Journal of Applied Behavior Analysis

JOURNAL OF APPLIED BEHAVIOR ANALYSIS 2016, **49,** 1–27 NUMBER 3 (FALL)

A COMPARISON OF A MODIFIED SEQUENTIAL ORAL SENSORY APPROACH TO AN APPLIED BEHAVIOR-ANALYTIC APPROACH IN THE TREATMENT OF FOOD SELECTIVITY IN CHILDREN WITH AUTISM SPECTRUM DISORDERS

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Treatments of pediatric feeding disorders based on applied behavior analysis (ABA) have the most empirical support in the research literature (Volkert & Piazza, 2012); however, professionals often recommend, and caregivers often use, treatments that have limited empirical support. In the current investigation, we compared a modified sequential oral sensory approach (M-SOS; Benson, Parke, Gannon, & Muñoz, 2013) to an ABA approach for the treatment of the food selectivity of 6 children with autism. We randomly assigned 3 children to ABA and 3 children to M-SOS and compared the effects of treatment in a multiple baseline design across novel, healthy target foods. We used a multielement design to assess treatment generalization. Consumption of target foods increased for children who received ABA, but not for children who received M-SOS. We subsequently implemented ABA with the children for whom M-SOS was not effective and observed a potential treatment generalization effect during ABA when M-SOS preceded ABA.

Key words: applied behavior analysis, escape extinction, feeding disorders, modified sequential oral sensory, oral-motor skills, sensory integration, sequential oral sensory, sequential oral sensory training, SOS, systematic desensitization

Children with autism spectrum disorders (ASD) often display food selectivity (Fodstad & Matson, 2008; Schreck & Williams, 2006), defined as consumption of a limited variety of foods. Schreck, Williams, and Smith (2004) found that 72% of 472 children with ASD had feeding problems, which was significantly higher than same-aged peers without ASD. Children with ASD ate approximately half the number of dairy items, fruits, proteins, and vegetables eaten by children without ASD. Schreck et al. included children up to the age of 12 years, suggesting that children with ASD do not "grow out of" feeding problems.

Selective diets of children with ASD are often high in fat, sodium, or both (e.g., French fries) and are low in nutritional content (e.g., candy), which is of concern because poor dietary intake is associated with health, learning, and behavior problems. For example, children who consume meals predominantly composed of high-glycemic-index foods (e.g., complex carbohydrates), foods that are high in fat (e.g., fast foods), or foods that are high in sugar (e.g., candy, soda) are at greater risk for severe health problems such as obesity, Type 2 diabetes, chronic constipation, and hypertension (Freedman, Dietz, Srinivasan, & Berenson, 1999; Ludwig et al., 1999).

The hypothesis based on applied behavior analysis (ABA) for the etiology of feeding disorders is that inappropriate mealtime behavior is developed and maintained, at least in part, by environmental events (Bachmeyer et al., 2009; Piazza, Fisher, et al., 2003). Borrero, Woods, Borrero, Masler, and Lesser (2010) observed caregivers and children with feeding disorders

The use of the modified sequential oral sensory (M-SOS) approach does not imply endorsement by the developer of the SOS approach. The developer of the SOS approach has not authorized or approved this evaluation.

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doi: 10.1002/jaba.332

during mealtime and found that caregivers were most likely to remove the spoon or cup or end the meal when the child engaged in inappropriate mealtime behavior. They also observed caregivers providing attention (e.g., "You like peas") or a tangible item (e.g., a preferred food) when the child engaged in inappropriate mealtime behavior. Piazza, Fisher, et al. (2003) conducted functional analyses to evaluate how caregiver consequences such as removal of the spoon or cup, adult attention, and giving the child a tangible item affected child behavior during meals. Results suggested that these consequences actually worsened inappropriate mealtime behavior for most children. For the children whose functional analyses were differentiated, the largest percentage had inappropriate mealtime behavior maintained by escape (90%). This finding is consistent with studies that have shown that escape extinction is an effective treatment (Ahearn, Kerwin, Eicher, Shantz, & Swearingin, 1996; Piazza, Patel, Gulotta, Sevin, & Layer, 2003; Reed et al., 2004). Multiple studies have shown that acceptance of bites increases and inappropriate mealtime behavior decreases when therapists use escape extinction (e.g., nonremoval of the spoon; Ahearn et al., 1996; Cooper et al., 1995; Piazza, Patel, et al., 2003; Reed et al., 2004). Studies also have shown that differential and noncontingent reinforcement may be associated with reductions in problem behavior (e.g., negative vocalizations) for some children when combined with escape extinction (Piazza, Patel, et al., 2003; Reed et al., 2004). In addition, studies have shown that these procedures are effective with children with ASD and food selectivity even when parents implement them in the home (Anderson & McMillan, 2001; Najdowski, Wallace, Doney, & Ghezzi, 2003; Tarbox, Schiff, & Najdowski, 2010). More generally, ABA's focus on demonstration of functional control using appropriate single-case designs provides the clinician with the flexibility to refine treatments over time based on the data.

An alternative treatment for feeding disorders is called the sequential oral sensory (SOS) approach. SOS is a popular alternative to ABA treatment and is used in many clinical settings (Benson, Parke, Gannon, & Muñoz, 2013; Boyd, 2007; Toomey & Ross, 2010). Unfortunately, SOS has limited empirical support. To our knowledge, there is one data-based study published in a peer-reviewed journal (Benson et al., 2013), one unpublished doctoral dissertation (Boyd, 2007), an article in a non-peer-reviewed periodical (Toomey & Ross, 2011), an article in a newsletter that is no longer in print (Grey, D'Andrea, & Westlake, 2010), and an article posted on an informational website (Banotai, 2010).

The SOS approach is a 12-week program (Benson et al., 2013, p. 290; Boyd, 2007, p. 5) with systematic desensitization and play as prominent components (Toomey & Ross, 2011). During SOS, the therapist introduces food, which is conceptualized as the anxiety-provoking stimulus, using a hierarchy consisting of six steps that include visual tolerance, interaction, smell, touch, taste, and eating. Playing with food is conceptualized as the relaxation response. If the child's level of stress becomes too great during food presentation, the therapist removes the food and returns to a lower step in the hierarchy so that the child can relax and reorganize (Boyd, 2007; Toomey & Ross, 2010, 2011).

Benson et al. (2013) reviewed the charts of 34 children who received 1 to 3 years of SOS to determine the extent to which children advanced through the hierarchy (e.g., advanced from tolerating strong odor to touching food with fingertip). Sixteen children (47%) showed no advancement, and seven children (21%) did not demonstrate advancements that were sustained long enough to consider them positive trends. Five children (15%) showed advancement for some but not all food types, and six children (18%) showed advancement for all food types. These data are discouraging in that

68% of children showed no advancement, even after a mean of 42 SOS sessions over the course of 1 to 3 years. In addition, it was not clear to which step in the hierarchy the 32% of children who showed improvement advanced. These data are difficult to interpret, however, because of the absence of (a) baseline data, (b) operational definitions for the measure of advancement, (c) a technological description of the procedure, and (d) a demonstration of functional control.

Boyd (2007) evaluated 3-day food records of children who participated in SOS group therapy at Toomey and Associates, Inc. over a 2-year period. Boyd reported that the number of different foods listed on 3-day records increased significantly after the first 12-week session (Session 1) and from after Session 1 to after the second 12-week session (Session 2). No further improvements in number of different foods consumed occurred for children who continued SOS beyond Session 2. These data are limited, however, because Boyd calculated the number of different foods for Session 1 as number of baseline plus Session 1 foods and the number of different foods for Session 2 as number of baseline plus Session 1 plus Session 2 foods. In addition, Boyd assumed that children continued to consume foods listed on earlier food records (e.g., baseline) even if those foods did not appear on later food records (e.g., Session 1). Finally, of the 76 children enrolled in the program in the 2-year study period, only 37 (49%) had 3-day food records at baseline and after at least one 12-week session. Boyd suggested that some parents may not have completed 3-day food records because the child was not eating enough to justify completing a record, caregivers did not want to or could not pay the $50 fee to have the record analyzed, or both.

Despite limited empirical support, SOS appears to be a popular approach used in many clinical settings (Boyd, 2007; Toomey & Ross, 2010). To assess its popularity, we conducted an Internet search by entering the terms *pediatric feeding disorders treatment, feeding disorders clinics, feeding disorders programs,* and *pediatric feeding therapy* into the Google search engine. We counted the number of self-identified pediatric feeding disorders programs and found that 64% specifically listed SOS as a primary form of treatment.

Given the high prevalence of and the negative consequences associated with food selectivity in children with ASD, validation and dissemination of effective treatments are critically important. The original purpose of the current study was to compare the effects of SOS, a treatment for feeding disorders that is used widely but has little empirical support, to an ABA treatment, nonremoval of the spoon and continuous interaction, which has good empirical support. To that end, the first author attended a 5-day workshop, which included a basic course on SOS and an advanced course on treatment of children with ASD given by Kay Toomey, which is how professionals train to implement SOS in clinical practice.

Although we modified the SOS procedure (M-SOS) to evaluate it scientifically, we made every attempt to make modifications that were consistent with the method described in the literature, in the workshop, and in the handouts Toomey distributed during the workshop. Before publication, we received a letter from J. Mark Smith, attorney for Kay Toomey, Toomey and Associates, and Sequential Oral Sensory and SOS Feeding Solutions. According to Smith, these modifications were "not the true and comprehensive SOS method," and we used SOS "in a manner that was not consistent with the SOS method, [using] metrics that were not relevant and were artificial to the SOS methodology" (J. Mark Smith, personal communication, October 6, 2015). To address these concerns, we did the following: (a) We changed the name of the procedure to M-SOS; (b) throughout the article, we refer to the procedure as M-SOS and the procedure as

referenced in the literature and the handouts Toomey distributed in the workshop as SOS; (c) we cited the specific page numbers in the handouts Toomey distributed in the workshop from which we derived each of the procedural components of M-SOS; (d) as in the original version of the article, we identified which modifications of the M-SOS procedure deviated from SOS as described in the literature, in the handouts Toomey distributed in the workshop, or both.

