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THE COSTS OF EATING: A BEHAVIORAL ECONOMIC ANALYSIS OF FOOD REFUSAL

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Behavioral economic concepts were applied to the analysis and treatment of pediatric feeding disorders in a clinical setting. In Experiment 1, children who chronically refused food were presented with varying amounts of food on a spoon (empty, dipped, quarter, half, and level). Each child exhibited a different but orderly demand function of response (acceptance, expulsion, and mouth clean) by cost (increasing spoon volume) for a constant pay-off of toys and social interaction. In Experiment 2, physical guidance or nonremoval of the spoon for food refusal was initiated at the smallest spoon volume with low levels of acceptance, and was subsequently introduced at the largest spoon volume with moderate levels of acceptance. Treatment was effective in increasing acceptance, and these effects generalized hierarchically across untargeted spoon volumes. The results of both studies provide preliminary support that increasing spoon volume can be equated conceptually with increasing response effort, and that the change from differential reinforcement to physical guidance or nonremoval of the spoon appears to have altered the elasticity of each child's demand function.

DESCRIPTORS: behavioral economics, behavioral medicine, food refusal, generalization, extinction

Behavioral economics is a subfield within the experimental analysis of behavior that describes and quantifies functional relationships between cost (in behavior, usually number or rate of response) and amount of a commodity (usually food, drugs, or both) (Allison, 1981, 1983; Hursh, 1980, 1984). These relationships, defined as demand functions, are determined empirically by changes in responding that occur as a function of changes in cost (Rachlin, Green, Kagel, & Battalio, 1976). Initially, responding increases with small increments in costs; however, with escalating costs, responding will eventually peak and then fall (Hursh & Bauman, 1987). The "cross point" at which responding decreases with increasing costs varies across commodities, individuals, and time (Stigler & Becker, 1977).

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In behavioral economic research, cost is usually manipulated by changing the number or intensity of the responses required to receive a constant quantity of reinforcement (Foltin, 1992; Tustin, 1994; Tustin & Morgan, 1985). Baum's (1973) refinement of the law of effect provides a context for extending the operationalization of cost beyond the numeric parameters of schedules of reinforcement to parameters of response effort. When response effort was manipulated by varying the force required to press a lever to produce reinforcement, rate of responding decreased with increasing response-force requirements in both nonhumans (Brener & Mitchell, 1989; Chung, 1965; Crossman & Serna, 1982; Ginter & Armus, 1989; Keehn, 1981; Mintz, Samuels, & Barber, 1976) and humans (McDowell & Wood, 1985; Miller, 1970). Thus, demand functions may be conceptualized not only as changes in schedule requirements for a constant quantity of reinforcement but also as changes in response effort required for qualitative or quantitative consequences (Tustin, 1994).

Food refusal is a class of behavior that may be especially interesting to analyze from a behavioral economic perspective. For children who refuse food, increased cost (i.e., effort expenditure) of eating may be established (Michael, 1982) by one or more of the following variables: (a) the prolonged association between eating and gastrointestinal distress, (b) the disruption of oral-motor skill development secondary to multiple acute or chronic illnesses, and (c) escape from or avoidance of meals resulting from refusal, maladaptive behaviors, or both (Babbitt et al., 1994; Budd et al., 1992; Geertsma, Hyams, Pelletier, & Reiter, 1985; Illingsworth & Lister, 1964; Iwata, Riordan, Wohl, & Finney, 1982). The presence of one or more of these variables makes eating much less probable, thereby increasing the response effort required by these children to exhibit behavior (food acceptance) they otherwise would not, in an environment that these children typically choose to avoid.

The cost of acceptance may also be affected by variables in the current eating situation. Specifically, larger amounts of food on the spoon or coarser textures of food require more finely integrated and controlled oral-motor movements (Logemann, 1983). Therefore, it is hypothesized that the increased motor control associated with increasing amounts of food on a spoon may represent increased cost. Orderly decreases in food acceptance and other relevant feeding responses correlated with systematic increases in amount of food on the spoon would provide tentative support for this hypothesis.

Experiment 1 represents a preliminary exploration of the application of behavioral economic concepts to food refusal. The purpose of this study was to examine responding (e.g., acceptance or expulsion) for a constant pay-off as a function of increasing cost. Children were presented with five levels of consumption requirements ranging from low cost to high cost: empty spoon, spoon dipped in food, quarter spoonful of food, half spoonful of food, and level spoonful of food. Regardless of the amount of food presented on the spoon, the child received the same quantity of reinforcement (access to social interaction and toys for a standard length of time contingent upon acceptance). Therefore, amount and intensity of reinforcement (commodity) were held constant while response requirement was systematically incremented by increasing food volume per spoon (cost), similar to manipulations in behavioral economic research (Hursh, 1978; Rachlin et al., 1976). For each child, increases in the quantity of food on the spoon may be associated with increased cost, eventually culminating in behavior strain (Collier, Hirsh, & Hamlin, 1972). This cross point from acceptance to refusal varies across children, permitting empirical determination of each child's demand function. The results of Experiment 1 provided the baseline for Experiment 2, which investigated the effects of physical guidance or nonremoval of the spoon on acceptance of targeted and untargeted spoon volume.

EXPERIMENT 1

METHOD

Subjects

Participants were 3 children with total food refusal who had been admitted to an inpatient unit with a common goal of increasing food acceptance. All children had documented gastrointestinal problems for which they were receiving appropriate treatment at the time of the study; therefore, eating was not expected to be actively associated with discomfort.

Linda was a 2.5-year-old female born prematurely. Delayed gastric emptying was documented via radionucleotide scintigraphy. At 1.5 months, Linda began drinking by bottle and continued to receive all of her nutrition (whole milk and baby food mixed together) by bottle at the time of admission. Spoon feeding was first introduced at 3 months of age; however, she would push the spoon out of her mouth with her tongue. If the spoon was held in her mouth, she would gag and retch. Despite repeated efforts, Linda persistently refused spoon feedings.

