements within a stimulus complex (Schreibman, 1975; Wolfe & Cuvo, 1978) or a superimposed stimulus positioned on the criterion stimulus (Rincover,

1978). Examples of extra-stimulus prompts include a pointing stimulus (Schreibman, 1975; Wolfe & Cuvo, 1978) or a stimulus positioned above the criterion stimulus (Rincover, 1978).

Schreibman (1975) examined within-stimulus and extra-stimulus prompting procedures, using a simultaneous discrimination paradigm, involving visual and auditory discriminations. The stimuli for the visual discriminations were different line forms presented on cards. The extra-stimulus prompt was a pointing stimulus. The experimenter faded the pointing stimulus by gradually moving her finger along the line forms of the S+. The within-stimulus prompt was an exaggeration of a part of the stimulus critical to the discrimination. The experimenter faded the exaggerated part of the stimulus gradually. The fading dimension chosen by the experimenters was intensity. The initial stimuli differed in both form and intensity, while the criterion stimuli differed in only form. When the stimuli were first presented, the S+ was at full intensity, while the S- was dark. Gradually, the intensity of the S- was faded in, until both stimuli were presented at criterion. Subjects acquired the discrimination on 15 of 16 tasks involving within-stimulus prompting, but they failed the discrimination on all tasks involving extra-stimulus prompting. The author concluded that within-stimulus prompting is superior to extra-stimulus prompting to teach visual and auditory discriminations to children with autism.

### *Stimulus Shaping*

Stimulus shaping involves gradual changes in the topography of the stimulus. While “shaping” is a term that usually refers to procedures involving the reinforcement of successive approximations of a target response, researchers in the errorless learning

literature have used the term stimulus shaping to distinguish stimulus shaping procedures from stimulus fading procedures. Like stimulus fading, stimulus shaping begins with an initial discrimination between two stimuli that the organism can easily discriminate. But unlike stimulus fading, the initial stimuli are altered until they resemble the final, criterion stimuli. Whereas stimulus shaping involves altering the overall configuration of the stimulus, stimulus fading does not (B. C. Etzel, personal communication, September 22, 2003). Also, while transfer of control of responding from the initial stimuli to the final criterion stimulus is needed in fading, stimulus shaping does not depend on the transfer of control of responding (Etzel, 1997). When a stimulus shaping procedure is carried out successfully, the control of responding is maintained by the gradually transformed stimulus.

Sidman and Stoddard (1966) used stimulus shaping procedures. After the subjects were taught the circle-ellipse discrimination using fading techniques, they were then taught a discrimination reversal. The stimuli that controlled responding reversed functions. Initially, the circles (S+ after the first part of the experiment) were transformed into squares and the ellipses (S- after the first part of the experiment) were transformed into circles. Next, the squares were transformed into flat rectangles and finally into ellipses. Thus, in the final discrimination, the ellipse functioned as an S+ and the circle as an S-. Both subjects with mental retardation acquired the reversal discrimination successfully.

Stimulus shaping programs have expanded across different responses and with different populations. For example, stimulus shaping has been used to teach a left-right discrimination to typically developing children and children with mental retardation

(Bijou, 1968), typically developing children were taught the correspondence between Japanese characters and their pictures (Schilmoeller & Etzel, 1977), typically developing preschool children were taught a conditional visual discrimination (Schilmoeller, et al., 1979), and children with mental retardation were taught visual-motor skills (Mosk & Bucher, 1984). Stimulus shaping can be used to teach a variety of responses, across individuals with different abilities.

*Stimulus superimposition and stimulus fading*

Stimulus superimposition and stimulus fading involves the use of known stimuli as prompts for the discrimination of unknown, criterion stimuli. For example, line forms, a known discrimination, are superimposed on colored keys, an unknown discrimination. The superimposed stimuli are then gradually faded in a manner that facilitates transfer to the criterion stimuli.

Terrace (1963b) trained pigeons to discriminate between two colors (red-green) using the same fading procedures as previously described (Terrace 1963a). Next, Terrace examined the transfer of responding from the color discrimination to a more difficult vertical-horizontal line-orientation discrimination. Lines were superimposed on the colored-keys. Then, the red- and green-backgrounds were slowly faded out. Successful transfer of responding from the easier color discrimination to the more difficult line discrimination resulted. In contrast, pigeons made errors when there was an abrupt transfer from color-to-line (no superimposition or fading), when the colors were not faded out progressively (superimposition without fading), and when training began with the more difficult line-orientation discrimination (no color- discrimination).

Stimulus superimposition and stimulus fading procedures have also been successfully demonstrated in studies involving human subjects (Touchette, 1968). Boys with severe mental retardation were presented with three panels, a center-display panel and two-response panels on either side of it, in a simultaneous discrimination paradigm. The subjects touched one of the two-response panels in the display that was more adjacent to the center-display panel containing a black square. At first, the incorrect and center panels were black and the correct panel was red, with a black horizontal line going through the latter. Gradually, both black panels were made progressively lighter until they were fully bright. This was followed by a gradual reduction in redness of the correct panel until it was identical to the other two panels. Next, the horizontal black line was shortened until it only appeared in the center panel. Finally, it was shortened again to its criterion-shape. All six subjects acquired the discrimination with few or no errors. Touchette concluded that children with retardation can acquire a discrimination using errorless learning procedures.

#### *Stimulus superimposition and stimulus shaping*

Stimulus superimposition and stimulus shaping involve the addition of known stimuli as prompts for the discrimination of unknown, criterion stimuli. Unlike stimulus superimposition and stimulus fading however, the topography of the stimulus is gradually changed and integrated into the criterion stimulus or parts of the superimposed stimulus are removed.

