A COMPARISON OF SENSORY INTEGRATIVE AND BEHAVIORAL THERAPIES AS TREATMENT FOR PEDIATRIC FEEDING DISORDERS

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We compared the effects of escape extinction (EE) plus noncontingent reinforcement (NCR) with sensory integration therapy as treatment for the feeding problems of 2 children. Results indicated that EE plus NCR was more effective in increasing acceptance, decreasing inappropriate behavior, and increasing amount consumed relative to sensory integration for both children. The results are discussed in terms of the challenges of evaluating sensory-integration-based treatments, and the reasons why component analyses of multicomponent treatments like sensory integration are important.

Key words: escape extinction, food refusal, food selectivity, feeding disorders, noncontingent reinforcement, pediatric feeding disorders, sensory integration

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The term *pediatric feeding disorders* describes a heterogeneous group of behaviors that may be characterized by inadequate oral intake, food refusal, selectivity by type or texture of food, and expelling or packing (pocketing) food, to name a few. Investigators have proposed a number of hypotheses to explain the etiology of feeding disorders. One hypothesis is derived from a neurodevelopmental theory proposed by Ayres (1972, 1974) known as *sensory integration theory*. Although a complete review of sensory integration theory is beyond the scope of this paper, some of the main tenets that are relevant to the current study are as follows (Kimball, 1999). The central nervous system (CNS) has a hierarchical organization such that sensory input must be organized by the lower brain for processing in higher levels of the brain to occur. All of the sensory systems (i.e., auditory, visual, vestibular, proprioceptive, tactile) interact to receive and organize information. Once organized, the sensory information can be processed by the CNS to produce end-product skills and abilities (e.g., concentration; Kimball, 1999). Rather than viewing behavior as determined by specific environmental influences (e.g., antecedents such as the absence of adult

attention), the sensory integrative framework proposes that behavior should be analyzed in the context of the antecedent effects of sensory system modulation (Kimball, 1999) or how the brain integrates sensory information to produce end-product behavior. That is, identification of a specific antecedent is not necessarily important (e.g., noisy cafeteria) because a child with a sensory integration dysfunction will not be able to process a variety of sensory stimuli (Kimball, 1999). Of interest to behavior analysts is that the sensory integration framework "shift[s] from viewing behavior as learned patterns to seeing symptoms as a whole and reflective of specific actions of the CNS that misidentifies nonnoxious environmental stimuli as irritating or even dangerous" (Kimball et al., 2007, p. 3).

The translation of sensory integration theory into practice is that difficulty modulating sensory information can result in sensory defensiveness, which will be indicated by an individual's under- or overresponsiveness to sensory stimuli (Wilbarger, 1984). There are a variety of overt behaviors that are associated with sensory defensiveness, and feeding problems are one example (Cermak, 2001). Sensory-based feeding problems may be diagnosed when a child demonstrates atypical responses to stimulation in and around the mouth such as coughing, gagging, spitting out, or refusing foods (Case-Smith & Humphry, 2005).

When a sensory-based feeding problem is identified, sensory integration therapy would be the treatment of choice (Case-Smith & Humphry, 2005; Cermak, 2001; Royeen & Lane, 1991; Tarbell & Allaire, 2002; Williamson & Anzalone, 1997). From a sensory integration perspective, the inappropriate feeding behavior is a symptom of the child's inability to process sensory information to make an adaptive response (Kimball, 1999). Intervention targets the underlying sensory processing deficits rather than the specific behaviors (Kimball, 1999). The goal of therapy is to promote sensory modulation, which should result in decreased sensory defensiveness.

No empirical studies have described the components of a sensory integration framework for the treatment of feeding problems; however, recommendations for treatment of sensory-based feeding problems appear in textbooks and review articles (e.g., Case-Smith & Humphry, 2005; Cermak, 2001; Cermak & Mitchell, 2006; Lane, 2008; Royeen & Lane, 1991; Williamson & Anzalone, 1997). According to these sources, treatment involves modification of the child's sensory diet, which is the sensory input needed by an individual to organize sensory information effectively (Kimball, 1999). Examples of a sensory diet for a child with feeding problems might include rhythm and music activities, proprioceptive activities, heavy work, and sensory modulation techniques (Cermak, 2001; Roley & Schneck, 2001). Koomar and Bundy (2002) note that it is not necessary to apply sensory input to the entire body; input to one system will affect other systems. They indicate that their clients usually prefer sensory input to the arms, legs, and back rather than to the face. Pruzansky and Farrington (1999) note that adaptive responding will be more likely if intervention involves several sensory systems and requires intersensory integration. Although sensory integration often is conducted by an occupational therapist (OT), the therapist also may serve as a consultant to parents and other professionals by developing a sensory diet that can be implemented with the child throughout the day (Wilbarger & Wilbarger, 1991).