Michael was a 3-year-old male with pancreatic insufficiency and status post aortic stenosis repair. Michael's feeding problems began at 2 weeks of age with poor oral intake accompanied by emesis. Numerous episodes of diarrhea and dehydration resulted in initiation of parenteral nutrition and the placement of a gastrostomy tube at 7 months of age. Parenteral nutrition was subsequently discontinued at 27 months of age. His gastrointestinal problems included gastroesophageal reflux with esophagitis, gastritis, duodenitis, and lactose intolerance. Michael had been hospitalized most of his life because of persistent failure to thrive despite tube feedings. Throughout these hospital admissions, food was rarely offered to Michael and when it was, he refused it. At the time of admission, Michael exhibited total food refusal.

Gary was a 5-year-old male with congenital pseudo-obstruction and hydronephrosis. He had decreased intestinal motility and a narrow esophagus with resulting symptoms of gastroesophageal reflux. As a result, he began receiving enteral (gastrostomy extended into jejunum) tube feedings at birth and parenteral feedings from 7 to 24 months of age. At birth, uncoordinated sucking-swallowing-breathing patterns were documented, as was vomiting. He had a history of documented aspiration, cyanosis, and gagging with oral feedings. Despite oral-motor therapy and subsequent documentation of competent oral-motor skills, Gary would not swallow food. On admission, Gary had no history of accepting food from a spoon; however, he had tasted gravy and salad dressing, and drank small amounts of water from a cup with some gagging noted.

Setting and Materials

All feeding sessions were conducted in one of two rooms (3.05 m by 3.66 m) located near the inpatient unit. Each room was always used for feeding sessions and was relatively free of distractions.

The type of spoon used for each child was based on oral-motor skill and chronologic age. Michael and Gary were fed with a youth spoon, and Linda was fed with an infant spoon. The amount of food on the spoon varied according to spoon size. Dipped spoon volume consisted of placing the spoon into food and then shaking off the excess food. Quarter, half, and level amounts were 0.25 cc, 0.50 cc, and 1.0 cc, respectively, for the infant spoon and 0.50 cc, 1.0 cc, and 2.0 cc, respectively, for the youth spoon.

Data Collection

Subjects received two to five meals daily (median of four), 7 days a week. A trained therapist conducted each session. Occurrence data were collected on all target behaviors for each trial.

Response Definitions

Acceptance. The subject opened his or her mouth 1.27 cm or wider within 5 s of the spoon presentation and allowed placement of the entire spoon into the mouth.

Refusal. The subject's mouth was not open 1.27 cm or wider within 5 s of the spoon presentation or the entire spoon was not placed into the mouth.

Expulsion. Following acceptance, the appearance of food past the outer edge of the lips.

Mouth clean. The absence of food (less than 0.64 cm square) in the oral cavity at the presentation of the next bite following acceptance of either the initial presentation of food or representation of expelled food.

Interobserver Agreement

Trained therapists independently collected occurrence and nonoccurrence data on targeted behaviors for each trial. Occurrence, nonoccurrence, and total reliability were calculated for each behavior by dividing the number of agreements by the number of agreement plus disagreements and multiplying by 100%. Interobserver agreement was assessed for 33% of the meals conducted for each child. Across behaviors and subjects, mean interobserver agreement was 83.8% for occurrence (range, 76% to 100%), 93.5% for nonoccurrence (range, 81% to 100%), and 94.3% for total (range, 79% to 100%). Mean total agreement for each target behavior across subjects was 91.2% for acceptance (range, 78% to 100%), 83.6% for expulsion (range, 74% to 100%), and 82.1% for mouth clean (range, 78% to 100%). Mean total agreement for each subject across all target behaviors was 93% for Michael, 83% for Linda, and 88% for Gary.

Experimental Design

A multielement design (Ullman & Sulzer-Azaroff, 1975) was used to evaluate the effects of varying spoon volume (empty, dipped, quarter, half, and level) for each subject. The order of conditions was randomized across children; the number of sessions at each spoon volume varied both within and across children and was determined primarily by medical clearance.

Procedure

Upon admission, each child was evaluated for an appropriate seating device by an occupational therapist. Within the first 3 days of admission, a stimulus preference assessment was conducted for each child (Pace, Ivancic, Edwards, Iwata, & Page, 1985). Subsequently, preferred items and activities were first shown to function as reinforcers for an operant response, such as hand clapping, prior to their use during the study (Fisher et al., 1994).

Each meal consisted of four pureed foods, one from each major food category (fruit, vegetable, protein, starch). A trial consisted of a bite of a food, rotating across the four foods in a random sequence for each meal. Each trial began with a verbal prompt ("[child's name], open") delivered simultaneously with the presentation of the spoon to the center of the child's lower lip. The spoon remained at the lower lip for 5 s or until the spoon was accepted, whichever came first. The number of trials for each feeding session was 20, with an intertrial interval of 30 s.

Differential reinforcement of an incompatible response to refusal (DRI) was used. Acceptance resulted in praise and access to toys for the remainder of the intertrial interval. Refusal resulted in removal of the spoon, and no attention for the remainder of the intertrial interval.

Results

The percentage of bites accepted across all spoon volumes for each subject is presented in Figure 1. Linda accepted one empty spoon in each of two sessions (Sessions 4 and 7). Linda's acceptance of all other spoon volumes was 0%.

Michael's acceptance of the empty spoon was high (M = 89.6%). Mean acceptance of the dipped, quarter, half, and level spoons was low, but decreased systematically with increasing spoon volumes (M = 8%, M = 3%, M = 1%, M = 1.67%, respectively). Michael's expulsion and mouth clean also varied with spoon volume. An average of 50% of accepted bites were expelled in the dipped spoon condition; expulsion at all other spoon volumes was 100%. Although Michael had low levels of mouth clean in the dipped spoon condition (M = 14.6%), all bites accepted at the quarter, half, and level spoon volumes had no instances of mouth clean.

Gary's percentage of bites accepted varied systematically from smallest to largest spoon volume (M = 100% empty, M = 90% dipped, M = 90.8% quarter, M = 77% half, and M = 75% level). Percentage of accepted bites expelled followed this same pattern (M = 6.5% dipped, M = 9.9% quarter, M = 41.7% half, M = 61% level), as did mean percentage of accepted bites with mouth clean (M = 93.5% dipped, M = 83.4% quarter, M = 42.3% half, M = 25% level).