Etzel et al. (1981), using Schreibman's (1975) stimuli, developed a stimulus superimposition and stimulus shaping procedure to teach a child with retardation an up-down discrimination involving stick figures with arms. Stimuli were superimposed on

the arms, thus extending the arms in their logical directions, up or down. For the S-, a dog attached to a leash was superimposed onto an arm, extending in a downward direction. For the S+, a balloon attached to a string was superimposed onto an arm, extending in an upward direction. The S+ was shaped first. Specifically, the balloon detached from the arm of the stick figure and flew away. Next, the S- gradually disappeared (the dog dug a hole in the ground). Acquisition of the up-down discrimination was successfully demonstrated using this superimposition and shaping procedure. The experimenters concluded that children with retardation could be taught a more complex discrimination using stimulus superimposition and stimulus shaping procedures.

#### *Time-delay procedure*

Time-delay does not involve the manipulation of stimuli as in stimulus fading, stimulus shaping, and stimulus superimposition procedures. Instead, a prompt is presented simultaneously with the criterion S+. The presentation of the prompt is gradually delayed over successive trials. Examples of prompts include a pretrained stimulus (Touchette, 1971) or finger pointing (Touchette & Howard, 1984). Successful performance is demonstrated when the subject responds correctly before the presentation of the prompt.

Touchette (1971) taught subjects to discriminate forms using a simultaneous discrimination paradigm. Initially, the subjects were taught to press a red key, as opposed to a white key. The red key functioned as the pretrained stimulus. Next, black letters (E) with legs down (S+), and legs up (S-), were superimposed on the red and white keys, respectively. When the subjects responded correctly by pressing S+, as opposed to

S-, the onset of the subsequent presentation of the red stimulus was delayed by 0.5 seconds. Each correct response resulted in increased delays of the red stimulus by an additional 0.5 seconds. Successful acquisition of the form discrimination was demonstrated when subjects responded correctly before the onset of the red stimulus. Touchette concluded that successful transfer of responding from the red stimulus to the S+ was a result of using time-delay procedures.

### *Stimulus equalization*

Stimulus equalization involves the abrupt removal of irrelevant dimensions of complex stimuli that are to be discriminated. The stimuli that are then presented are alike, except for the elements critical to the final discrimination. Once subjects can discriminate the stimuli, the irrelevant stimulus dimensions are gradually faded back in.

Hoko and LeBlanc (1988) designed a study to examine the effectiveness of stimulus equalization procedures on the acquisition of a complex discrimination by preschool children. The simultaneous discrimination involved four figures that differed across four stimulus dimensions—color, shape, number of hairs, and orientation of the feet. Trial-and-error training was first implemented, and after incorrect responding, stimulus equalization was used. The experimenters programmed one correct dimension during each condition. For example, when color was the correct element, the stimuli differed only in color, but the shape, number of hairs, and foot orientation of the figures were identical. Once the subjects responded correctly on the basis of one stimulus dimension, a second stimulus dimension was faded in. The procedure repeated for each stimulus dimension, until the criterion discrimination was established. The subjects acquired the discrimination more frequently using stimulus equalization than trial-and-

error procedures. The experimenters demonstrated the functionality of stimulus equalization procedures when discriminations involve dimensionally complex stimuli.

### *Exclusion*

Exclusion refers to a procedure that involves the simultaneous presentation of two stimuli, one trained and the other untrained, in a matching-to-sample paradigm. For example, to teach someone the capital of Missouri using an exclusion procedure, one might present trained stimuli, such as “San Francisco” and “New York”, with the untrained stimulus, “Jefferson City.” The person would respond correctly from the beginning of training, away from the trained stimuli, “San Francisco” and “New York”, to the untrained stimulus, “Jefferson City.” Dixon (1978) examined exclusion in a study of the control of spoken words on the selection of visual stimuli by children with mild and borderline mental retardation. Two visual stimuli, S+ and S-, were presented to the subjects in a matching-to-sample paradigm. The subjects selected one of the visual stimuli corresponding to a novel spoken word that functioned as a discriminative stimulus. All subjects responded by selecting the S+ when presented with the trained word and the S- when presented with novel words. The experimenter then presented two S- visual stimuli in a matching-to-sample paradigm with novel spoken words. The subjects produced errors on these trials. Dixon concluded that control of responding could be established in discrimination procedures using an exclusion procedure. Subjects will select S-, given a choice of S+ and S-, in a two-choice simultaneous discrimination paradigm.

*Summary of errorless learning procedures*

A variety of errorless learning procedures are found in the literature. All the procedures are similar in that fading is involved, and they differ in how the stimuli are manipulated. Stimulus fading is used when stimuli share a common dimension, such as a big figure and a small figure. Instructors exaggerate the size of the figures, very large and very small, and gradually fade the size of the figures until the criterion discrimination is established. The dimension used for fading, in this case size, is part of the criterion discrimination. Stimulus shaping involves the direct manipulation of complex stimuli that cannot be faded along a common dimension, for example, words. Uninformed instructors might use colors to teach children to discriminate words. To illustrate, one word is written in blue and the other red. Subjects respond correctly on the basis of the color discrimination, but when color is faded out, errors are produced. Control of responding is maintained by color, rather than the word. The dimension chosen for fading, color, is not part of the criterion discrimination. Stimulus superimposition is more successfully involved with stimuli that cannot be manipulated along any dimension. Such stimuli are often referred to as non-reducible or primitive stimuli (B. C. Etzel, personal communication, September 22, 2003). An example is stimuli that differ in left-right orientation, such as the letters “b” and “d.” Stimuli that are easily discriminated are superimposed on the non-reducible stimuli. Stimulus superimposition and fading involves gradually removing the superimposed stimuli. Stimulus superimposition and shaping involves changing the overall configuration of the superimposed stimuli.