Sensory integration appears to be a widely recommended therapy for feeding problems (Baranek, 2002; Lane, 2008; Mailloux & Roley, 2004; D. Parham & Mailloux, 2005; Schaaf & Miller, 2005; Yack, Sutton, & Aquilla, 2002). Studies on occupational therapy practice suggest that sensory integration is the therapeutic strategy used most frequently by OTs (Brown, Rodger, Brown, & Roever, 2005; Case-Smith & Miller, 1999; Storch & Eskow, 1996; Watling, Deitz, Kanny, & McLaughlin, 1999), who are often the first-line clinicians for

<mark>children with feeding disorders (Caretto, Topolski, Linkous, Lowman, & Murphy, 2000).</mark>

An alternative hypothesis for the etiology of feeding disorders is that inappropriate mealtime behavior is maintained, at least in part, by environmental events. This hypothesis suggests that feeding disorders develop as a result of the pairing of eating with aversive events such as gagging, choking, or vomiting (e.g., Di Lorenzo et al., 2005). Children who have these aversive experiences may exhibit refusal behavior (e.g., crying, batting at the spoon) at mealtime, and parental responses such as providing escape from spoon presentations may function as reinforcement for refusal behavior (Borrero, Woods, Borrero, Masler, & Lesser, 2010; Girolami & Scotti, 2001; Najdowski et al., 2008; Piazza, Fisher, et al., 2003). In fact, Borrero et al. (2010) showed that parents of children with feeding problems frequently removed the spoon or cup or terminated the meal following refusal behavior.

Reviews of the literature by Kerwin (1999) and Volkert and Piazza (2012) concluded that procedures based on the principles of operant conditioning are the only interventions for feeding problems with empirical support. More specifically, results of numerous studies have shown that escape extinction (EE) is effective as treatment (Ahearn, Kerwin, Eicher, Shantz, & Swearingin, 1996; Bachmeyer et al., 2009; Cooper et al., 1995; Piazza, Patel, Gulotta, Sevin, & Layer, 2003; Reed et al., 2004). Conceptually, EE involves no longer providing escape for inappropriate mealtime behavior. One of the most commonly used EE procedures to treat feeding problems is nonremoval of the spoon, in which the spoon remains at the child's lips until the feeder can deposit the bite into the child's mouth. For example, Reed et al. (2004) compared the effects of noncontingent reinforcement (NCR), NCR plus EE using nonremoval of the spoon, and EE with four children with feeding disorders. Acceptance increased and inappropriate behavior decreased during NCR plus EE and EE alone. Noncon-

tingent reinforcement in combination with EE was associated with lower levels of inappropriate behavior or negative vocalizations for some children.

Taken together, results of the literature on pediatric feeding disorders suggest that there are at least two potential explanations of their etiology, which are associated with specific methods of treatment. Given the widespread use of, but lack of empirical support for, sensory integration as treatment for feeding problems, it seems that evaluation of the approach is warranted. The logical method of evaluation would be to compare sensory integration to a procedure with empirical evidence as treatment for pediatric feeding disorders. Therefore, in the current investigation, we compared the effects of sensory integration with an operant-based treatment (NCR plus EE) for two children with feeding problems. We selected EE because the results of functional analyses suggested that escape functioned as reinforcement for inappropriate behavior for both children. In addition, EE is the operant-based treatment with the most empirical support (Volkert & Piazza, 2012). We added NCR to EE per parental request and the results of Reed et al. (2004), which suggested that NCR plus EE was effective as treatment for feeding problems.