METHOD

Participants

The study included children who (a) consumed less than 20 but more than three foods (Toomey & Ross, 2010, p. 84), (b) consumed at least 90% of caloric needs by mouth, (c) were physician-identified safe oral feeders, (d) had the oral-motor skills to chew table food as determined by a speech therapist (Toomey & Ross, 2010, pp. 38–40), and (e) had a diagnosis of ASD. We excluded children who (a) had untreated ongoing medical problems diagnosed by a physician, (b) were not maintaining their growth relative to their own growth curve (Centers for Disease Control and Prevention, 2002), (c) consumed less than 90% of caloric needs by mouth, or some combination of these criteria. The six participants were male, between the ages of 4 and 6 years, and had been diagnosed with ASD by an interdisciplinary team of an autism diagnostic clinic. The diagnostic evaluation included, at a minimum, (a) a detailed, structured interview assessing the history and current status of developmental, behavioral, and psychiatric disorders for the child and his family and previous therapies and medication trials; (b) administration of a structured interview and the Autism Diagnostic Observation Schedule (Lord, Rutter, DiLavore, & Risi, 2000); and (c) a mental status examination. Greg, James, Sam, and Jerry had been receiving early intervention services for 15, 30, 3, and 3 months, respectively. None of the children had exposure to feeding therapy. Before the study, Greg consumed proteins and starches for a total of 12 foods; James consumed fruits and starches for a total of 14 foods; Sam consumed proteins and starches for a total of nine foods; Jerry consumed proteins and starches for a total of seven foods; Bryce consumed Pediasure and proteins and starches for a total of six foods; and Barry consumed fruits, proteins, and starches for a total of 17 foods. All participants also consumed sugary "junk" foods (e.g., cookies, candy). Caregivers often had to make special meals for the child because he did not eat foods the family ate.

Random Assignment with Counterbalancing

We randomly assigned children to treatment in pairs using the research randomizer (available at www.random.org/lists/) in an attempt to equate treatment length for ABA and M-SOS. Pair 1 was Greg (ABA) and James (M-SOS); Pair 2 was Sam (ABA) and Jerry (M-SOS); and Pair 3 was Bryce (ABA) and Barry (M-SOS). Participants attended 1.5-hr appointments (Toomey & Ross, 2010, p. 101) three times per week. We conducted a minimum of 12 appointments for children in the M-SOS group (Benson et al., 2013). To approximate treatment length for pairs of children, when acceptance was greater than 80% across all foods for one child in the pair, we conducted three additional appointments with the treatment for the other child in the pair. The caveat was that if treatment was effective in less than 12 appointments for a child assigned to ABA, we continued to conduct appointments for the child assigned to M-SOS until we completed 12 appointments, then we conducted three more appointments before concluding that M-SOS was not effective. ABA was effective in 12, 9, and 16 appointments for Greg, Sam, and Bryce, respectively; therefore, we conducted 15, 15, and 19 appointments with

James, Jerry, and Barry, respectively, before concluding that M-SOS was not effective.

Setting and Materials

We conducted feeding sessions in rooms (4 m by 4 m) with adjacent one-way observation panels and sound. We conducted the M-SOS sensory preparation routine in an indoor playground equipped with a slide, swings, merry-go-round, and other play materials (e.g., large blocks, yoga ball; Banotai, 2010; Grey et al., 2010; Toomey & Ross, 2010, p. 103).

We seated the child upright in a 90-90-90 position with his back flat against the back of the chair, his upper thighs resting on the seat of the chair, and his feet supported on a foot rest of appropriate height in an age-appropriate seat (Toomey & Ross, 2010, pp. 31–32). Other materials included a scale, timers, gloves, a Flip video camera, paper towels, and laptop computers. Eating utensils included small Maroon spoons, rubber-coated baby spoons, plastic bowls, and a Nuk brush (James only) for ABA and paper plates, plastic utensils, soap, a bin for soapy water, and washcloths for M-SOS (Toomey & Ross, 2010, p. 95). We used different-colored bowls for baseline and treatment for ABA.

Caregivers selected three target foods that the child did not eat currently and three additional target foods for James, as described below. We identified target foods (a) to have a method to measure treatment outcomes consistently across children and (b) so the child and family would eat some of the same foods at the end of treatment. However, "identifying specific target foods is inconsistent with SOS as the SOS method lets the child come to their desired end with of a variety of foods" (J. Mark Smith, personal communication, October 6, 2015). The target foods were broccoli, apple, and fish stick for Greg; pear, chicken, green bean, hamburger, peach, and carrot for James; green bean, chicken, and pear for Sam; pea, carrot, and green bean for Jerry; green bean, potato, and chicken for Bryce; and macaroni and cheese, hamburger, and green bean for Barry. During M-SOS, the therapist also presented nontarget foods, including (a) purees, smooth foods of a uniform consistency that did not require chewing (e.g., yogurt); (b) meltable hard solids, foods with a well-defined exterior that melted in the mouth (e.g., Cheetos); (c) hard munchable solids, foods with hard exteriors cut 5 cm in length that required well-developed chewing skills (e.g., beef jerky); (d) wet ground, small chunks of food in a liquid medium; and (e) chopped, table foods finely diced into small pieces. The therapist presented at least one protein, one starch, and one fruit or vegetable in each M-SOS treatment session (Toomey & Ross, 2010, pp. 113–114).

Therapists and Observers

The ABA therapists and observers (a) were trained in behavior analysis and pediatric feeding disorders, (b) held a minimum of a bachelor's degree, and (c) were employed in a pediatric feeding disorders clinic. The first author was the therapist for M-SOS and had completed 3-day basic and 2-day advanced SOS training, had a master's degree, and was a doctoral student.

Dependent Variables, Response Measurement, and Reliability

Trained observers used laptop computers to collect data on acceptance, mouth clean, and inappropriate mealtime behavior. Observers scored *acceptance* when the child used the utensil or his fingers to put the entire bite of food in his mouth within 8 s of presentation, not including placement of the bite in the mouth during re-presentation, except during backward chaining with Bryce. During backward chaining, observers scored acceptance when Bryce deposited the bite into his mouth and removed

the empty spoon from his mouth from the point at which the therapist guided his hand with the spoon.

We converted acceptance to a percentage after dividing the number of bites accepted by the number of bites presented. A presentation occurred when the feeder placed a bite on a spoon in a bowl in front of the child with a verbal prompt to "take a bite" in ABA or on the table without utensils in front of the child with a nondirective statement about the food (e.g., "James likes green beans") in M-SOS. We use the term *nondirective prompt* because therapist vocalizations during M-SOS were comments about the food that were positive "do" statements, educational, playful, descriptive about the sensory characteristics of the food (e.g., "the crunchy orange Cheetos want to kiss you!"), or some combination, rather than an instruction (e.g., "take a bite"; Toomey & Ross, 2010, pp. 76, 96, 114, 116). We cut each target food into pieces (0.6 cm by 0.6 cm), and we defined one piece as a bite, with each bite weighing between 0 and 1 g.

Observers scored *mouth clean* when there was no food larger than a grain of rice in the child's mouth 30 s after the entire bite entered the mouth, excluding the absence of food in the mouth as a result of expulsion (i.e., spitting out the bite). Observers had the potential opportunity to score mouth clean once for each bite that entered the child's mouth. We converted mouth clean to a percentage after dividing the number of mouth cleans by the number of bites entering the child's mouth, excluding bites that entered the mouth during re-presentation. Observers scored *inappropriate mealtime behavior* each time the child moved the spoon or bite of food away from the mouth before the child or therapist deposited the bite into the mouth, threw the spoon or the bite, hit the spoon or bite against a surface, touched the feeder's arm or hand, covered his mouth, or turned his head or moved his torso 45° away from the spoon or bite while the spoon or bite was within arm's reach of the child. We converted data on inappropriate mealtime behavior to responses per minute by dividing the total number of inappropriate mealtime behaviors by the total time the spoon or bite was within arm's reach of the child. These dependent variables are similar to the rejection behavior described by Toomey and Ross (2011) and to those listed in the handout distributed at the SOS training workshop (Toomey & Ross, 2010, pp. 50–53).

Observers recorded *grams consumed* on an electronic spreadsheet after placing each bowl of food on a scale and recording the weight before and after each session. The therapist used paper towels to wipe up spill. We calculated grams consumed as preweight–postweight food bowls minus paper towels with spill minus paper towels without spill. Toomey and Ross (2011) and Benson et al. (2013) state that consumption of sufficient calories for optimal growth is a goal of SOS, and measurement of amounts consumed was a routine component of the 3-day food records completed by caregivers of children who participated in SOS at Toomey and Associates, Inc. in the 2-year study period (Boyd, 2007, p. 46).

Two observers independently and simultaneously collected data on acceptance, mouth clean, and inappropriate mealtime behavior during at least 31% of sessions and on grams consumed during at least 34% of sessions for each participant. We calculated interobserver agreement for acceptance and mouth clean by dividing the number of agreements by the total number of agreements plus disagreements and converting that ratio to a percentage. We defined an agreement as both observers scoring the behavior within the same 10-s interval and a disagreement as one observer scoring and one observer not scoring the behavior in a 10-s interval. Mean interobserver agreement across participants was 99% (range, 75% to 100%) for acceptance and 99% (range, 75% to 100%) for mouth clean. We calculated exact

agreement coefficients for inappropriate mealtime behavior by dividing the number of agreements (10-s interval in which both observers scored the same frequency of inappropriate mealtime behavior) by the total number of agreements plus disagreements (10-s interval in which observers scored different frequencies of inappropriate mealtime behavior) and converting the ratio to a percentage. Mean interobserver agreement across participants for inappropriate mealtime behavior was 91% (range, 35% to 100%). We calculated interobserver agreement for grams consumed by adding the number of sessions in which both observers' grams consumed were within 0.5 of each other, dividing by the number of sessions in which both observers collected data, and converting the ratio to a percentage. Mean interobserver agreement across participants for grams consumed was 99% (range, 75% to 100%).