Time-delay involves the presentation of a prompting stimulus coinciding with presentation of the S+. The delay before the presentation of the prompting stimulus is

gradually increased on successive trials. An instructor might use a time-delay procedure in a matching-to-sample paradigm when teaching a student to point to a picture, given the corresponding spoken word. On the first trial, the instructor would immediately point to the correct visual stimulus while presenting the spoken word. The instructor would gradually increase the delay of the pointing stimulus, based on correct responding by the student. After repeated trials, the subject would select the correct response to the stimuli before the instructor's pointing stimulus was presented. Stimulus equalization is used to facilitate discrimination of complex, multi-dimensional stimuli. Two stimuli are presented that are alike with the exception of the critical features needed for the final discrimination. The redundant stimulus elements are gradually reinstated once correct responding is produced. Exclusion is a procedure that involves the selection of an untrained stimulus given the presence of a previously trained stimulus. Students immediately select away from the trained stimulus to the untrained stimulus.

In summary, a number of studies have been conducted demonstrating a variety of errorless learning procedures. Although experimenters were at times successful in producing errorless or nearly errorless performance in children with serious learning deficits (Bijou, 1968; Dixon et al., 1974; Duffy & Wishart, 1987; Richmond & Bell, 1983; Schilmoeller et al., 1979; and Touchette, 1968), not all errorless learning procedures resulted in successful acquisition of new skills by these subjects. Sometimes, attempts to produce errorless performance have been unsuccessful (Cheney & Stein, 1974; Gollin & Savoy, 1968; Koegel & Rincover, 1976; Rincover, 1978; and Schwartz, et al., 1971). This has led researchers to analyze what factors are critical in the successful

demonstration of acquisition of new skills using errorless learning procedures. In the next section, these critical factors will be discussed.

Critical factors that promote stimulus control  
in errorless learning procedures

Because not all errorless learning procedures have been successful, it is important to identify those factors that are critical when designing these programs (Lancioni et al., 1986). Different parameters, such as the use of criterion-related as opposed to non-criterion-related stimulus elements (Schilmoeller & Etzel, 1977; Stella & Etzel, 1983) and fading or shaping along the S+ or S- (Schreibman & Charlop, 1981; Stella & Etzel, 1986), were identified. Researchers have also examined the effectiveness of stimulus shaping, as opposed to stimulus fading, procedures (Schilmoeller et al., 1979).

Although the factors that promote stimulus control differ across studies, one of the most important factors for researchers is to determine what stimulus element is manipulated (Bijou, 1968). Schilmoeller and Etzel (1977) noted two guidelines in choosing the right element of the stimulus. The first was to choose the element that produces correct responding and the second was to choose elements that demonstrate a smooth shift in control from the initial stimulus elements to those required for the final discrimination. Furthermore, Etzel (1997) identified two possible ways that failure to demonstrate successful transfer has been demonstrated. One was that the initial stimuli were not manipulated soon enough (see Terrace 1963). The other was that the initial stimuli used to teach a difficult discrimination were not related to the criterion stimuli (see Gollin & Savoy, 1968). These critical factors in the successful demonstration of transfer of control in errorless learning procedures will be discussed.

*Criterion-related stimulus elements*

A number of studies have demonstrated the importance of manipulating the stimulus elements that contain the features of the stimuli critical to the final discrimination (Bijou, 1968; Dixon et al., 1974; Doran & Holland, 1979; Schilomoeller & Etzel, 1977; Schreibman, 1975; Stella & Etzel, 1983; and Wolfe & Cuvo, 1978). When stimulus elements are manipulated that are related to the final discrimination, they are considered to be criterion-related.

Etzel and LeBlanc (1979) designed a criterion-related fading program using arbitrary stimuli to illustrate the procedure. Children were taught to discriminate two faces with different-sized ears. The criterion discrimination was of two faces: one face had two regular-sized ears (S+), while the other face had one regular-sized ear and one smaller ear (S-). Because size of the ears was the relevant stimulus dimension, the element chosen for fading was ear size. On the initial presentation of the stimuli, the size of both ears of the S+ was enlarged, while the size of one ear of the S- was enlarged and the size of the smaller ear was reduced. The enlarged ears of the S+ and S- were gradually reduced over successive trials. By the 20<sup>th</sup> trial, the S+ was presented at its criterion level, with both ears presented at regular-size. In contrast, one ear of the S- was presented at criterion level, while the smaller ear remained reduced. Over the next 20 trials, the smaller ear of the S- was gradually enlarged, until, by the 40<sup>th</sup> trial, the ears on both faces were presented at criterion level. The criterion-related stimulus fading procedure resulted in transfer of responding, from the initial stimuli that were easily discriminated, to the criterion stimuli needed for the discrimination.

Similarly, Schilmoeller and Etzel (1977) designed a criterion-related stimulus shaping program using arbitrary stimuli. Children were taught to match Japanese characters (Kanji) to their corresponding pictures. Initially, the S+ was identical to the sample picture. Gradually, the S+ was topographically altered into the Japanese character that the sample picture represented. The stimulus elements chosen for shaping were the elements that were critical to the final discrimination, resulting in a successful shift from the stimuli being shaped to the criterion stimuli. The subjects acquired the discrimination between Kanji and their corresponding pictures. The authors concluded that complex discriminations can be taught using criterion-related stimulus shaping procedures.

In summary, both of these studies demonstrated the importance of manipulating criterion-related stimulus elements. Specifically, control of responding shifts, from the initial stimuli to the criterion stimuli, when criterion-related stimulus elements are manipulated. When stimulus elements are chosen that are unrelated to the criterion stimuli, failures to demonstrate successful performance have been reported (Cheney & Stein, 1974; Gollin & Savoy, 1968; Koegel & Rincover, 1976; and Schwartz et al., 1971). That is, when experimenters chose non-criterion-related stimulus elements to be manipulated in fading procedures, subjects often did not acquire the discrimination. Studies that involved the manipulation of non-criterion-related stimuli will be discussed next.