Discussion

When presented with five volumes of food ranging from an empty spoon to a level spoon, each child in this study exhibited a different

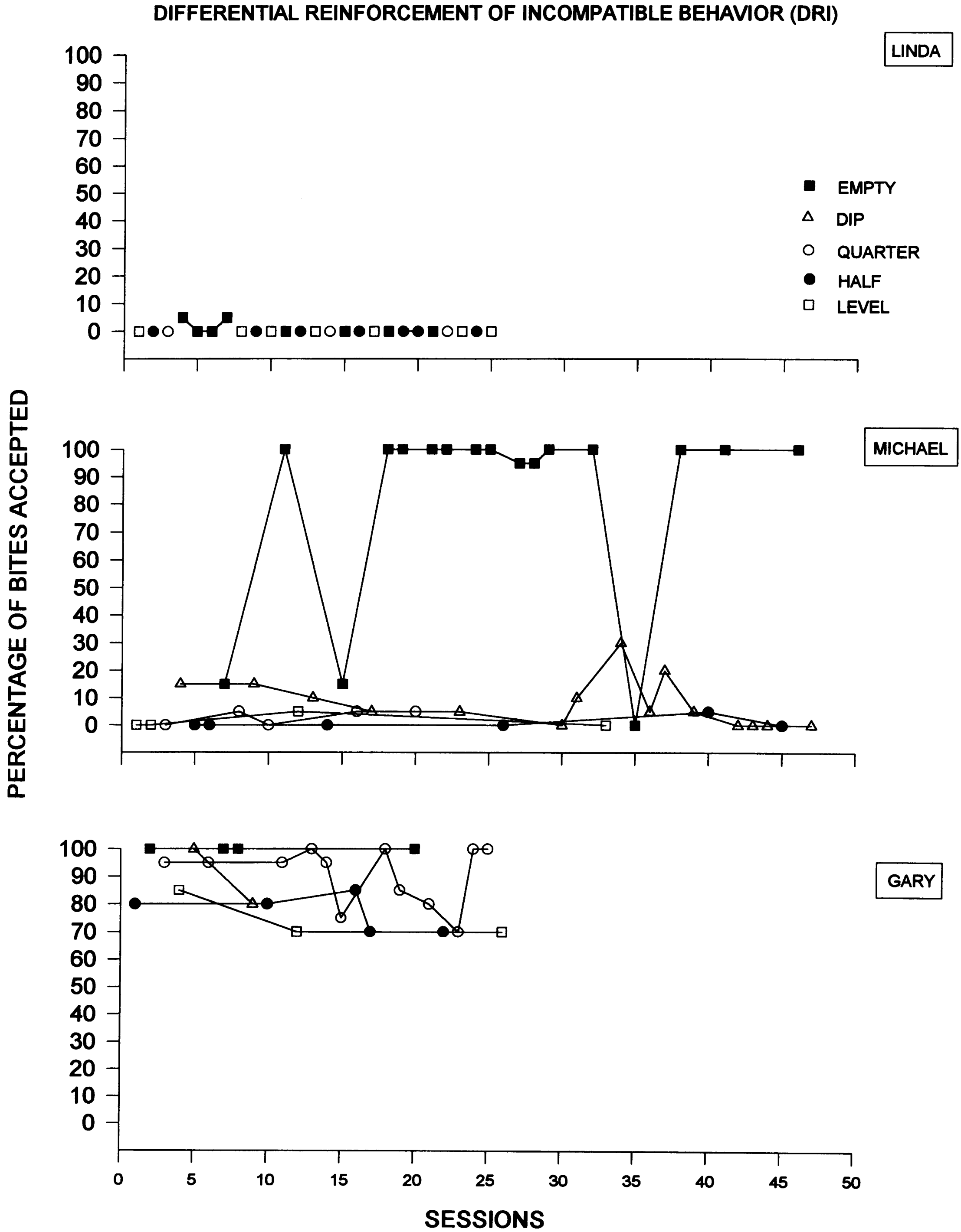

Figure 1. Percentage of bites accepted across spoon volumes under DRI for Linda, Michael, and Gary.

demand function. Linda accepted an empty spoon, albeit rarely. In contrast, she never accepted a spoon with food. Michael accepted the empty spoon most of the time. Although he exhibited low levels of acceptance of the other spoon volumes, his acceptance did decrease across increasing spoon volumes. Gary's acceptance decreased systematically with increasing spoon volumes. In addition, his instances of expulsion and mouth clean also varied systematically as a function of spoon volume. These data provide preliminary evidence suggesting that increased amount of food (or the mere presence of food) on a spoon may be associated with increased cost (response requirement) for at least some children with food refusal. Although Linda rarely accepted any spoon, the only spoon volume she chose to accept was an empty spoon. Michael demonstrated an almost bimodal acceptance distribution (no food vs. food); however, the dipped spoon was accepted more often than the level spoon.

Because there is some provisional support for a relationship between increasing spoon volumes and increasing cost of responding, the parametric analysis of acceptance, expulsion, and mouth clean across spoon volumes under DRI may be conceptualized as an assessment of the child's baseline economy. In this economy, toys and social interaction are the commodity and food acceptance at increasing spoon volumes is the price. Each child in this study exhibited a different demand curve; therefore, the cross point at which responding (acceptance) decreased with increasing spoon volume varied across children.

These data provide preliminary information about the role of history in predicting each child's economy. In contrast to Michael and Gary, Linda had fewer medical problems and fewer hospitalizations and had never received supplemental tube feedings. According to Linda's mother, repeated attempts to initiate spoon feedings had failed. Linda's refusal of any spoons with food may reflect this history. Future research should address the relationship between feeding history and acceptance of food across various spoon volumes.