Treatment Integrity

Applied behavior analysis. At least one observer scored treatment integrity for 100% of ABA sessions. Observers scored *correct spoon presentation* by activating a duration key when the therapist met criteria for correct spoon presentation and deactivating the key if the therapist did not meet criteria for 3 s or more. Observers scored correct spoon presentation during baseline and treatment when the therapist (a) presented the spoon with a bite in a bowl within arm's reach of the child, (b) removed the spoon and the bowl after the bite entered the child's mouth, and (c) presented the next bite 30 s after the previous bite entered the child's mouth, except as indicated below. Observers also scored correct spoon presentation during baseline when the therapist removed the spoon and bowl after 30 s if the child did not accept the bite. If the child did not accept the bite within 8 s of presentation during treatment, observers also scored correct spoon presentation when the therapist (a) touched the spoon to the child's lips; (b) followed the child's head with the spoon and held the spoon touching the child's lips if the child engaged in inappropriate mealtime behavior; (c) left the spoon touching the child's lips if the bite of food did not remain on the spoon and the therapist needed to obtain another bite; (d) deposited the bite when the child opened his mouth; and (e) held the spoon to the side of the child's lips if the child vomited, coughed, or gagged while the therapist was holding the spoon at the child's lips. Observers also scored correct spoon presentation during treatment when the therapist (a) returned the spoon or bowl within arm's reach if the child moved the items out of arm's reach, (b) scooped up expelled food within 3 s of expulsion and placed the spoon with the bite back to the child's lips, and (c) re-presented fresh bites after an episode of vomiting. During treatment, if the child expelled and the therapist re-presented a bite repeatedly so that 30 s elapsed from when the bite entered the child's mouth initially, observers scored correct spoon presentation when the therapist presented the next bite when the previously expelled bite remained in the child's mouth for 3 s. We converted correct spoon presentation to a percentage by dividing the duration of correct spoon presentation by the session time. Mean correct spoon presentation was 99% (range, 90% to 100%) for all participants.

Observers scored *incorrect praise* if the therapist did not provide behavior-specific praise within 5 s of acceptance and mouth clean or provided praise when bites entered the mouth after 8 s or when packing (food larger than a grain of rice in the mouth at the mouth check) occurred. We converted incorrect praise to a percentage after dividing the instances of incorrect praise by the total opportunities to provide praise, which was the sum of acceptance and mouth clean. Therapists provided incorrect praise during 0.3% (range, 0% to 25%) of

sessions across participants. Observers scored *incorrect attention* each time the therapist provided attention (e.g., reprimands, coaxing, eye contact, physical contact, descriptive statements) immediately after inappropriate mealtime behavior. We divided the instances of incorrect attention by the number of inappropriate mealtime behaviors and converted the ratio to a percentage. Incorrect attention was 0% across participants.

Two independent observers simultaneously and independently collected data on correct spoon presentation, incorrect praise, and incorrect attention during at least 31% of ABA sessions for each participant. We calculated interobserver agreement for treatment integrity by dividing the number of agreements by the total number of agreements plus disagreements and converting the ratio to a percentage. Mean interobserver agreement was 92% (range, 85% to 100%) for correct spoon presentation, 100% (range, 99% to 100%) for incorrect praise, and 100% for incorrect attention across participants.

M-SOS treatment. At least one observer scored treatment integrity during at least 72% of treatment sessions across participants. We developed a treatment-integrity checklist that included each of the major steps of the M-SOS treatment. Observers scored *correct protocol implementation* by indicating yes or no on an 11-item treatment-integrity checklist whether the therapist conducted the steps described for the M-SOS treatment (See Appendix A in Supporting Information). We divided the number of steps implemented correctly by the total number of steps on the checklist and converted the ratio to a percentage. Correct protocol implementation was 100% across participants. Two observers simultaneously and independently collected data on correct protocol implementation during at least 50% of the M-SOS sessions for each participant. We calculated interobserver agreement by dividing the number of agreements by the total number of agreements plus disagreements on the checklist and converting that ratio to a percentage. Mean interobserver agreement was 100% across participants.

To address the potential that observer bias might affect the treatment-integrity measures, we developed a 40-item checklist that produced a more detailed analysis of treatment integrity for M-SOS. We sent this checklist to an independent occupational therapist, who was living in a different state and who was not associated with the program or study. The therapist received her occupational therapy license in 2000, her SOS training and certificate in 2009, and had been implementing SOS for children with feeding disorders for 5 years. The therapist reported that the items on the checklist would provide an accurate assessment of treatment integrity, and she did not recommend the inclusion of any additional items. We then sent the therapist a 24-min video with samples of all of the M-SOS treatment components and asked her to complete the 40-item treatment-integrity checklist (See Appendix B in Supporting Information). The therapist's rating of correct protocol implementation was 100%.

Design

We used a combination multiple baseline across foods and multielement design. We conducted baseline with each food until we observed stable levels of acceptance, mouth clean, and grams consumed. We then implemented ABA treatment across foods in accordance with a multiple baseline design except as follows. With James and Jerry, we observed increases in acceptance, mouth clean, and grams consumed and decreases in inappropriate mealtime behavior for the target foods in the second and third legs of the multiple baseline design (chicken and green bean for James, carrot and green bean for Jerry) when we implemented ABA treatment with the target food in the first leg of the multiple baseline design

(pear for James, pea for Jerry). Therefore, we did not implement ABA treatment with target foods in Legs 2 and 3 of the multiple baseline design with James and Jerry. We modified the multiple baseline design for children in the M-SOS group, and we describe these modifications in the General Procedure. We also returned to baseline and back to treatment for some foods in the M-SOS treatment. These "reversals" were programmed components of the M-SOS treatment and were not reversals as conceptualized for an ABAB design, as explained below (Toomey & Ross, 2010, p. 94). The multielement component consisted of periodic baseline sessions for an individual food after we initiated ABA or M-SOS treatment with that food.

General Procedure

A challenge in the current investigation was to collect comparable data for ABA, in which the child had multiple, discretely defined opportunities to accept a bite of target food, and M-SOS, in which there are no discretely defined opportunities for the child to accept a bite of target food. Each data point that appears in the figures for baseline and treatment for ABA and M-SOS represents five discrete bite presentations of a single target food. Before initiating the ABA or M-SOS treatment, therapists conducted multiple five-bite baseline sessions with brief breaks between sessions during the child's 1.5-hr appointment.

When we began ABA treatment, therapists conducted multiple five-bite sessions with the target foods in treatment. Therapists also conducted five-bite baseline sessions with target foods not yet in treatment and with target foods in treatment to assess treatment generalization. After we started treatment, we randomly selected the beginning or end of the 1.5-hr ABA appointment to conduct baseline sessions so that the timing of baseline sessions for ABA and M-SOS were comparable (see below). For example, the 1.5-hr ABA appointment might consist of a baseline session with apple, a baseline session with fish stick, a baseline session with broccoli, and 16 treatment sessions with broccoli.

We used the research randomizer to select one ABA treatment session for each food in treatment within the 1.5-hr appointment to serve as the representative data for ABA treatment for that day for a specific target food. We entered the range of session numbers for that day (e.g., Sessions 20 through 35) into the research randomizer and selected the first number from the randomized sequence that the program generated.

Therapists conducted the M-SOS protocol described below for 68 min of the 1.5-hr appointment. Therapists also conducted five-bite baseline sessions with target foods not yet in treatment and with target foods in treatment to assess treatment generalization. After we started treatment, we randomly selected the beginning or end of the 1.5-hr M-SOS appointment to conduct baseline sessions so we did not have to disrupt the M-SOS procedure, which we programmed to be continuous. The addition of these five discrete bite presentations before and after treatment was inconsistent with the SOS method.

Therapists presented five discrete bites embedded within the M-SOS treatment for target foods in M-SOS treatment (see below). Therefore, the 1.5-hr treatment session of M-SOS might consist of 68 min of the M-SOS treatment with five discrete bite presentations of chicken (e.g., at Minute 31) embedded in the M-SOS protocol while chicken was in the M-SOS treatment. After the 68-min M-SOS treatment, the therapist might conduct baseline sessions with chicken, green bean, and hamburger during the remainder of the 1.5-hr appointment. Embedding five discrete bite presentations in the M-SOS treatment represents a departure from how professionals conduct SOS treatment typically, which we included in our

M-SOS treatment to give the children assigned to each treatment group equal opportunities to consume the five bites.

Applied Behavior Analysis

Baseline. The therapist said to the child, "I'm going to put the bite of food in front of you and say, 'take a bite.' If you take your bite, I will say 'good job.' If you swallow your bite, I will say, 'good job.'" The therapist presented sequential bites of a single target food approximately every 30 s until she had presented five bites. The therapist placed the bite of food on a spoon in a bowl in front of the child simultaneous with the prompt, "take a bite." The therapist provided praise for acceptance and activated a timer for 30 s. At the expiration of 30 s, the therapist said, "show me" while modeling an open mouth. If the child did not open his mouth after the prompt, the therapist used a baby spoon to prompt the child to open by inserting the spoon at the lips and turning the spoon 90°. The therapist provided praise for mouth clean. If the child was packing, the therapist said "swallow your bite" and presented the next bite. The maximum number of potential packed bites was five per session. Before the study, we ensured that each participant had the skills to manage this amount of food safely. If the child was packing a bite 30 s after the therapist presented the fifth bite, she prompted the child to "show me" and "swallow your bite" every 30 s until the child swallowed or expelled the bite or 10 min had elapsed from the start of the session. The therapist removed packed food from the child's mouth at the expiration of the 10-min time cap. If the child did not place the bite in his mouth within 30 s of presentation, the therapist removed the bowl, spoon, and bite and presented the next bite. The session ended 30 s after the therapist presented the fifth bite if the child did not have food in his mouth. The therapist provided no differential consequence for expulsions, inappropriate mealtime behavior, coughing, gagging, or vomiting.

Nonremoval of the spoon and continuous interaction. The therapist said to the child, "I'm going to put the bite of food in front of you and say, 'take a bite.' If you take your bite, I will say 'good job.' If you swallow your bite, I will say, 'good job.' If you don't take your bite, I will help you. We can talk and sing the whole time." The procedure was similar to baseline with the following modifications. If the child did not accept the bite within 8 s of presentation, the therapist used hand-over-hand guidance to touch the spoon to the child's lips and insert the bite when the child opened his mouth. If the therapist was unable to keep the spoon touching the child's lips for 3 s or more using hand-over-hand guidance, she discontinued hand-over-hand guidance and held the spoon at the child's lips without the child's hand. The therapist re-presented expelled bites by guiding the child's hand to scoop up the bite and place it back in his mouth. If the child was expelling and the therapist was re-presenting a bite 30 s after the bite entered the mouth initially, the therapist presented the next bite as soon as the previous bite remained in the child's mouth for at least 3 s. We did this to minimize interruption of the re-presentation procedure and escape from the subsequent bite presentation as a function of expulsion. The session continued until the child consumed all five bites or 10 min elapsed from the start of the session. Throughout the session, the therapist continuously interacted with the child by talking and singing.