#### *Non-criterion-related stimulus elements*

Problems were encountered, in errorless learning procedures, when the stimulus dimensions chosen for manipulation were unrelated to the criterion discrimination. When experimenters chose non-criterion-related stimulus elements, the

elements of the stimuli that initially control responding were not the critical features needed for the final discrimination. It follows that control of responding must transfer, from the nonfunctional stimulus features, to features that differentiate the stimuli in the final discrimination. Because transfer of responding using non-criterion-related stimulus elements is expected to occur without direct stimulus manipulation of the critical features of the stimuli, Etzel and LeBlanc (1979) likened the transfer to train and hope generalization (Stokes & Baer, 1977). Stokes and Baer (1977) argued that it is more useful to program generalization through direct training. Similarly, to promote a shift in responding using errorless learning procedures, the elements of the stimuli chosen to be manipulated must be criterion-related (Etzel & LeBlanc, 1979). Direct manipulation of the stimulus elements that are critical to the final discrimination is required. When stimulus elements are chosen that are non-criterion-related, researchers often fail to demonstrate successful performance using errorless learning procedures (Cheney & Stein, 1974; Gollin & Savoy, 1968; Koegel & Rincover, 1976; and Schwartz et al., 1971).

Gollin and Savoy (1968) taught a discrimination reversal task to two groups of children. Either a stimulus fading procedure or trial-and-error procedure was used. The criterion stimuli were a circle and a triangle, and the backgrounds for both stimuli were multiple horizontal stripes. The fading procedure involved gradually increasing the brightness of the form and background of the S-. Experimenters examined transfer of responding from the reversal discrimination to a conditional discrimination problem. More subjects from the trial-and-error group performed without errors on the conditional discrimination problem. In tasks involving transfer of responding from an original discrimination to a conditional discrimination, transfer is facilitated by experience with

both the S+ and the S-. Because of the gradual introduction of the S- in the fading procedure, the subjects did not have enough experience with the S-. It follows that transfer was not facilitated for subjects in the fading group. While Gollin and Savoy (1968) attributed the failure to lack of sufficient experience of the S- by the subjects in the fading group, other researchers attributed the failure to the incorrect choice of the element of the stimuli to be manipulated (Etzel & LeBlanc, 1979; Schilomoeller & Etzel, 1977). That is, the element of the stimulus that was chosen was non-criterion-related. The basis for the initial discrimination, intensity, was unrelated to the basis for the final discrimination, form (e.g., Gollin & Savoy, 1968).

Schwartz et al. (1971) taught children to discriminate symmetrical and asymmetrical figures, using non-criterion-related fading procedures. That is, the dimension of the stimuli chosen for fading, color, was unrelated to the criterion discrimination, symmetrical form. Initially, the fading dimension controlled responding, with only 5% of the subjects producing errors on the discrimination when the fading element was present. Once the element was completely faded, subjects produced more errors. Specifically, the proportion of subjects who made errors increased to 20%. Responding did not transfer from the faded dimension to the criterion discrimination using non-criterion-related fading procedures.

Cheney and Stein (1974) also compared fading and trial-and-error procedures to teach an oddity problem to children. First, an oddity problem was taught, then, transfer to a more complex oddity problem was tested. Although the relevant stimulus dimension needed for the final discrimination was form or size, the element chosen to be manipulated for fading was color. Consequently, no significant differences in

performance on the oddity task between subjects in the fading groups as opposed to the trial-and-error groups were demonstrated.

Koegel and Rincover (1976) examined the effectiveness of using a stimulus superimposition procedure, as opposed to a trial-and-error procedure, to teach four discriminations to typically developing children and children with autism. Subjects in the superimposition group acquired a discrimination between red and green. Color was then used as the fading stimulus for the four discriminations. The four discriminations were letters (X-O), shapes (hexagon-octagon), tones (low-high), and white noise (quiet-moderate). The colors were gradually faded from the slides. Results demonstrated that all of the typically developing children acquired the four discriminations using the trial-and-error procedures, but two of eight typically developing children in the superimposition group acquired all four discriminations. In addition, none of the children with autism in the superimposition group acquired all four discriminations. Koegel and Rincover (1976) concluded that superimposed stimuli used to teach unknown skills to children, especially children with autism, interfere with discrimination performance. As in the previous studies, the stimulus element chosen for fading was non-criterion-related.

The results from these studies demonstrate the importance of choosing the right stimulus element to be faded or shaped when using errorless learning procedures. These studies illustrated the failure to demonstrate transfer of stimulus control when non-criterion-related stimulus elements were manipulated. Although these experimenters failed to demonstrate transfer of stimulus control initially, revisions were made to the programs, and as a result, successful performance by subjects was demonstrated (Dixon et al., 1968; Etzel & LeBlanc, 1979; Schilmoeller et al., 1979; and Sidman & Stoddard,

1966). Etzel (1997) and Sidman & Stoddard (1966) emphasized the importance of program revisions when designing errorless learning procedures. They stated that if initial attempts by researchers are unsuccessful, programs should be redesigned to facilitate learning, rather than faulting student performance or ability. In fact, errors should be considered to be teacher errors, rather than student errors.