This study is a first step towards exploring a parametric analysis of how food acceptance varies differentially across spoon volumes; however, no child consistently accepted level spoonfuls of food under DRI. Thus, performance during Experiment 1 served as a baseline for the introduction of more intensive treatment for food refusal in Experiment 2. Two effective interventions for food refusal have been described in the literature (Hoch, Babbitt, Coe, Krell, & Hackbert, 1994; Hyman et al., 1986; Riordan, Iwata, Finney, Wohl, & Stanley, 1984). Riordan et al. documented the effectiveness of physically guiding the mouth open contingent upon refusal, whereas Hoch et al. described a procedure in which the feeding utensil remained at the child's lips until acceptance occurred. The results of these studies suggest that physical guidance and nonremoval of the spoon do not allow escape from food and are aversive contingencies that will be avoided (Iwata, 1987). Thus, independent acceptance is reinforced both positively (access to toys and praise) and negatively (avoidance of physical guidance or nonremoval of the spoon). Facilitation of independent acceptance through avoidance contingencies for refusal brings the child into contact with positive reinforcement contingencies scheduled for independent acceptance. Although these interventions differ procedurally, they both combine extinction of an escape response (food refusal) with reinforcement of food acceptance.

In Experiment 1, each child received access to toys and social interaction contingent upon acceptance and was ignored contingent upon all other responses. In Experiment 2, access to toys and social interaction remained contingent upon acceptance; however, refusal resulted in either physical guidance or nonremoval of the spoon. The purpose of Experiment 2 was to evaluate the effect of physical guidance or nonremoval of the spoon on increasing food acceptance in both targeted and untargeted spoon volumes.

The parametric analysis of acceptance as a function of spoon volume in Experiment 1 provides information about the conditions under which a child will accept and refuse food (i.e., cross point of responding). Targeting treatment at the cross point spoon volume may have several potential advantages. At the initiation of treatment, the child should contact positive contingencies more often than aversive consequences because the intervention is directed either at a spoon volume with nonzero levels of independent acceptance or at the smallest spoon volume with no independent acceptance. As a result, the negative side effects of treatment (e.g., crying, tantrums) may be minimized; this is especially important in a population of children who may be traumatized by the feeding environment. In addition, the risk of aspiration in this medically fragile population may be minimized by employing the smallest bolus size accepted or predicted to be accepted. Finally, this approach of targeting spoon volumes may create a least restrictive treatment environment for these children.

EXPERIMENT 2

METHOD

Subjects and Setting

The subjects, settings, materials, and data collection procedures were the same as those in Experiment 1.

Interobserver Agreement

Reliability data were collected and calculated as in Experiment 1. Across behaviors and subjects, mean interobserver agreement was 88.4% for occurrence (range, 79% to 100%), 94.7% for nonoccurrence (range, 76% to 100%), and 95.5% for total (range, 82% to 100%). Mean total agreement for each target behavior across subjects was 96.1% for acceptance (range, 81% to 100%), 89.4% for expulsion (range, 75% to 100%), and 86.3% for mouth clean (range, 79% to 100%).

Procedure

As in Experiment 1, each meal consisted of four pureed foods, one from each major food category. Each trial consisted of a bite of a food, rotating across the four foods in a random sequence for each meal. Each trial began with a verbal prompt ("[child's name], open") delivered simultaneously with the presentation of the spoon to the center of the child's lower lip.

Baseline

DRI was used across spoon volumes during baseline. Acceptance resulted in praise and access to toys for the remainder of the intertrial interval (30 s), whereas refusal resulted in removal of the spoon and no attention for the remainder of the intertrial interval. Each session consisted of 20 trials.

For Gary, an increase in the frequency of sessions of the half spoon volume resulted in a decrease in acceptance (Session 25); therefore, access to preferred videotapes was made contingent upon acceptance of all spoon volumes in Session 50 and again in Session 70. Although acceptance increased initially following this change (Session 50), instances of mouth clean decreased; therefore, access to preferred videotapes contingent upon a clean mouth was implemented with a resulting decrease in acceptance.

Treatment

Scheduled contingencies for targeted behaviors depended on the specific procedure, which was randomly assigned to each child.

Nonremoval of the spoon. At the beginning of each session, the therapist gave the verbal instruction, "You have to stay in the chair until you take all the bites." The spoon remained at the child's lower lip until acceptance occurred. Expelled food was re-presented to the lower lip until acceptance occurred. Attempts to disrupt spoon presentation were blocked, but hands were not restrained. Once acceptance occurred, praise and access to preferred toys were delivered for the remainder of the intertrial interval

(30 s) or for at least 15 s. Thus, the actual length of the intertrial interval was dependent upon the rate of acceptance.

This procedure was implemented initially with the dipped spoon for Michael (Session 48). The first treatment session consisted of three spoon presentations in an attempt to keep the expected meal duration under 60 min. The number of spoon presentations per meal was increased in subsequent sessions to 6, 12, 15, 17, and 20, and remained at 20 trials for the remainder of the study.

Physical guidance. At the beginning of each session, the therapist gave the verbal instruction, "If you do not take a bite, I will have to help you." The spoon remained at the lower lip for 5 s or until acceptance occurred, whichever came first. Acceptance of the spoon within 5 s of the presentation resulted in access to preferred toys and praise. Expelled food was re-presented to the lower lip. Refusal of the initial presentation and refusal of the re-presented expelled food resulted in physically guiding the mouth open by applying gentle pressure to the mandibular junction of the jaw, and placing the spoon into the open mouth. Attempts to disrupt spoon presentation were blocked without physical restraint. Once the spoon was placed into the mouth using guidance, praise and access to toys were delivered for the remainder of the intertrial interval (30 s) or for at least 15 s, whichever was longer. Each feeding session consisted of 20 trials.

Experimental Design

The results of Experiment 1 served as baseline for Experiment 2. In Experiment 2, a multiple baseline design (Barlow & Hersen, 1988) across spoon volumes was used. For each subject, baseline for all spoon volumes consisted of DRI. Treatment for acceptance was initially introduced at the smallest spoon volume with less than 80% acceptance. Once a spoon volume was targeted for intervention, the majority of each day's feeding sessions for each child were scheduled to occur at that target spoon volume, with other spoon volumes scheduled to occur less frequently. For Michael and Gary, treatment was briefly withdrawn and then reintroduced at the largest spoon volume with moderate levels of acceptance ($M > 50\%$).