Individualized ABA treatment (Bryce). We implemented an avoidance procedure with Bryce because levels of acceptance were zero during nonremoval of the spoon and continuous interaction with green bean (Rivas et al., 2014; Vaz, Volkert, & Piazza, 2011). The procedure was similar to nonremoval of the spoon and continuous interaction, with the following modification. If Bryce did not accept the bite

of target food within 8 s of presentation, the therapist fed him the bite of target food plus four bites of the same food at a pureed texture. After no change in acceptance, we added backward chaining in which the therapist presented the bite on the spoon and guided Bryce to complete part of the acceptance response according to the following steps implemented across sessions. The therapist guided Bryce to place the spoon (a) inside his mouth, (b) at the lips, (c) 2.54 cm from the lips, (d) 5.08 cm from the lips, (e) 7.62 cm from the lips, (f) 10.16 cm from the lips, (g) 12.7 cm from the lips, (h) 15.24 cm from the lips, (i) just above the bowl, and (j) inside his hand. After the therapist guided Bryce to place the spoon in the targeted position, she discontinued guidance. If he completed the acceptance response, the therapist provided praise. If he did not complete the acceptance response, the therapist used hand-over-hand guidance to complete the acceptance response and then implemented the avoidance procedure. If he completed the acceptance response on 80% or more of bite presentations and had less than five inappropriate mealtime behaviors for three consecutive sessions (which we referred to as mastery), the therapist implemented the next step. The therapist conducted probes of the terminal step after Bryce mastered two to three steps. The terminal probe was identical to the nonremoval of the spoon, continuous interaction, and avoidance treatment, which we continued if acceptance and mouth clean were at or above 80%. We discontinued probes and went to the next step if acceptance and mouth clean were below 80% during the probe. Levels of acceptance and mouth clean were high and stable during a terminal probe after mastery of placement of the spoon just above the bowl. Therefore, we continued terminal probes for green bean and implemented the same treatment with potato and chicken. Bryce immediately began to self-feed bites when we initiated backward chaining with potato and chicken. Therefore, after one session each with potato and chicken, we conducted terminal probes with those foods and continued with the terminal probes when acceptance and mouth clean remained high.

M-SOS Approach

Baseline. The baseline was similar to the ABA baseline except the therapist placed the bite of food directly on the table (no utensils) in front of the child and simultaneously made a nondirective statement (e.g., "Green beans are good for you," "It's fun to drive the green bean across the table").

M-SOS treatment. Each M-SOS treatment appointment involved multiple components, beginning with a sensory preparation routine in an indoor playground (Toomey & Ross, 2010, pp. 103, 146). We decreased this routine to 10 min relative to SOS's recommended 15 to 20 min (Toomey & Ross, 2010, p. 103) to keep the amount of exposure to food in the ABA and M-SOS groups roughly equivalent and because Toomey and Ross (2010, pp. 101, 137) recommend approximately 45 min of work with food. After the preparation routine, the therapist and child transitioned to the feeding room by marching and singing (Toomey & Ross, 2010, p. 104). Only Jerry did not march or sing; he transitioned by walking and remaining silent. The therapist guided the child through hand and face washing, table washing and setting, and blowing bubbles in the therapy room (Toomey & Ross, 2010, p. 105). Next, the therapist began food presentation. The goal of food presentation was to progress the child through the six steps and 32 substeps of the M-SOS treatment within and across appointments. The six steps were visual tolerance, indirect interaction, smelling, touching, tasting, and eating (Toomey & Ross, 2010, p. 57). For the visual tolerance step, the therapist placed the food within incrementally closer proximities to the child (e.g., in the same room, across the table, directly in front). For the step that

involved indirect interaction, the therapist prompted the child (a) to assist in food preparation and (b) to use the utensils or napkins to serve or touch food. During the smelling step, the therapist prompted the child (a) to sit at the table with the food present, (b) to sit at the table with the food in front of the child, and (c) to lean down to pick up and smell the food. During the touching step, the therapist prompted the child (a) to touch the food with the fingertips, fingers, and hands; and (b) to touch the food to the arms or shoulders, neck, top of the head, chin or cheek, nose, lips, and teeth. During the tasting step, the therapist prompted the child (a) to touch the tip and then the top of the tongue to the food; (b) to lick the food with the full tongue; (c) to bite off a piece of food and spit it out immediately; (d) to bite off a piece of food and hold it in the mouth before spitting it out; and (e) to bite off a piece of food, chew it, and then spit it out. During the eating step, the therapist prompted the child (a) to chew a piece of food, swallow part of it, and spit out the remainder; (b) to chew and swallow a bite followed by a drink; and (c) to chew and swallow a bite with no drink.

The therapist presented one food approximately every 4 min (Toomey & Ross, 2010, p. 137). The volume of presented food was 1 tablespoon per 1 year of the child's age, which is the "rule of thumb" recommended in the handout distributed at the SOS workshop (Toomey & Ross, 2010, p. 72) with a total of 11 foods. After the therapist had presented all 11 foods and one drink (Toomey & Ross, 2010, pp. 104, 115), she prompted the clean-up routine. The therapist provided a clear signal that the session had ended (e.g., "All done, time to clean up") and instructed the child to "blow or throw away" at least one piece of each food by placing the piece of food to his lips and spitting the food into a trash can. If the child refused to place food to his lips, the therapist prompted the child to pick up small pieces of each food with his fingers or grasp the food through a napkin and throw the pieces into the trash can. The therapist prompted the child to assist washing the table, throwing away trash, and washing hands (Toomey & Ross, 2010, p. 107).

Throughout each component of the M-SOS treatment, the therapist delivered instructions by sequentially (every 30 s) (a) using a positive "do" statement that referred to the task (Toomey & Ross, 2010, p. 96); (b) modeling the behavior in a playful and relaxing manner (Toomey & Ross, 2010, p. 106); (c) using a light physical prompt; and (d) using an approximation of physical guidance (Toomey, 2010, p. 20; Toomey & Ross, 2010, p. 134). If the child resisted physical guidance, the therapist guided the child to do whatever he was willing to do (Toomey & Ross, 2010, p. 134). The therapist stood or sat close to the child, used an enthusiastic tone of voice to make nondirective, positive statements, and modeled the activities. The therapist allowed the child to engage in alternative activities and direct the routine (Toomey, 2010, p. 20; Toomey & Ross, 2010, p. 134).

To progress the child through the steps, the therapist presented multiple nontarget foods according to specific guidelines. One to three of the 11 foods was a target food, and the therapist selected all remaining nontarget foods based on (a) their shared sensory properties with target foods, (b) no history of allergies to the foods (Toomey & Ross, 2010, p. 116), and (c) parent approval. The first food presented during the first three appointments was a child-preferred food (Toomey & Ross, 2010, p. 114), and each subsequently presented food shared at least one sensory property (e.g., color, taste) with the previously presented food (Toomey & Ross, 2010, p. 114). For example, the therapist might start by presenting Cheetos (preferred food) for 4 min, followed by sweet potato (nontarget food) for 4 min, then carrot (target food) for 4 min, and so on, with foods that shared the sensory property of color. Food

11 was always a sweet, chewy food (e.g., licorice) followed by a liquid (Toomey & Ross, 2010, p. 114). Each time the therapist presented a food, she used the sequence described above (verbal, model, light physical prompt, approximation of physical guidance) to prompt the child to interact with the food in the manner specified by the substep. The therapist used positive or neutral descriptors for food, made verbal statements about the sensory properties of the food, and described how the target food was similar to the child's preferred food (Toomey, 2010, pp. 76, 96, 114, 116). For example, at the touching step, the therapist might say, "The orange carrots are coming to meet you, they are orange like Cheetos" as she held two pieces of baby carrots and "walked" them across the table toward the child. When the carrots were within arm's reach of the child, she said, "The carrot wants to shake hands with you" as she held a carrot out to prompt the child to touch the carrot. When the child did not touch the carrot, she modeled "shaking hands" with the carrot. When the child did not touch the carrot, she lightly prompted his hand to touch the carrot, and when he did not touch the carrot, she attempted to guide his hand to touch the carrot. When he resisted, she moved his hand as close to the carrot as he would allow.

The therapist provided praise if the child engaged in the target behavior specified by the substep after the vocal, model, or light physical prompt and proceeded to the next substep. The therapist provided praise if the child engaged in an alternative appropriate behavior after any prompt (Toomey & Ross, 2010, pp. 74–76, 94, 106). The therapist complied with safe and socially appropriate child requests; however, if the child talked about nonfood topics, the therapist redirected the child to food topics (Toomey & Ross, 2010, p. 99).

If the child did not engage in the target behavior during the prompt sequence for a substep, the therapist repeated the prompt sequence for that substep. If the child did not engage in the target behavior when the therapist repeated the prompt sequence for the substep, she returned to and prompted the previous substep (Toomey & Ross, 2010, p. 137). The therapist discontinued interaction with a food after 4 min or if the child engaged in negative vocalizations or sensory over- or underresponding, defined as 2 min of hand flapping or ear, mouth, nose, or eye covering; five or more instances of aggression or destruction; or showing interest in a previously presented food by pointing to, naming, touching, or eating the food (Toomey & Ross, 2010, pp. 50–54, 94). The food remained on the table after the therapist discontinued interaction with a food so that there were 11 foods on the table by the end of the food-presentation component of M-SOS (Toomey & Ross, 2010, pp. 97, 106).

If the child failed a substep with a food for three consecutive appointments, the therapist modified the sensory properties of the food for the next three appointments (e.g., the texture, shape, or size of the food; Toomey & Ross, 2010, p. 109). If the child did not pass the substep after sensory modifications or if the child did not reach the eating step with a food after six consecutive appointments, the therapist discontinued M-SOS with that food by removing it from the presentation array for six to nine appointments and substituted the failed food with a different food. The therapist returned the previously failed food to the M-SOS treatment by including the food in the presentation array after its removal for approximately six to nine appointments, unless the child had reached the cap on appointment number.

In the first appointment, the therapist prompted the child to interact with each food at the substep with which the child was likely to comply based on her clinical judgment (Toomey & Ross, 2010, p. 57). For example,

if the presented food was preferred, the therapist might start with the food across the table, but then quickly move the food to within arm's reach of the child so that he could eat it. If the food was novel or nonpreferred, the therapist might start with the food across the table as far away from the child as possible and progress the child more slowly through the substeps. Within and across appointments, the therapist progressed the child through the substeps of the hierarchy as follows.