### *Revision*

Schilmoeller et al. (1979) modified the procedure used by Gollin and Savoy (1968). The stimulus element chosen for fading (intensity) was unrelated to the elements of the criterion stimuli (form). Once intensity was completely faded out, transfer from the initial stimuli, to the final stimuli, was not demonstrated. In the revised program, Schilmoeller et al. designed a stimulus shaping procedure to transform the topography of the stimuli. Initially, the stimuli were discriminable from each other. Instead of beginning with the unknown form discrimination, two pictures were presented to the subjects, a tree-on-hill and an apple with a worm. The stimuli were altered gradually, into the criterion forms, with background stripes. Subjects then acquired the conditional discrimination using the revised-stimulus shaping procedure. Although subjects were unable to acquire the discrimination using non-criterion-related stimulus elements, subjects acquired the discrimination when the program was modified to include criterion-related stimulus elements.

Etzel and LeBlanc (1979) modified the procedure designed by Schwartz et al. (1971) that involved the fading of non-criterion-related stimulus elements. Schwartz et al. (1971) attempted to teach children to discriminate between two shapes, one symmetrical (S+) and one assymetrical (S-). Schwartz et al. (1971) chose the dimension

of color to be faded, while the criterion stimuli differed in shape. Early in training, correct responding was maintained by the fading stimulus, color. By the last few trials, color was completely faded and the remaining difference between the stimuli was shape. The children responded incorrectly and, thus, were unable to discriminate between the two stimuli. It follows that control of responding did not transfer from the stimulus dimension chosen for fading, color, to the criterion dimension needed for discrimination, shape. Etzel and LeBlanc (1979) stated that the dimension of color that was chosen for fading was too salient. That is, color was easily recognized and discriminated by children. The modified program (Etzel & LeBlanc, 1979) involved stimulus shaping and stimulus fading procedures. The procedure began with presentations of the stimuli that were readily discriminated by the subjects (the criterion stimuli of the faces with differences in ear sizes, discussed earlier, Etzel & LeBlanc, 1979). First, the shapes of the faces and the body parts (eyes, noses, mouth, and ears) were gradually and successively changed, until both shapes were presented at criterion level. Second, the colors of the stimuli were simultaneously and gradually faded in during the final steps of the program. Subjects acquired the criterion discrimination, and thus, there was a shift in control of responding from the initial stimuli to the criterion stimuli.

Additionally, in two studies, experimenters failed to acquire control of responding using errorless learning procedures, and therefore, revised their own programs (Sidman & Stoddard, 1966; Dixon et al., 1974). Although they had established control of responding initially, subjects were unable to maintain correct responding when the criterion stimuli were presented. In their first attempt, Sidman and Stoddard (1966) chose elements of the stimuli to be faded that were not critical to the final discrimination. The subjects were

taught to discriminate two forms, a circle and an ellipse. Initially, the circle (S+) and its background were presented at full intensity, while the ellipse keys (S-) and their backgrounds were dark. The fading procedure involved gradually fading in the brightness of the form of the ellipse keys and their backgrounds simultaneously, until both S+ and S- keys were presented at the same intensity and the only remaining difference between the stimuli was form. Early in programming, the subjects responded correctly. Once the discrimination was no longer of intensity, but of form only, the subjects produced errors. Transfer of control was not demonstrated. This is a good example of the problems that accrue to manipulating two variables at the same time, as it does not guarantee which variable is controlling the responding by the subjects. In their second attempt, Sidman and Stoddard (1966) faded in the intensity of the background of the ellipse keys first, while the intensity of the form of the ellipse keys were unchanged. Next, the intensity of the form of the ellipse keys was gradually faded in. A successful shift in control of responding from the initial stimuli, bright S+ and dark S-, to the criterion stimuli, bright S+ and bright S-, was demonstrated.

Dixon et al., 1974, revised the program to include criterion-related stimulus elements. The experimenters chose the stimulus dimension, proximity. The correct referent object was positioned in front of the figure. A moving pointing response was then required from the front of the figure to the referent object. Gradually, the proximity of the referent object was increased, and incorrect referent objects were added to other positions, around the figure. Successful transfer of responding from proximity to position was demonstrated.

Dixon et al. (1974), Etzel & LeBlanc (1979) Schilmoeller et al. (1979), and Sidman & Stoddard (1966) all demonstrated the effectiveness of program revisions, after initial attempts by researchers were unsuccessful. When programs include non-criterion-related stimulus elements, a shift in responding is often not demonstrated. Researchers have attempted to explain why procedures that incorporate non-criterion-related stimulus elements are unsuccessful.

### *Blocking*

One account for the failure of stimulus control has been attributed to the phenomenon of blocking (Etzel, Milla, & Nicholas, 1996; Lancioni et al., 1986). Blocking occurs when, during compound conditioning, previous history with one stimulus in a compound prevents acquisition of control by the other stimulus in the compound (Feldman, 1975; Kamin, 1969). Doran and Holland (1979) likened fading procedures to compound conditioning. That is, in fading procedures, stimulus elements that are easily discriminated are added to unknown stimuli, to facilitate discrimination acquisition. The initial stimulus elements that are manipulated are gradually removed, until only the criterion stimuli are presented during the final discrimination. Before the initial stimuli are removed completely, the initial stimuli and the final stimuli are presented simultaneously, and thus, combine to form a compound stimulus. During the initial stages, control of responding may be established by either feature of the compound stimulus. When the features presented are made too salient or relied on too long, the initial stimulus features can block control of responding by the criterion stimuli (Etzel, 1997). When the added stimulus is irrelevant to the criterion discrimination, transfer of responding to the relevant stimuli may not occur. Because either element in the stimulus

compound can control responding, dual control by both stimulus elements must be demonstrated before the initial stimulus elements are faded (Doran & Holland, 1979).