Following introduction of treatment in the empty spoon condition, Linda began accepting other spoon volumes; however, the accepted food was expelled. Because her mean level of acceptance was highest and most stable in the half spoon condition, expelled food was re-presented to the lower lip in this condition (Session 72). Refusal to accept the expelled food within 10 s of the re-presentation resulted in removal of the spoon from the lower lip and no attention for the remainder of the intertrial interval. Physical guidance contingent upon refusal of the re-presented expelled food (Session 84) and refusal of the initial spoon presentation (Session 100) was then implemented in the half spoon condition and in the level spoon condition (Sessions 110 and 125, respectively).

RESULTS

Michael

Figure 2 depicts the percentage of bites accepted by spoon volume. Because Michael exhibited low acceptance of all spoon volumes except the empty spoon, nonremoval of the spoon was implemented initially with the dipped spoon (Session 48). The percentage of bites accepted of the dipped spoon increased from a mean of 8% to 100% within two sessions. Expulsion decreased from a mean of 50% to less than 5%, and mouth clean increased from a mean of 14.6% to greater than 95%. In addition, treatment generalized to the quarter and half spoon conditions (acceptance was 70% and 100%, respectively).

Nonremoval of the spoon was then withdrawn (Session 56) while DRI remained in effect across all spoon volumes. Two sessions after the withdrawal, the percentage of bites accepted dropped to 0% in the dipped spoon condition. Nonremoval of the spoon was then reimple-

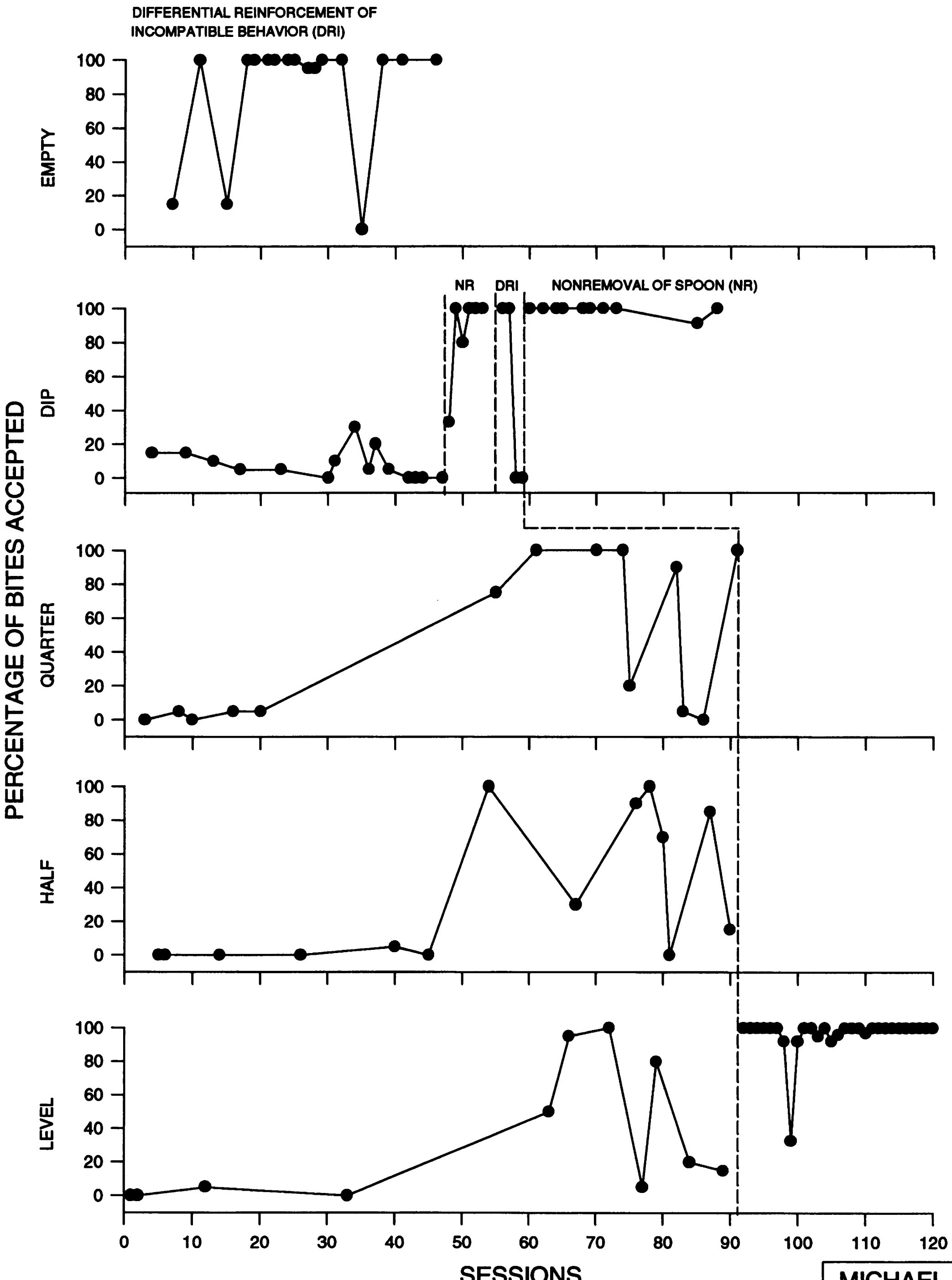

Figure 2. Percentage of bites accepted by spoon volume and condition for Michael.

mented for the dipped spoon condition only (Session 60); DRI remained in effect for all other spoon volumes. Percentage of bites accepted increased to 100% for the dipped spoon, expulsions were low (M = 3.7%), and instances of mouth clean were high (M = 96.3%).

Treatment effects also generalized to untargeted volume conditions. Even though acceptance increased in all other untargeted spoon volume conditions, the mean percentage of bites accepted decreased systematically across increasing spoon volumes: quarter spoon (M = 64.4%), half spoon (M = 55.7%), and level spoon (M = 52.1%). Accepted bites were rarely expelled in the quarter and half spoon conditions (M = 0.71% and M = 3.9%, respectively); however, expulsions were higher in the level spoon condition (M = 25.1%). Similarly, Michael had a clean mouth for over 95% of the accepted quarter and half spoons bites, with a decrease in the level spoon condition (M = 72.1%).