The therapist presented the same 11 foods in the same order for the first three appointments (Toomey & Ross, 2010, p. 109). During the fourth and subsequent appointments, the therapist changed the first food to a different preferred food. The therapist also began changing the sensory properties of target or nontarget foods by (a) cutting the food differently, (b) heating or cooling it, or (c) mashing or chopping it (Toomey & Ross, 2010, p. 116). SOS does not provide specific guidelines for precisely when to change the sensory properties of foods but does provide general guidelines based on session number (e.g., "Sessions 4–6, introduce small changes in sensory properties of previous foods" and advice such as "when play no longer has a purpose" or "when the child is readily eating the food"; Toomey & Ross, 2010, pp. 109, 137). The criteria we developed for changing sensory properties of food or adding new foods were that the child (a) interacted with three or more foods at the touching step, (b) interacted with one or more foods at the eating step, or (c) did not interact with any of the foods past the touching step for three consecutive appointments. After the child began to consume a nontarget food, the therapist faded praise for consumption of the nontarget food. Then, the therapist added new nontarget foods and removed an equivalent number of previously presented nontarget foods that the child was eating consistently from the 11-food presentation array (Toomey & Ross, 2010, pp. 109, 137). After the therapist had presented a target food for three appointments, she replaced one nontarget food from the 11-food presentation array with another target food until all three target foods were included in the array. The presentation protocol was flexible in that the therapist could make modifications in the sensory properties of the food, the presentation order, or the foods themselves if her clinical judgment suggested that one or more of these changes would increase acceptance of the target food, or the child's behavior suggested that modifications would be appropriate or helpful (Toomey & Ross, 2010, p. 137).

The programmed M-SOS contingencies were for the therapist to terminate the session if the child's levels of stress became too great during food presentation (Toomey & Ross, 2011). SOS does not operationally define criteria for session termination. Our session termination criteria were 1.5 inappropriate behaviors per minute or more, tantrums during 30% or more of the session, or engagement in the prompted activities for 30% or less of the session. No child met these criteria.

In contrast with the logic of a multiple baseline design, the therapist discontinued treatment with a target food if the child was not successful with that food and implemented treatment with a different target food. This occurred for all foods for all children. The therapist followed these guidelines in that she introduced the M-SOS treatment sequentially across the three target foods, even though the treatment was not effective with any food, to approximate the logic of a multiple baseline design. When the M-SOS treatment did not result in increases in acceptance for any child, the therapist conducted ABA baseline and treatment for all children.

When a target food was on the table during M-SOS, it remained on the table, the child could consume the target food at any time, and we measured the child's consumption of target food. However, we also included a dependent

measure that would be comparable for ABA and M-SOS. We embedded five discrete bite presentations within the 68-min M-SOS session. The contingencies for the bite presentations were identical to those of the M-SOS baseline except that the therapist conducted the M-SOS treatment during and between bite presentations. The therapist presented the food targeted for M-SOS treatment as described above. After the target food was on the table and the therapist had implemented M-SOS for approximately 30 s to 60 s, she placed one bite of the same target food on the table in front of the child, activated a timer for 30 s, and made a nondirective statement (e.g., "Green beans are green and juicy!") while continuing M-SOS. The presentation of the nondirective statement was consistent with the SOS method. The therapist continued M-SOS so that presentation of the target bite interrupted M-SOS for approximately 1 to 2 s. The target bite remained on the table for 30 s, and the therapist made no further reference to it. The therapist removed the target bite after 30 s and presented another bite. She continued to present bites while she implemented M-SOS until she had presented five bites. The therapist provided praise if the child accepted the bite or removed the bite at the expiration of 30 s if the child did not accept the bite. For example, if the therapist initiated treatment with green bean in Minute 30 of the M-SOS session, she began the discrete bite presentations at Minute 31. While the therapist was mashing the target food green bean into the table in accordance with M-SOS, she presented one bite of green bean in front of the child while saying, "Green beans are yummy!" As soon as she placed the bite of green bean on the table, she continued to mash the other green beans on the table and to prompt the child to imitate her behavior in accordance with M-SOS. The presence of these bites within arm's reach of the child did not otherwise change how the therapist implemented M-SOS; it simply gave the child another opportunity to consume target bites. Only one child accepted target bites, but he spit them out immediately. The programmed contingencies were for the therapist to move the target bite away from but still within arm's reach of the child if the child's level of stress became too great as described above, but this never happened. The therapist continued M-SOS as described above after she had presented the five discrete bites. By inserting five discrete bite presentations into M-SOS, we were able to equate the discriminability of bite presentations and the response effort of bite consumption as well as produce data for ABA and M-SOS that were comparable. Thus, these are the treatment data for M-SOS shown in the figures.

M-SOS to ABA. The M-SOS treatment was not effective for any child for the target behaviors in this investigation; therefore, we implemented ABA baseline and treatment as described above. We added redistribution with a Nuk brush (Gulotta, Piazza, Patel, & Layer, 2005) to the ABA treatment with James when packing increased for chicken (only). The therapist conducted a mouth check 15 s after the bite entered his mouth. If James had food larger than a grain of rice in his mouth, the therapist collected the food with a Nuk brush and redeposited the food onto the center of the tongue by rotating the brush on the tongue and pulling the brush out of the mouth. The therapist repeated redistribution if James had food larger than a grain of rice in his mouth 30 s after the bite entered his mouth and then presented the next bite.

We evaluated ABA treatment with three additional foods (hamburger, peach, and carrot) due to carryover that occurred with the original three target foods for James. We used the same procedure, but we conducted sessions in a different room with different-colored utensils and a different feeder from the original target foods. We did not conduct baseline sessions during treatment with the additional foods due to time constraints.

Poststudy Caregiver Training

After the study, we trained caregivers to implement ABA treatment with 90% or greater integrity in the clinic using written instructions, modeling, and feedback (Mueller et al., 2003). We then conducted training in the home and gave the family a plan for maintenance and advancement of feeding skills. Data on caregiver training are available from the first author.

RESULTS

Figure 1 displays acceptance for Greg for broccoli (first), apple (second), and fish stick (third) and for James for pear (fourth), chicken (fifth), and green bean (sixth). For Greg, mean acceptance, mouth clean, grams consumed, and inappropriate mealtime behavior per minute were 22% (range, 0% to 100%), 97% (range, 75% to 100%), 0.5 (range, 0 to 3), and 19 (range, 0 to 45) across foods during ABA baseline. Acceptance (M = 97%; range, 60% to 100%) and grams consumed (M = 2; range, 1 to 6) increased, and inappropriate mealtime behavior per minute (M = 1; range, 0 to 14) decreased across foods during ABA treatment. Mean mouth clean was 98% (range, 60% to 100%) during ABA treatment. Mean acceptance, mouth clean, grams consumed, and inappropriate mealtime behavior per minute were 9% (range, 0% to 100%), 100%, 0.1 (range, 0 to 2), and 34 (range, 0 to 55), respectively, across foods during baseline sessions conducted while one or more of the target foods were in ABA treatment.

For James, mean acceptance, mouth clean, and grams consumed across foods were zero during M-SOS baseline, M-SOS treatment, baseline sessions conducted while one or more of the target foods were in the M-SOS treatment, and the return to the M-SOS baseline. Mean inappropriate mealtime behavior per minute across foods was 19 (range, 3 to 37) during the M-SOS baseline, 12 (range, 3 to 24) during the M-SOS treatment, 16 (range, 15 to 17) during baseline sessions conducted while one or more of the target foods were in the M-SOS treatment, and 14 (range, 0 to 44) during the return to the M-SOS baseline. Mean acceptance, mouth clean, and grams consumed were zero, and mean inappropriate mealtime behavior per minute was 31 (range, 27 to 37) during ABA baseline with pear. Acceptance (M = 92%; range, 0% to 100%), mouth clean (M = 82%; range, 20% to 100%), and grams consumed (M = 1.5; range, 0 to 3) increased and inappropriate mealtime behavior per minute (M = 1; range, 0 to 7) decreased with pear during ABA treatment. Mean acceptance, mouth clean, grams consumed, and inappropriate mealtime behavior per minute were 96% (range, 80% to 100%), 93% (range, 60% to 100%), 1.6 (range, 1 to 2), and 3 (range, 0 to 23), respectively, during baseline sessions conducted with pear while pear was in ABA treatment. Mean acceptance, mouth clean, grams consumed, and inappropriate mealtime behavior per minute were 74% (range, 0% to 100%), 78% (range, 0% to 100%), 1.4 (range, 0 to 3), and 6 (range, 0 to 34), respectively, during ABA baseline with chicken and green bean. Mean acceptance, mouth clean, grams consumed, and inappropriate mealtime behavior per minute were 98% (range, 80% to 100%), 100%, 1.7 (range, 1 to 2), and 3 (range, 0 to 7), respectively, with chicken when we added redistribution. Mean acceptance, mouth clean, grams consumed, and inappropriate mealtime behavior per minute were 98% (range, 80% to 100%), 73% (range, 40% to 80%), 1.6 (range, 1 to 2), and 3 (range, 0 to 18), respectively, during baseline sessions with chicken conducted after we added redistribution.