Doran and Holland (1979) examined control by stimulus features during fading. Experimenters taught three groups to discriminate between forms of different sizes. One group used trial-and-error procedures alone, a second group used fading procedures, and a third group used both procedures. That is, trial-and-error was followed by fading. The stimulus element chosen for fading was brightness. Probe trials were presented to assess control by brightness and size. One of the probe stimuli was the same size as the S+, but of different luminance, while the other probe stimulus had the same luminance as the S+, but it was of different size. As demonstrated by correct responding by subjects on all probe trials, the subjects acquired the discrimination when both stimulus features controlled responding. Alternatively, subjects produced errors once the fading stimulus was completely removed, and thus, the fading stimulus alone controlled responding. The former results characterized performance by the subjects in the fading group, whereas the latter characterized the performance by the subjects in the trial-and-error groups. The authors concluded that transfer was successful because the criterion stimulus feature controlled responding before the initial stimulus element was faded out. The importance of dual control by both stimulus features before the initial stimulus elements are faded was demonstrated.

#### *Successful non-criterion-related fading*

Doran and Holland (1979) demonstrated that stimulus control could be transferred in fading procedures, using non-criterion-related stimulus elements. That is, although the element critical to the final discrimination was size, the stimulus element chosen for

fading was intensity. A number of studies have also demonstrated transfer from the initial stimuli to the criterion stimuli using non-criterion-related stimulus elements (Dixon et al., 1974; Moore & Goldiamond, 1964; Schreibman, 1975; and Sidman & Stoddard, 1966). Sidman and Stoddard (1966) faded the stimulus element of intensity while the element critical to the final discrimination was form. Although the fading element was non-criterion-related, acquisition of the circle-ellipse discrimination was demonstrated. The program revision did not involve changing the element chosen for fading, but rather, the non-criterion-related element was faded early in training.

Schreibman's (1975) subjects acquired a discrimination between different forms using fading procedures. Although the element critical to the final discrimination was line direction, intensity was the stimulus element chosen for fading. When the stimuli were first presented, the S+ was at full intensity, while the S- was dark. Gradually, the intensity of the S- was faded in until both stimuli were presented at criterion. These results further demonstrate the success of fading procedures when using non-criterion-related stimulus elements. Researchers have identified factors that facilitate transfer using non-criterion-related stimulus elements.

To guarantee that non-criterion related cues can transfer to criterion-elements, transfer from the initial stimuli to the criterion stimuli should occur early during training (Etzel et al., 1996). The fading procedure used by Sidman and Stoddard (1966) involved two steps. The background intensity of the ellipse keys (S-) was faded in first. Once the backgrounds of both the S+ and S- keys were of the same intensity, the form of the ellipse was gradually faded in. Schreibman (1975) also faded in the intensity of the S- early in training. The remainder of the program involved fading out size and position,

followed by fading in the redundant stimulus elements. In both of these programs, the experimenters faded out the initial, unrelated stimulus elements early in training, so that for the remaining steps of the program, the critical stimulus elements could control responding.

Transfer is also facilitated in non-criterion-related fading programs when there is only one basis for the discrimination, after the non-criterion-related stimulus elements are faded (Etzel & LeBlanc, 1979). After Schreibman (1975) faded intensity first, the only basis remaining for the discrimination was line direction. The line directions of the arms were the critical elements, whereas the heads of the stick figures were redundant stimulus elements. The redundant stimulus elements were not faded in until the end of the program, and therefore, the only stimulus elements that controlled responding after intensity was faded out, were line directions.

Transfer of stimulus control has been demonstrated despite the use of non-criterion-related fading procedures. Key features of successful non-criterion-related fading programs include dual control by both stimulus features before the initial stimulus elements are faded (Doran & Holland, 1979), fading the initial stimuli early in training (Etzel et al., 1996), and providing the subjects with only one basis for the discrimination after the initial stimuli are removed completely (Etzel et al., 1979). While some experimenters have demonstrated successful acquisition of new skills using non-criterion-related fading programs, results from stimulus fading procedures have been inconsistent. As a result, researchers have examined the effectiveness of using stimulus shaping procedures, as opposed to stimulus fading procedures.

*Stimulus shaping as opposed to stimulus fading*

When designing errorless learning procedures, experimenters must choose a procedure. Choosing between stimulus fading and stimulus shaping procedures depends on the nature of the stimuli (B. C. Etzel, personal communication, September 22, 2003) or the task (Schilmoeller et al., 1979). Because many errorless learning procedures involve complex discriminations, stimulus elements that are easy to fade, such as color or size, are often unrelated to the criterion stimuli (Etzel et al., 1979). For example, some of the complex discriminations that have been taught using stimulus shaping procedures have involved left-right concepts (Bijou, 1968), visual-motor skills (Mosk & Bucher, 1984), shapes (Sidman & Stoddard, 1966), Japanese characters (Schilmoeller & Etzel, 1977), and words (Smeets, Lancioni, & Hoogeveen, 1984). The critical differences between the criterion stimuli involved in these studies were unrelated to the physical stimulus elements that are easy-to-fade.

Experimenters demonstrated the effectiveness of stimulus shaping procedures as opposed to stimulus fading procedures in teaching new skills (Schilmoeller et al., 1979). Schilmoeller et al. (1979) revised the program used by Gollin and Savoy (1968) using stimulus shaping procedures. In addition, the experimenters included a stimulus fading group and trial-and-error group to compare the performance of the subjects in each group, similar to the procedure of Gollin and Savoy (1968). The intensity of the forms and backgrounds of the S- were gradually faded in, until the stimuli were presented at criterion. More subjects acquired the conditional discrimination in the stimulus shaping group than in the other two groups. While 12 of the 16 subjects in the stimulus shaping group acquired the conditional discrimination, only 3 of the 16 subjects in the stimulus

fading group, and only 2 of the 8 subjects in the trial-and-error group acquired the discrimination. Stimulus shaping procedures were more effective than stimulus fading procedures in teaching a conditional discrimination to children.