Because the level spoon volume was the largest spoon volume with moderate levels of acceptance (over 50%), nonremoval of the spoon was then introduced in this condition (Session 92). During the remainder of Michael's treatment (including parent training), percentage of bites accepted remained over 90%, expulsion occurred during less than 10% of spoon presentations, and percentage of accepted bites with a clean mouth remained over 90% in this condition. On discharge and at 1-, 3-, and 6-month follow-up, acceptance of the level spoon remained high and stable, and Michael was consuming 60 level spoonfuls of food per meal.

Gary

Percentage of bites accepted across spoon volumes is depicted in Figure 3. Physical guidance was provided in the dipped spoon condition (Session 78), while DRI remained in effect for all other spoon volumes. Percentage of bites accepted immediately increased to above 95% in the dipped spoon condition; no bites were expelled and all were swallowed within 30 s (baseline M = 6.5% and M = 93.5%, respectively). (Because there were multiple manipulations that did not result in stable improvements during Sessions 50 to 70, these data are not presented in the graph.)

Treatment also generalized to untargeted volume conditions. Although acceptance increased in all untargeted volume conditions, percentage of bites accepted decreased systematically across increasing volumes (M = 71% for quarter spoon, 40% for half spoon, and 20% for level spoon). Percentage of accepted bites expelled was less than 5% in the quarter and half spoon conditions and 75% in the level spoon condition. The percentage of bites with an instance of mouth clean also varied systematically by volume (M = 95% for the quarter spoon, 63% for the half spoon, and 25% for the level spoon).

Physical guidance was withdrawn from the dipped spoon in Session 92 (acceptance decreased to less than 30%) and was reintroduced in Session 94. Only the first bite of the next two meals was refused. Physical guidance was then implemented in the quarter spoon condition; however, subsequent to the treatment instruction at the beginning of the session, no bites (regardless of spoon volume) were refused for the remainder of the study.

Although acceptance remained high and stable across targeted and untargeted spoon volumes, expulsion varied systematically by condition (M = 3.7% quarter, M = 16.4% half, and M = 30% level). Similarly, percentage of bites with instances of mouth clean also varied systematically with increasing volume (M = 92.3% quarter, M = 42.1% half, and M = 51.3% level). Since discharge, Gary has continued to accept food without contacting physical guidance and is competently eating 55 level spoonfuls of pureed table foods.

Linda

Figure 4 presents the percentage of accepted bites across spoon volumes. Because Linda did not accept bites at any volume, physical guidance was implemented in the empty spoon con-

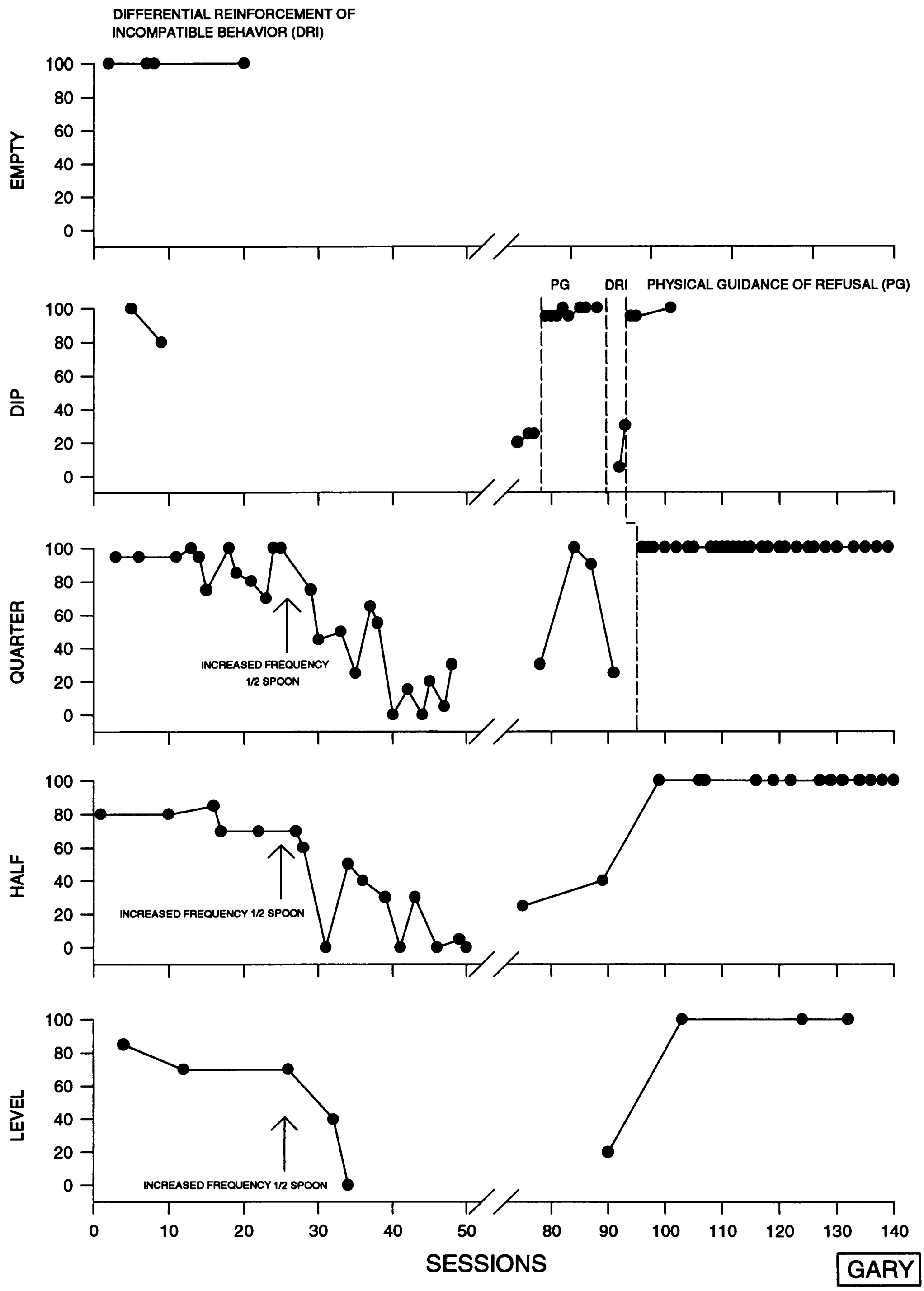

Figure 3. Percentage of bites accepted by spoon volume and condition for Gary.