Figure 2 displays acceptance for James for hamburger (top), peach, (middle), and carrot (bottom). Mean acceptance, mouth clean, grams consumed, and inappropriate mealtime behavior per minute were 9% (range, 0% to

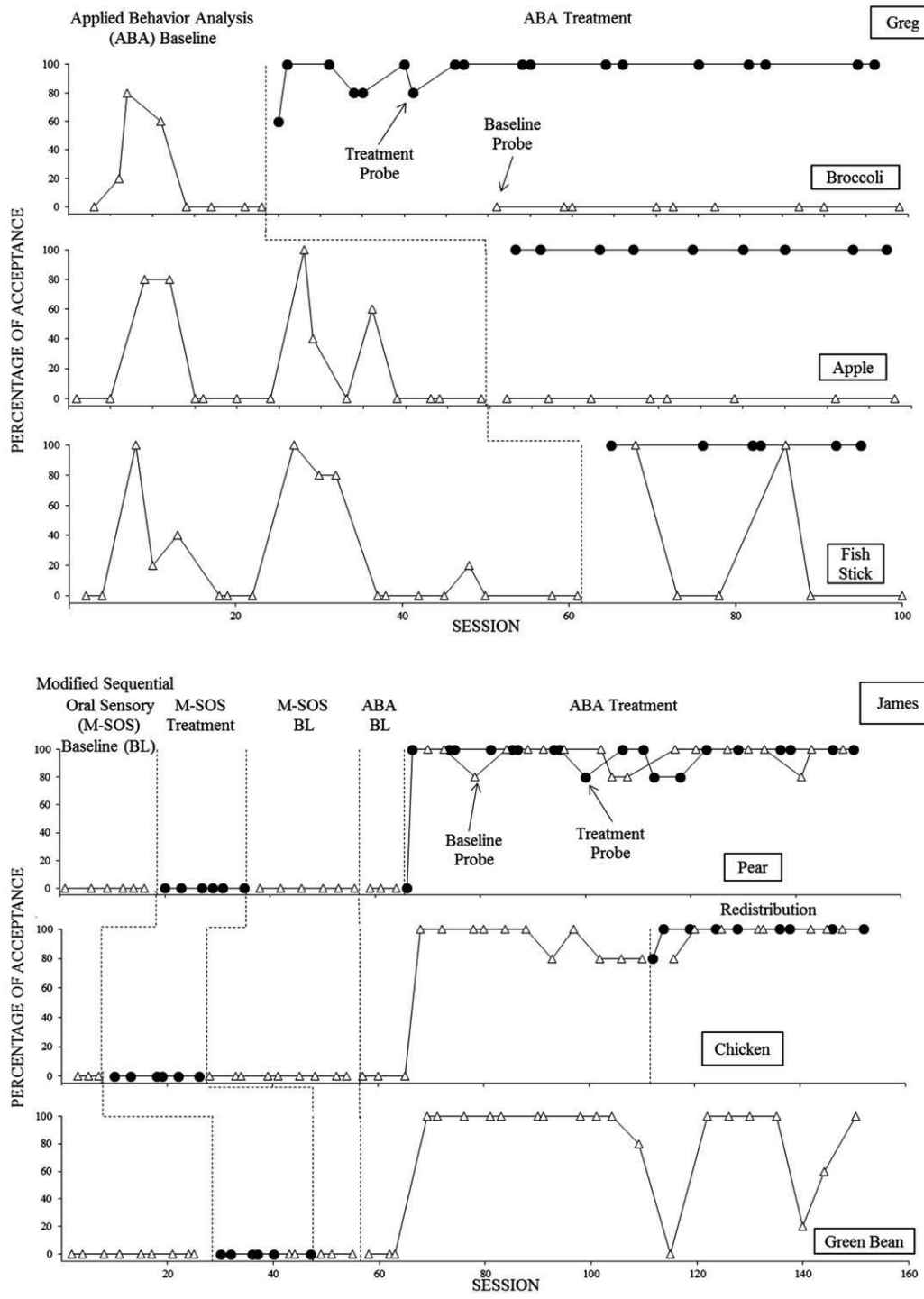

Figure 1. Percentage of acceptance for Greg for broccoli (first), apple (second), and fish stick (third) and for James for pear (fourth), chicken (fifth), and green bean (sixth).

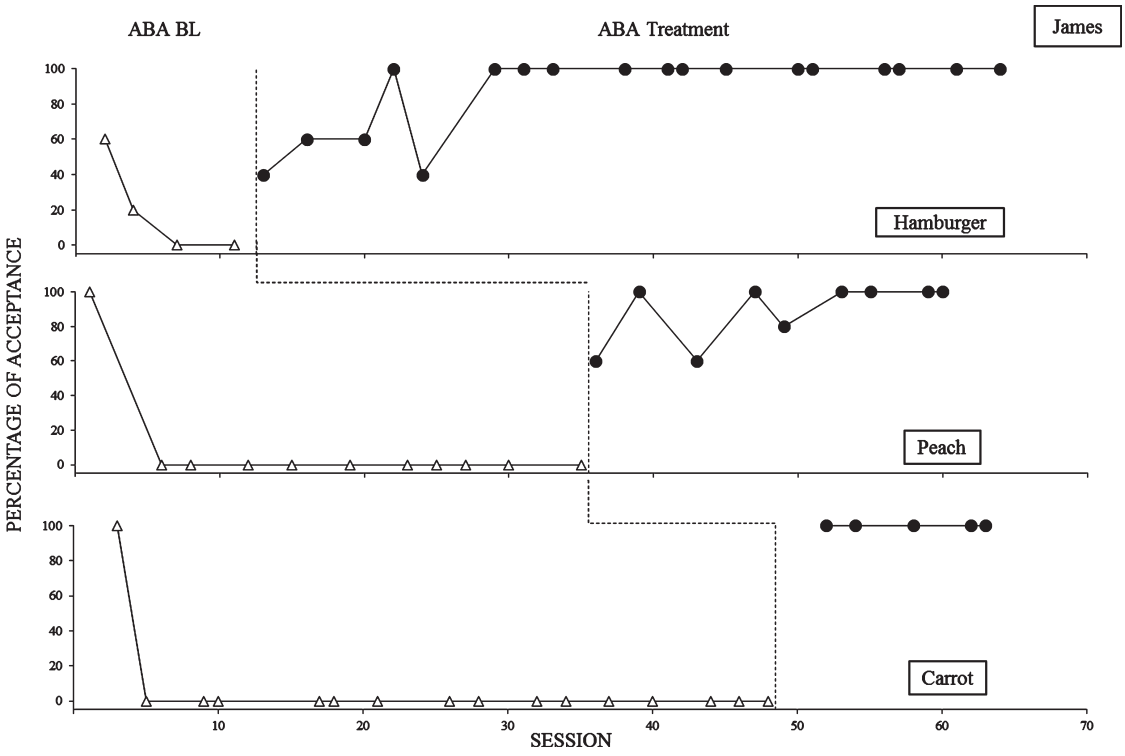

Figure 2. Percentage of acceptance for James for hamburger (top), peach (middle), and carrot (bottom).

100%), 55% (range, 0% to 100%), 0.1 (range, 0 to 1), and 35 (range, 0 to 65) across foods during ABA baseline. Acceptance (M = 91%; range, 40% to 100%), mouth clean (M = 73%; range, 0% to 100%), and grams consumed (M = 1.6; range, 0 to 2) increased and inappropriate mealtime behavior per minute (M = 3; range, 0 to 19) decreased across foods during ABA treatment.

Figure 3 displays acceptance for Sam for green bean (first), chicken (second), and pear (third) and for Jerry for pea (fourth), carrot (fifth), and green bean (sixth). For Sam, mean acceptance, mouth clean, grams consumed, and inappropriate mealtime behavior per minute were 1% (range, 0% to 20%), 100%, 0.01 (range, 0 to 1), and 6 (range, 0 to 16) across foods during ABA baseline. Acceptance (M = 94%; range, 20% to 100%) and grams consumed (M = 2; range, 1 to 3) increased, inappropriate mealtime behavior per minute (M = 1; range, 0 to 6) decreased, and mouth clean maintained at 100% across foods during treatment. Mean acceptance, mouth clean, grams consumed, and inappropriate mealtime behavior per minute were 59% (range, 0% to 100%), 100%, 2 (range, 1 to 3), and 2 (range, 0 to 12), respectively, across foods during baseline sessions conducted while one or more of the target foods were in ABA treatment.

For Jerry, mean acceptance, mouth clean, and grams consumed were zero and inappropriate mealtime behavior per minute was 8 (range, 4 to 21) across foods during the M-SOS baseline. Mean acceptance was 2% (range, 0% to 40%), mean mouth clean and grams consumed were zero, and mean inappropriate mealtime behavior per minute was 6 (range, 0 to 26) during the M-SOS treatment. Mean acceptance, mouth clean, and grams consumed were

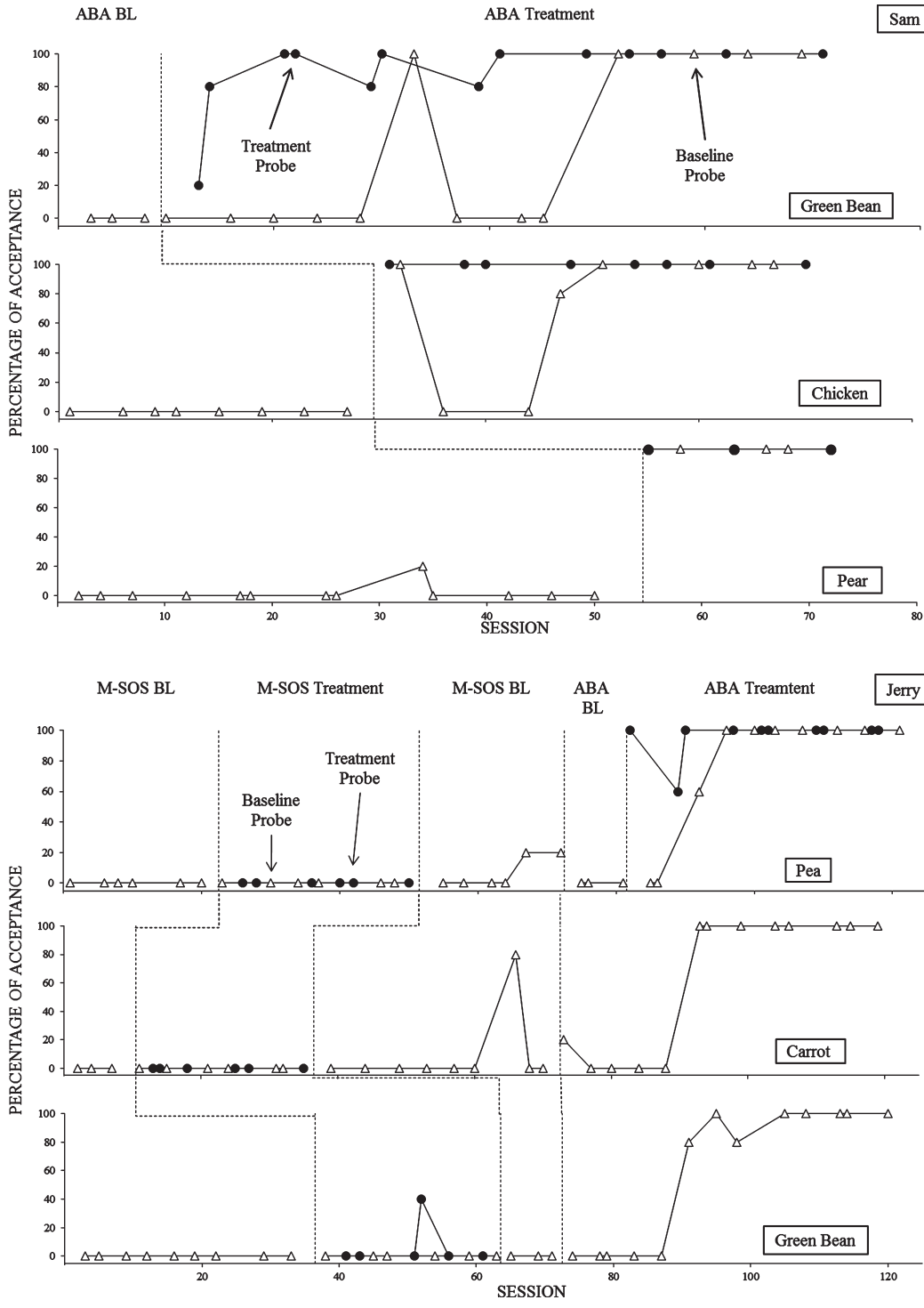

Figure 3. Percentage of acceptance for Sam for green bean (first), chicken (second), and pear (third) and for Jerry for pea (fourth), carrot (fifth), and green bean (sixth).