There are procedural differences between stimulus shaping and stimulus fading procedures that illustrate the advantages of using the former, as opposed to the latter. One of the main differences is that transfer of stimulus control from the initial stimuli to the criterion stimuli is often needed in stimulus fading procedures (Etzel et al., 1996). Initially, control of responding is maintained by the initial stimuli that are easily discriminable by the subjects. Then, the initial stimuli are faded out, and control of responding is expected to transfer to the criterion stimuli. Although transfer should occur in fading procedures when using criterion-related stimulus elements, when the stimulus element chosen is salient, such as color, the subject may rely on it too long to make the criterion-related discrimination (Etzel et al., 1979). Under these conditions, when the initial stimulus is faded out, the stimuli are no longer discriminable. Alternatively, transfer of stimulus control is not needed in stimulus shaping procedures (Etzel, 1997). Initially, the criterion stimuli are altered into forms that are discriminable to the subjects. Gradually, the initial stimuli are transformed into the criterion stimuli. It follows that transfer from the initial stimuli to the criterion stimuli is not needed because stimulus control is maintained by the criterion stimuli.

When choosing between stimulus fading and stimulus shaping procedures, researchers should examine the nature of the task and the stimuli involved (Etzel, personal communication, September 22, 2003; Schilmoeller et al., 1979). When experimenters are designing errorless learning procedures that involve criterion stimuli

that can be faded along a relevant physical dimension, stimulus fading procedures should be used (Etzel & LeBlanc, 1979). Alternatively, when the criterion stimulus element is more complex and cannot be faded along a physical dimension, stimulus shaping should be used (Etzel, 1997).

Other critical factors in the demonstration of successful performance using errorless learning procedures were examined, including the manipulation of the correct stimuli involved in discriminations. That is, experimenters have examined the extent of manipulating S+, S-, or both (Schreibman & Charlop, 1981; Stella & Etzel, 1986; and Zawlocki & Walls, 1983).

*Fading or shaping S+ only, or S- only, or both S+ and S-*

Experimenters manipulated S+ only, S- only, or both S+ and S-, either simultaneously or successively. In some studies involving one stimulus manipulation, S- was manipulated, whereas presentations of S+ remained constant throughout the procedures (Dixon et al, 1974; Moore & Goldiamond, 1964; and Terrace, 1963a). Alternatively, some procedures involved manipulations of S+, whereas S- remained constant (Touchette, 1971). Other procedures involved manipulations of both stimuli (Etzel & LeBlanc, 1979; Etzel et al., 1981; Schilmoeller & Etzel, 1977; Schilmoeller et al., 1979; Schreibman, 1975; Stella, 1980; Terrace 1963b; and Touchette 1968). Few studies have specifically analyzed the effectiveness of manipulating the S+, or S-, or both the S+ and S-.

First, Stella (1980) examined responding in programs where the S+, S-, or both stimuli were manipulated. The number of correct responses, errors, and eye orientations to the stimuli were measured. Results demonstrated that fewer errors were produced by

children when the S+ was manipulated last. In addition, fewer errors were produced in programs that involved shaping of both stimuli.

Next, Schreibman and Charlop (1981) examined the effectiveness of manipulating either the S+ or S- first. A visual discrimination was taught to children with autism involving the same two sets of stimuli used in the study by Schreibman (1975). One set of stimuli was two stick figures with arms, each with an arm positioned in a different line direction (S+ up-down directions and S- figure directed down only). The second set of stimuli was two large letters (X) with dots positioned in different places on either stimulus (S+ above and below and S- left and right). Two different procedures were used to teach the discrimination: (a) S+ was faded in, whereas the S- was held constant and (b) S- was faded in, whereas the S+ was held constant. Next, size, position, and other redundant components of the stimuli were simultaneously and gradually faded out in the final steps of the procedures. The criterion stimuli used in both procedures were identical at the end (e.g., S+ of [a] and [b] was a stick figure with up-down directed arms and S- of [a] and [b] was a stick figure with down-only directed arms). Every subject was presented with both procedures, counterbalanced across subjects. Two sets of stimuli were used with both procedures and the order of stimuli was also counterbalanced. Significantly fewer trials to acquire the discrimination were needed when the S+ was manipulated, as opposed to the S-. The authors also concluded that early manipulations of the S+, as opposed to the S-, resulted in slower acquisition of a visual discrimination.

Furthermore, Stella and Etzel (1986) examined the effectiveness of shaping S+ alone, compared to shaping S- alone. The same sets of stimuli used in the Schreibman (1975) study were used, except the procedures involved stimulus shaping, as opposed to

stimulus fading. The dependent measures included the number of pointing responses to the stimuli, the number of eye orientations to the stimuli, and the durations of eye orienting to the stimuli. One procedure involved manipulations of the S+, whereas the S- was held constant at criterion level. The second procedure involved manipulations of the S-, whereas the S+ was held constant at criterion level. During the procedure involving manipulations of the S+ with S- constant, more frequent eye orientations and pointing responses to the S+ were produced, than when S- was manipulated and S+ was held constant. In addition, when the S+ was shaped and S- was held constant, the duration of eye orientation to the S+ was longer than the duration of eye orientation to the S-. Alternatively, when the S- was shaped and the S+ was held constant, duration of eye orientation to the S- was longer than the duration of eye orientation to the S+. When the duration of eye orientation to one of the stimuli was longer, more pointing responses to that stimulus were produced. The results demonstrated differential control of responding by manipulating stimuli using alternative procedures.