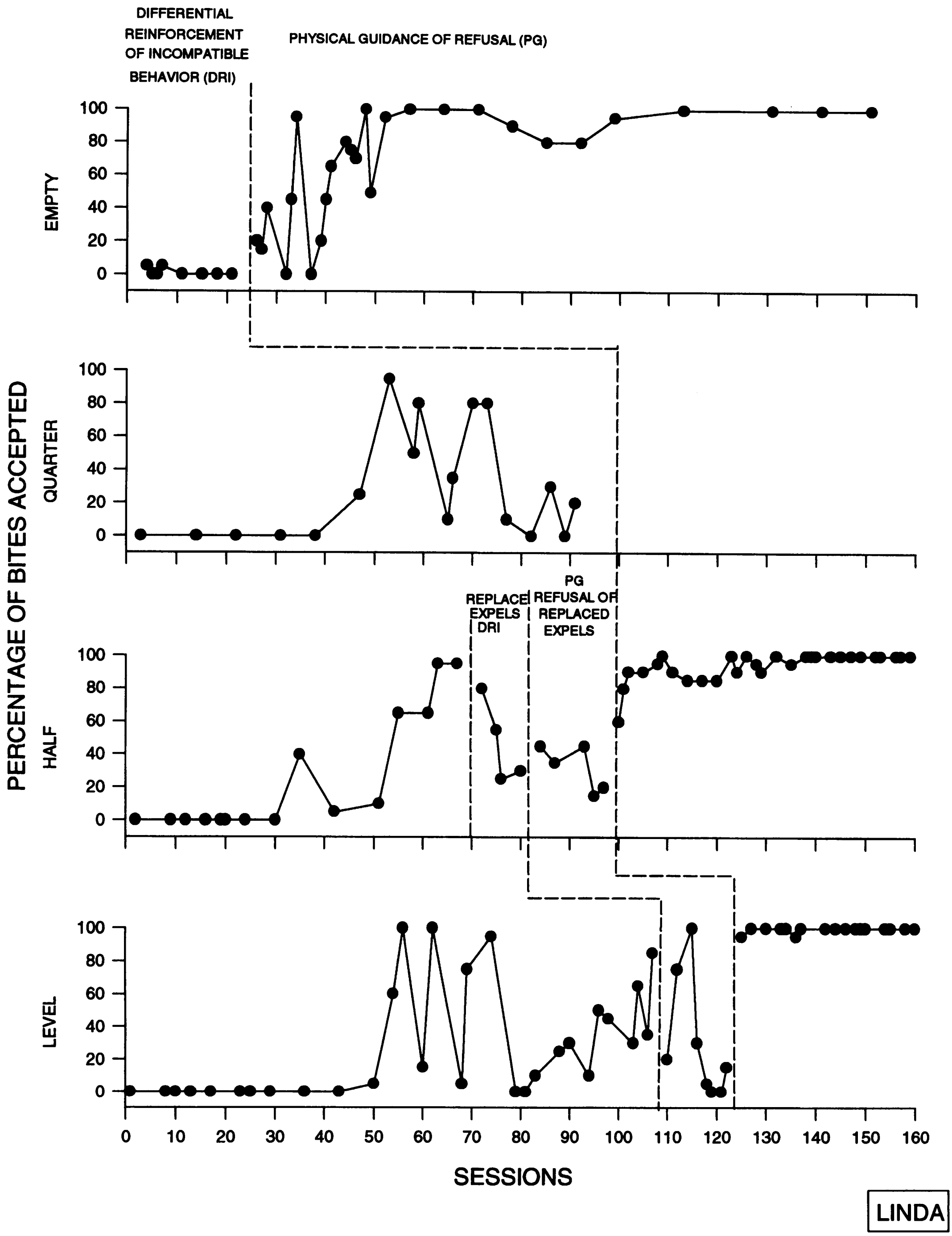

Figure 4. Percentage of bites accepted by spoon volume and condition for Linda.

dition (Session 26); DRI was in effect for all other volumes. Percentage of bites accepted increased in the empty spoon condition as well as across untargeted spoon volumes. Mean percentage of bites accepted was 41.7% in the quarter spoon condition, 46.8% in the half spoon condition, and 36% in the level spoon condition.

Although acceptance increased across spoon volumes, expulsion was high (over 80%) at every volume. Because mean percentage of bites accepted was nearly 50% in the half spoon condition, expelled food was re-presented to the lower lip for the half spoon only (Session 72). Percentage of bites accepted decreased across all volumes except the empty spoon (range, 25% to 55% for the half spoon, with less than 10% in the quarter and level spoon conditions).

Guidance was then implemented for refusal of the re-presented expelled food (Session 84). Acceptance remained low in the half spoon condition (M = 29%), and expulsions remained high (M = 98%). Acceptance also remained low in the quarter spoon condition (M = 16%); however, there was an increasing trend in the level spoon condition (M = 32%).

Guidance was then introduced contingent upon refusal of the initial presentation (Session 100) in the half spoon condition. Percentage of bites accepted increased in the half spoon condition (more than 90%) and continued to increase in the level spoon condition (range, 30% to 85%). Expulsion remained high (100%) in both the half and level spoon conditions.

Physical guidance was then introduced in the level spoon condition for refusal of re-presented expelled food (Session 110). Within three sessions, percentage of bites accepted decreased to less than 30% in the level spoon condition but remained high in the half spoon condition (more than 85%). Treatment was then made contingent upon refusal of the initial level spoon presentations (Session 125). Percentage acceptance increased to 90% or higher for the remainder of treatment across all spoon volumes.

Although expulsion remained high and instances of mouth clean remained low across all spoon volumes and conditions, expulsion began to decrease slightly after completion of the study (M = 85% for half and M = 86.6% for level). This decrease in percentage of accepted bites expelled was preceded by an increase in percentage of bites with instances of mouth clean in the half spoon condition starting at Session 140 (M = 45.8%). Once instances of mouth clean became more frequent and stable, spoon volume was gradually increased from 0.50 cc to 0.65 cc, then to 0.80 cc, and finally to 1.0 cc. At 1, 4, and 6 months postdischarge, Linda continued to accept food at high levels without use of guidance, expulsions were low (less than 10%), and instances of mouth clean were high (over 80%).