zero and mean inappropriate mealtime behavior per minute was 15 (range, 0 to 32) across baseline sessions conducted while one or more of the target foods were in the M-SOS treatment. Mean acceptance was 7% (range, 0% to 80%), mouth clean and grams consumed were zero, and mean inappropriate mealtime behavior per minute was 24 (range, 0 to 40) across foods during the return to the M-SOS baseline. Mean acceptance, mouth clean, and grams consumed were zero and inappropriate mealtime behavior per minute was 22 (range, 18 to 24) for pea during ABA baseline. Acceptance (M = 96%; range, 60% to 100%), mouth clean (M = 100%), and grams consumed (M = 1.7; range, 1 to 3) increased and inappropriate mealtime behavior per minute (M = 0.5; range, 0 to 3) decreased with pea during ABA treatment. Mean acceptance, mouth clean, grams consumed, and inappropriate mealtime behavior per minute were 76% (range, 0% to 100%), 100%, 1.6 (range, 0 to 3), and 7 (range, 0 to 31), respectively, during baseline sessions conducted with pea while pea was in ABA treatment. Mean acceptance, mouth clean, grams consumed, and inappropriate mealtime behavior per minute were 61% (range, 0% to 100%), 94% (range, 0% to 100%), 1.3 (range, 0 to 3), and 9 (range, 0 to 32), respectively, during ABA baseline with carrot and green bean.

Figure 4 displays acceptance for Bryce for green bean (first), potato (second), and chicken (third) and for Barry for macaroni and cheese (fourth), hamburger (fifth), and green bean (sixth). Mean acceptance, mouth clean, and grams consumed were zero, and mean inappropriate mealtime behavior per minute was 16 (range, 2 to 37) across foods during baseline. Although Bryce did not put the bites of green been in his mouth (M acceptance = 0%) during nonremoval of the spoon and continuous interaction, he did allow the feeder to guide the green bean into his mouth, with accompanying increases in mouth clean (M = 77%; range, 50% to 100%) and grams consumed (M = 1.3; range, 1 to 3) and decreases in inappropriate mealtime behavior per minute (M = 2; range, 0 to 7). Acceptance and grams consumed were zero and mean inappropriate mealtime behavior per minute was 18 (range, 2 to 33) for green bean during baseline sessions conducted while green bean was in treatment with nonremoval of the spoon and continuous interaction. Mean acceptance, mouth clean, grams consumed, and inappropriate mealtime behavior per minute were 0%, 0%, 3, and 1 (range, 1 to 2), respectively, for green bean during nonremoval of the spoon, continuous interaction, and avoidance. Mean acceptance, mouth clean, and grams consumed were zero, and mean inappropriate mealtime behavior per minute was 19 (range, 0 to 36) for green bean during baseline sessions conducted while green bean was in treatment with nonremoval of the spoon, continuous interaction, and avoidance. Mean acceptance, mouth clean, grams consumed, and inappropriate mealtime behavior per minute were 95% (range, 80% to 100%), 95% (range, 80% to 100%), 2.3 (range, 2 to 3), and 1 (range, 0 to 4), respectively, for green bean during nonremoval of the spoon, continuous interaction, avoidance, and backward chaining. Mean acceptance, mouth clean, and grams consumed were zero, and inappropriate mealtime behavior per minute was 0.6 (range, 0 to 6) for green bean during baseline sessions conducted while green bean was in treatment with nonremoval of the spoon, continuous interaction, avoidance, and backward chaining. Mean acceptance, mouth clean, grams consumed, and inappropriate mealtime behavior per minute were 100%, 90% (range, 80% to 100%), 2.2 (range, 1 to 3), and 1 (range, 0 to 6), respectively, across foods during nonremoval of the spoon, continuous interaction, avoidance, and backward chaining terminal step and 2% (range, 0% to 100%), 1% (range, 0% to 100%), 0.1 (range, 0 to 2), and 19 (range, 0 to 36), respectively, across foods during

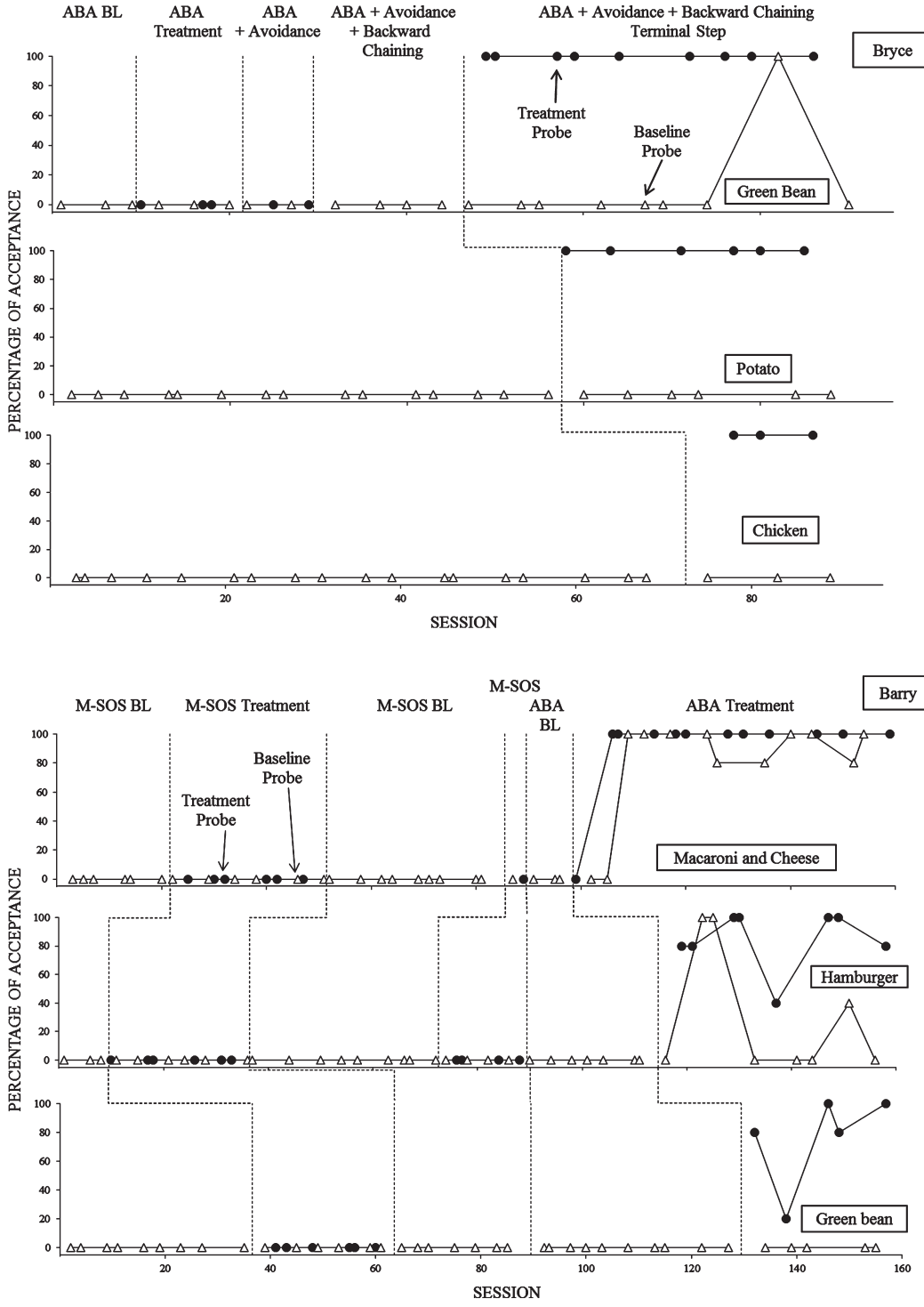

Figure 4. Percentage of acceptance for Bryce for green bean (first), potato (second), and chicken (third) and for Barry for macaroni and cheese (fourth), hamburger (fifth), and green bean (sixth).

baseline sessions conducted while the target foods were in treatment with nonremoval of the spoon, continuous interaction, avoidance, and backward chaining terminal step.

For Barry, mean acceptance, mouth clean, and grams consumed were zero during the M-SOS baseline, M-SOS treatment, baseline sessions conducted while one or more of the target foods were in the M-SOS treatment, the return to the M-SOS baseline, the return to the M-SOS treatment for macaroni and cheese and hamburger, and baseline sessions conducted while macaroni and cheese and hamburger were in the return to the M-SOS treatment. Mean inappropriate mealtime behavior per minute across foods was 13 (range, 2 to 44) during the M-SOS baseline, 18 (range, 0.4 to 49) during the M-SOS treatment, 31 (range, 3 to 50) during baseline sessions conducted while one or more of the target foods were in the M-SOS treatment, 36 (range, 11 to 48) during the return to the M-SOS baseline, 32 (range, 18 to 43) during the return to the M-SOS treatment for macaroni and cheese and hamburger, and 48 (range, 33 to 59) during baseline sessions conducted while macaroni and cheese and hamburger were in the return to the M-SOS treatment. Mean acceptance, mouth clean, and grams consumed were zero, and mean inappropriate mealtime behavior per minute was 40 (range, 10 to 55) across foods during ABA baseline. Acceptance (M = 86%; range, 0% to 100%), mouth clean (M = 98%; range, 80% to 100%), and grams consumed (M = 2.3; range, 1 to 3) increased and inappropriate mealtime behavior per minute (M = 4; range, 0 to 13) decreased across foods during ABA treatment. Mean acceptance, mouth clean, grams consumed, and inappropriate mealtime behavior per minute were 43% (range, 0% to 100%), 97% (range, 80% to 100%), 1 (range, 0 to 3), and 10 (range, 0 to 55), respectively, across foods during baseline sessions conducted while one or more of the target foods were in ABA treatment.