While the previous findings demonstrate differences in responding as a result of the order in which the S+ and S- are manipulated during training, Zawlocki and Walls (1983) produced different results. They examined the effectiveness of fading the S+, or the S-, or both the S+ and S-, to teach a size and number discrimination to children with mental retardation. In the first condition, the S+ was faded and the S- was held constant. In the second condition, the S- was faded and the S+ was held constant. In the third condition, both the S+ and S- were faded simultaneously. No significant differences in the mean number of correct responses among the three conditions were demonstrated.

Useful conclusions may be drawn from the above literature even though manipulations of the S+, or S-, or both stimuli have varied across errorless learning procedures. Etzel and LeBlanc (1979) revised the unsuccessful procedure designed by Schwartz et al. (1971) to teach the symmetrical-assymetrical discrimination to children. Etzel and LeBlanc (1979) also pointed out other important procedures that were included in their revised program. First, manipulations along both stimulus dimensions were important. That is, dimensions of both the S+ and S- were manipulated. The stimuli were manipulated successively, rather than simultaneously. While the first stimulus was manipulated, the second stimulus was held constant at entry level. Once manipulation of the first stimulus was completed, the second stimulus was manipulated, and the first stimulus was held at criterion. Another important procedure that Etzel and LeBlanc (1979) recommended was shaping the S- first and the S+ last. In the second part of the program, the S+ was manipulated, whereas the S- was held constant. According to Etzel and LeBlanc (1979), in procedures involving stimulus shaping, the S+ should always be shaped last. In addition, the criterion-related cue in the S+ should be adjusted in the criterion level S+ (reduced in size, etc.) last.

These results, as well as those of Schreibman and Charlop (1981) and Stella and Etzel (1986), demonstrated some evidence that manipulations of the S+ are superior to manipulations of the S-. Additionally, manipulations of both stimuli are better than manipulation of one stimulus and the S+ should be manipulated last (Etzel & LeBlanc, 1979; Stella, 1980). A possible reason that the S+ should be manipulated last is that at the end of the program (when the discrimination becomes more difficult) as S+ changes to be more like S-, stimulus control by the critical features of the terminal discrimination

becomes more likely. More research needs to be conducted to examine the effectiveness of different types of stimulus manipulations.

Because of inconsistent results regarding manipulations of stimuli demonstrated in the research literature (e.g., Zawlocki & Walls, 1983; Stella & Etzel, 1986), Schilmoeller et al. (1979) concluded that the manipulation of one stimulus or both stimuli may be less important than the extent to which criterion-related cues are used effectively. Instead, "...the selections of cues as well as the particular manipulation procedures may be more critical to successful discrimination acquisition than the manipulation of S+ only, S- only, or both S+ and S-" (p. 418).

#### Recommendations for teaching

Critical factors that promote stimulus control in errorless learning procedures were identified. Etzel & LeBlanc (1979) and Schilmoeller & Etzel (1977) demonstrated the importance of manipulating criterion-related stimulus elements. Control of responding remains consistent from the initial stimuli to the criterion stimuli, when criterion-related stimulus elements are manipulated. Gollin & Savoy (1968), Schwartz et al. (1971), Cheney & Stein (1974), and Koegel & Rincover (1976) illustrated the problem of not manipulating the right stimulus elements. These experimenters failed to demonstrate stimulus control when responding did not transfer from initial to later criterion elements. Errorless learning procedures should be revised if initial attempts by teachers are unsuccessful. Dixon et al. (1968), Sidman & Stoddard (1966), Schilmoeller & Etzel (1977), and Etzel & LeBlanc (1979) demonstrated the importance of program revisions. The programs were revised when subjects did not acquire discriminations using errorless learning procedures, and as a result, successful performance was

demonstrated. Transfer of control can sometimes occur in when non-criterion-related stimulus elements are manipulated. Researchers demonstrated successful transfer in studies involving non-criterion-related stimulus elements and described specific procedures that facilitated the transfer (Dixon et al., 1968; Doran & Holland, 1975; Moore & Goldiamond, 1964; Schreibman, 1975; and Sidman & Stoddard, 1966). Transfer was facilitated in non-criterion-related fading procedures by dual control by both stimulus features before the initial stimulus elements were faded out (Doran & Holland, 1979), when the initial stimulus was faded early in training (Etzel et al., 1996), and when there was only one basis for making the discrimination after the initial stimuli were faded out (Etzel & LeBlanc, 1979). Teachers have a choice of a variety of errorless learning procedures. The effectiveness of different procedures is dependent on the nature of the task and the stimuli involved (Schilmoeller et al., 1979; B. C. Etzel, personal communication, September 22, 2003). When the criterion stimuli involve elements that are easy to fade along some physical dimension, stimulus fading procedures should be used (Etzel & LeBlanc, 1979). Alternatively, when the criterion stimuli are more complex, and do not involve elements that are easy to fade along some physical dimension, stimulus shaping procedures should be used (Etzel, 1997). Researchers also need to consider the order of the manipulation of stimuli. There have been some inconsistent results regarding manipulations of the S+, or S-, or both stimuli, but the following results are consistent: (a) Etzel and LeBlanc (1979), as well as Stella (1980), demonstrated that manipulations of both stimuli were important, the stimuli were manipulated successively rather than simultaneously, and the S+ was shaped last and (b) Schreibman and Charlop (1981) and Stella and Etzel (1986) demonstrated additional

evidence that manipulations of the S+ are superior to manipulations of the S-.

Nevertheless, the decision to manipulate either S+ or S- first may be of less importance than other considerations. Those other considerations, as emphasized by Schilmoeller, et al. (1979), have to do with the initial selection of stimuli for manipulation and with the type of errorless learning procedure used to teach the discrimination in question. Both of those considerations are predicated on the assumption that one has correctly identified the critical criterion-related stimuli involved in the discrimination training procedure.

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