Discussion

The results of this study systematically replicate the effectiveness of nonremoval of the spoon and physical guidance for the treatment of food refusal (Hoch et al., 1994; Riordan et al., 1984). Both procedures produced an increase in percentage of bites accepted to levels greater than 80%.

The treatments were effective not only in increasing acceptance of the targeted spoon volumes but also in promoting generalization of independent acceptance to untreated, larger spoon volumes for all 3 subjects. These generalized effects varied systematically across untargeted volumes for all three target behaviors (acceptance, expulsion, and mouth clean). Furthermore, acceptance progressively decreased with increases in spoon volume. The only exception occurred with Linda, for whom acceptance in the quarter and half spoon conditions was comparable. Similarly, treatment effects on expulsion and instances of mouth clean also generalized in an orderly fashion across increasing, untargeted spoon volumes for Michael and Gary. For both subjects, expulsions were low in the quarter and half spoon conditions and moderate in the level spoon condition. For Michael, mouth-clean data resembled the pattern seen with expulsions; however, instances of mouth clean generalized more systematically across decreasing spoon volumes for Gary.

Stimulus generalization does not readily explain this orderly relationship between spoon volume and degree of treatment generalization. It is possible that the graded generalization reflected nascent efficiency of oral-motor skill at each spoon volume. However, introduction of treatment at a particular volume usually resulted in immediate and appropriate oral-motor skill (high acceptance and mouth clean and low expulsion); therefore, it does not appear that these children required practice to exhibit functional eating at larger spoon volumes.

GENERAL DISCUSSION

The results of both experiments can be conceptualized within a behavioral economic framework. Taken together, the studies provide preliminary support that increasing spoon volume can be equated with increasing response effort (Neef, Shade, & Miller, 1994). In Experiment 1, each child exhibited a different, but orderly, demand function of response (acceptance, expulsion, and mouth clean) by cost (spoon volume) for the same pay-off (social attention and toys). Gary's instances of acceptance and mouth clean decreased systematically with increasing spoon volumes, whereas expulsion increased with increasing spoon volumes. Michael exhibited high levels of acceptance of an empty spoon and low levels of acceptance of spoons with food; however, even with these low levels, acceptance decreased systematically across the dipped, quarter, half, and level spoons. In addition, expulsion was moderate with the dipped spoon and high with any larger volume of food, whereas instances of mouth clean were low with the dipped spoon and zero with any larger volume of food. In Experiment 1, Linda accepted only an empty spoon. In Experiment 2, acceptance generalized systematically from targeted to untargeted larger volumes for all 3 children; expulsion and mouth clean also generalized systematically to untargeted larger volumes for Michael and Gary.

During DRI, the cost of acceptance for a constant pay-off (toys and social interaction) increased systematically with larger spoon volumes. Because the pay-off was constant, each child's demand function was determined by the relative costs of acceptance and refusal. Specifically, the cross point for each child's demand function occurred when the cost of refusal (lack of access to toys and social interaction) was greater than the cost of acceptance (larger spoon volume). In a sense, toys and social interaction were "luxuries" (unessential events) for these children under DRI. Because these experiments were conducted in the context of an open economy for toys and social interaction, refusal had minimal cost (i.e., it only delayed access to toys and social interaction until after the feeding session). The cross point was the price at which access to toys and social interaction became unaffordable relative to the cost of acceptance.

Treatment made the cost of refusal higher and more immediate at the targeted volume, thus altering the cost of acceptance relative to the cost of refusal for a constant pay-off (Baum, 1973). Specifically, refusal at the targeted volume resulted in physical guidance of the jaw or holding the spoon at the lip. As a result, the pay-off (toys and social interaction) for independent acceptance at the targeted volume was now elevated relative to the increased cost of refusal, or the consequences for refusal were aversive enough to shift the cross point. Recall that under DRI, the most costly consequence scheduled for refusal was a delay in access to toys and social interaction until after the session had ended. By contrast, under treatment contingencies, the consequence for refusal was both immediate and aversive. Treatment contingencies made acceptance a "necessity"; therefore, the probability of paying the high price at larger spoon volumes was increased.

Systematic generalization of the target behaviors to untargeted larger spoon volumes is not as easily explained from a behavioral economic perspective. Although stimulus generalization across volumes may have occurred following the implementation of treatment, the hierarchical order of this generalization suggests that stimulus generalization is not the sole cause of these effects. Initially, the cost of refusal (nonremoval of the spoon or guidance) at the targeted volume facilitated the acquisition and maintenance of independent acceptance at the targeted volume. With extended exposure to treatment, the pay-off for independent acceptance (toys and social interaction) may have come to control responding in the untargeted volumes. This may have occurred even though the pay-off was initially contacted as generalization of the avoidance of the contingencies for the targeted volume.

The change from DRI to a more intensive treatment appears to have altered the elasticity of each child's demand function from relative elasticity to relative inelasticity. Under DRI, increased cost was associated with marked decreases in the probability of acceptance. During treatment, acceptance avoided aversive consequences and "purchased" access to toys and social interaction. Whether or not the avoidance of the contingencies for refusal or the combination of avoidance and positive pay-off for acceptance caused the resulting change in demand function cannot be determined from these data.

Although the results from these studies may be explained without relying on a behavioral economic perspective, this perspective provides an integrative framework that allows a more parsimonious interpretation of these data. Changes in performance across more than two situations as a function of changes in both response effort and consequences uniquely capture the dynamic interdependence of responding and reinforcement inherent in a behavioral economic approach (Hursh, 1984). In addition, this approach permits a priori prediction of responding, reinforcement, and punishment in situations of choice (Herrnstein, 1970, 1990). Finally, a behavioral economic framework allows integration of these clinical assessment and treatment data with the growing synthesis of behavioral and economic principles (Akerlof, 1991; Becker, 1976; Goltz, 1992; Hantula & Crowell, 1994; Hursh, 1980; Tustin, 1994) predicted by Kagel and Winkler (1972) over two decades ago.

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