DISCUSSION

For children in the ABA group initially, we observed 80% or greater acceptance and mouth clean for the first food exposed to treatment after 16 min, 54 min, and 249 min of ABA treatment for Greg, Sam, and Bryce, respectively. By contrast, James, Jerry, and Barry participated in 1,020, 1,020, and 1,292 min of M-SOS treatment, respectively, with no increases in acceptance or mouth clean. We observed 80% or greater acceptance and mouth clean after less than 65 min of exposure to ABA for those children who transitioned from M-SOS to ABA. Specifically, acceptance and mouth clean increased after 64 min, 15 min, and 39 min of ABA treatment for James, Jerry, and Barry, respectively.

From a conceptual standpoint, we hypothesize that the ABA treatment was effective because we eliminated escape for inappropriate mealtime behavior. Results of studies on functional analysis of inappropriate mealtime behavior suggest that escape often functions as reinforcement (Bachmeyer et al., 2009; Girolami & Scotti, 2001; Najdowski et al., 2008; Piazza, Fisher, et al., 2003). We added continuous interaction to the escape-extinction treatment based on the results of Reed et al. (2004), which showed that continuous interaction was associated with reductions in inappropriate mealtime behavior, negative vocalizations, or both, for some children when combined with escape extinction. The extent to which continuous interaction was beneficial to the participants in the current investigation was not clear, because we did not evaluate its contribution. By contrast, children in the M-SOS treatment could control the contingencies and thereby access escape from nonpreferred food by demonstrating resistance during food presentation. The therapist moved the target food away from the child if he became stressed during the presentation of the target food. In the tasting and eating steps, the therapist prompted the child to emit the target behavior and then

spit out the bite. Participants also accessed escape by exhibiting resistance when the therapist attempted to guide the child physically to comply with a step in the procedure. Recall that, to be consistent with SOS, the therapist did not follow through with physical guidance or only guided the child to do what he was willing to do.

Although the goal of the current study was to increase acceptance, mouth clean, and grams consumed of specific target foods, these restrictive measures were not consistent with the goals of SOS, according to J. Mark Smith (personal communication, October 6, 2015). According to Smith, "The SOS method lets the child come to their desired end with of a variety of foods … and focuses more on progress through the steps."

We did evaluate each child's progress through the steps in M-SOS. Each child progressed to at least the visual tolerance step for all target foods. James touched bites of chicken to his teeth. Barry touched hamburger to his tongue. Jerry was the only child to place bites of target food inside his mouth; however, he expelled every bite. Although Boyd (2007) reported that the number of different foods consumed increased significantly after 12 weeks of SOS, she also noted that some children may require additional 12-week sessions. By contrast, children in Benson et al. (2013) participated in up to 3 years of SOS with a mean of 42 sessions per child, and only 32% made progress through the steps. Benson et al. noted that the children with ASD in the study demonstrated variability in their responding and cautioned, "Some children with autism will respond [to SOS and] some children may not" (p. 299). Nevertheless, it is possible that children in M-SOS would have continued to make progress had we continued the treatment for a longer period. "It may be unrealistic to expect that children with moderate to severe autism would achieve the goals of SOS in the number of sessions conducted in the current study" (J. Mark Smith, personal communication, October 6, 2015).

According to proponents, SOS focuses less on quantities of food consumed and specific target behaviors (e.g., acceptance) and more on age-appropriate skill development (J. Mark Smith, personal communication, October 6, 2015). Interestingly, it was the ABA treatment that resulted in the most age-appropriate eating behavior. The children who received ABA treatment sat in a regular chair at a table, self-fed bites from a bowl with a utensil or their fingers, and chewed and swallowed nutritional foods that the rest of their family members ate.

Proponents of SOS might argue that results for M-SOS were due to the rigidity of the experimental manipulations because systematic methods may not produce a child's typical response to treatment (Parham et al., 2007). For example, we used a consistent 4-min presentation interval for foods, with the caveat that the therapist would remove the food if the child became too stressed, based on the data from Toomey (2010, p. 137) who reported that the mean length of food presentation across therapists was 4.5 min (range, 2.4 to 6.4). By contrast, SOS is intended to be a highly individualized, dynamic, and child-directed process in which therapists modify components throughout, depending on the child's responding. Therefore, implementation of procedures according to a specific sequence, in a sterile environment, or for a specified period of time likely would not be effective (J. Mark Smith, personal communication, October 6, 2015). However, these tenets may make it difficult to conduct investigations with technological precision and limit the extent to which procedures can be defined and replicated (Addison et al., 2012). Despite these challenges, we attempted to keep M-SOS dynamic and child directed by following the child's lead, imitating the child's actions with food, complying with the child's directions if they were socially acceptable, and removing foods if the

child's level of stress became too great. Regularly assessed treatment integrity for each component of the M-SOS treatment was 100%. In addition, treatment integrity for M-SOS, assessed by an independent occupational therapist, was 100%. The independent occupational therapist reported that we conducted M-SOS "in a very similar way to how our clinic does; overall, it looked like a great session; the child appeared to be engaged and benefitting from the sessions" (personal communication, September 23, 2013). Her criticisms included that we (a) conducted sessions in a one-to-one format instead of a group with multiple peers and therapists to allow social role modeling, (b) did not conduct ongoing parent training, and (c) wore gloves during the M-SOS session when handling food. We implemented the M-SOS treatment in a one-to-one format (a) to equate the M-SOS treatment to ABA in which one-to-one treatment for feeding problems is standard practice in our setting and (b) because the children in the study had been diagnosed with ASD. Ongoing parent training provides an opportunity for the child to have additional exposures to the food during M-SOS practice meals conducted by the parents. We did not conduct ongoing parent training because we wanted to equate amount of therapy for ABA and the M-SOS treatment, and we typically do not train parents to implement the ABA treatment until we demonstrate its efficacy. However, we encouraged each child's parents to observe the M-SOS treatment sessions; only Barry's parents did so. Use of gloves to handle food is a requirement of our facility. Future research should compare group to individual treatment, incorporate ongoing parent training, and eliminate the use of gloves, if possible.

Another limitation of our M-SOS protocol was that we embedded five discrete bite presentations for the purposes of discrete-trial data collection, which is not typical of SOS. None of the children demonstrated increased observable stress during the five discrete bite presentations. In addition, the therapist continued the M-SOS treatment simultaneously with the five discrete bite presentations. Recall that the child had additional opportunities to consume bites during and after presentation of the target food in M-SOS because the target food remained on the table after presentation. However, we included the five discrete bite presentations to ensure that children in the M-SOS treatment had opportunities to accept the bite when it was in arm's reach, similar to the opportunities provided to the children in the ABA group. Nevertheless, these five bite presentations may have altered the flow of therapy, risked advancement through the hierarchy at inappropriate times, or moved the focus from child to therapist directed. Therefore, this modification is a limitation and should be addressed in future research.

One potentially important finding was that we observed treatment generalization for two of the three children who participated in M-SOS (James and Jerry) when we subsequently implemented ABA. When we implemented ABA for one target food, they began to accept the other two target foods in the absence of treatment. We did not observe a similar pattern of treatment generalization for children who received only ABA. To evaluate whether previous exposure to the target foods during M-SOS played a role in treatment generalization, we conducted ABA treatment with James using three foods that we never presented during M-SOS or ABA. We did not observe treatment generalization with the three novel target foods. One possible explanation for this finding is that exposure to the target foods during M-SOS produced a desensitization effect that was observable only when we implemented ABA with one of the foods. This explanation is tentative, given that we conducted the treatment generalization assessment with only one participant. Nevertheless, this finding is potentially important for several reasons. Although ABA was highly effective, one criticism of ABA is

that some children eat only when treatment is present and not when it is absent. Therefore, methods to increase the likelihood of more age-typical eating (i.e., eating without treatment) are needed. Second, many investigators have advocated for alternatives or adjuncts to non-removal of the spoon (Seubert, Fryling, Wallace, Jiminez, & Meier, 2014). If this treatment generalization finding is robust, then implementation of M-SOS before ABA would reduce the number of applications of nonremoval of the spoon needed to achieve treatment effectiveness and may be associated with sustained eating in the absence of ABA treatment for some children. More research is needed to replicate this finding.

Another potential criticism of the ABA treatment is that Bryce's acceptance was low until we included individualized treatment components. We observed high levels of mouth clean and grams consumed during ABA initially, but there was no change in acceptance because Bryce did not self-feed. That is, he allowed the therapist to put the bites in his mouth, but he would not put them in his mouth independently. Even though it took 10 appointments for Bryce to self-feed the first food and 16 appointments to self-feed all target foods, the other child in his pair, Barry, never accepted or self-fed bites during M-SOS, even after 19 appointments. Critics might argue that we had to modify the ABA procedure for Bryce several times before we identified an effective treatment. Recall, however, that modifications of M-SOS were a programmed component of treatment. If the child did not accept the target food after several appointments, the therapist altered the sensory properties of foods, changed the order of food presentation, and added novel foods to the presentation array. Therefore, the therapist made ongoing modifications to M-SOS for Barry throughout his treatment.

These results are important because this was the first prospective study, to our knowledge, to evaluate an approach based on a modified version of SOS in the treatment of pediatric feeding disorders. Given the widespread use and popularity of SOS, empirical investigations are necessary to determine whether SOS or treatments based on SOS, like the modified version of SOS used in the current investigation, will lead to improvements in feeding disorders. Although the results did not show that M-SOS produced changes in acceptance, the use of M-SOS before ABA appeared to produce beneficial effects for some children. The results of the study also supported previous research on the efficacy of ABA treatment for feeding disorders in children with ASD. Future studies should continue to evaluate and refine treatments for pediatric feeding disorders in this population.

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Received December 12, 2014
Final acceptance June 23, 2015
Action Editor, Dorothea Lerman

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