METHOD

Participants

Two children who had been admitted to a pediatric feeding disorders day-treatment program participated. The children were included in the study because their primary presenting problem was a feeding disorder. In addition, the program OT diagnosed the feeding problems as sensory based and recommended sensory integration as treatment. Following the recommendation of Wilbarger and Wilbarger (1991), she based her recommendations on an interview with the parents and direct observation of child behavior, from which she determined that each child had difficulties with

sensory processing that contributed to their feeding problems. Both of these children had food refusal characterized by overreaction (crying, gagging, spitting food out) to presentation of food and other indicators of sensory integration dysfunction (e.g., overresponsive to tags in clothing, difficulties during tooth brushing, aversion to touch around the mouth and face, aversion to walking in sand or grass). These end-product behaviors were indicators of dysfunction for sensory system modulation, specifically, overregistration of sensory input from oral and tactile stimuli (Kimball, 1999).

Mark was a 1-year-old boy who had been admitted for food refusal and failure to thrive. His diagnoses included gastroesophageal reflux disease, high blood pressure, asthma, and a coarctation of the aorta. His medications included Lasix, Enalapril, Prilosec, Periactin, Metoclopriamide, Pulmacort, and Xopenex. These medications were stable throughout the study. Irma was a 3-year-old girl who had been admitted for poor oral intake and food selectivity by type and texture. Her diagnoses included developmental delays, dysphagia, and mitochondrial disorder. Her medications included Coenzyme Q10 and Carnitor. Both children ate some foods and drank some beverages, but not enough to sustain their nutritional, caloric, or hydration needs.

Therapists

The feeding therapists were predoctoral interns in psychology or individuals with bachelor's or master's degrees in psychology or a related field. The feeding therapists conducted the feeding sessions, including all sessions during the functional analysis and the treatment evaluation. The OT did not conduct any feeding sessions. The feeding therapists and the OT conducted the sensory integration protocol described below. The OT had been in her profession for more than 20 years, had extensive training and experience in sensory integration therapy and pediatric feeding disorders, and was licensed in her profession. In addition, she had advanced certification in the administration and interpretation of the Sensory Integration and Praxis Tests.

Setting and Materials

The feeding therapist conducted feeding sessions in rooms (4 m by 4 m) equipped with one-way observation. A high chair, food or drink, scale, gloves, fluid-resistant bib with crumb catcher (the bottom of the bib folded and snapped to form a receptacle), and eating or drinking utensils were present during all sessions. The feeding therapists and the OT conducted the sensory integration activities in the sensory integration room (4 m by 4 m) that was equipped with floor mats, a mirror, and the items listed below. Feeding sessions were not conducted in the sensory integration room, and the sensory integration activities were not conducted in the feeding therapy rooms.

Dependent Variables and Data Collection

Trained observers used laptop computers to score *acceptance* and *inappropriate behavior*. Observers scored acceptance once per presentation. A presentation occurred when the feeder placed the cup or spoon 4 cm from the child's lips, not including the placement of the cup or spoon following re-presentation of expelled drinks or bites. Acceptance occurred when any amount of liquid or the entire bolus of food (Irma, eating) passed the child's lips within 5 s of presentation. Data on acceptance were collected by dividing the number of acceptances by the number of presentations and converting the ratio to a percentage. Observers scored inappropriate behavior each time the child turned his or her head 45° or more away from the cup or spoon, hit the cup or spoon or the feeder's arm or hand, or covered the mouth when the cup or spoon was within arm's reach of the child. Observers scored the length of time in which the cup or spoon was within arm's reach of the child by activating a timer within the data-collection program when the feeder presented the cup or spoon by placing it within 4 cm of the child's lips and turning off the timer when the feeder moved the cup or spoon approximately 30 cm from the child (i.e., out of the child's reach). The computer then calculat-

ed the duration of cup or spoon within arm's reach of the child. The frequency of inappropriate behavior was converted to a rate by dividing the number of inappropriate behaviors by the amount of time (in minutes) the cup or spoon was within arm's reach of the child. Feeding therapists also measured how much the child drank or ate in grams, using a Tanita 1475T scale. To calculate grams consumed, the feeder placed the cup of liquid or bowl of food on the scale prior to and after the session and recorded the pre- and postweights. The feeder used paper towels, which weighed 2 g each, to clean up spills. The feeder cleaned spills by using the paper towels to wipe up any drink or food that was on the child's face, bib, tray, or floor after each session. The feeder then calculated grams consumed with the formula (presession food weight minus postsession food weight) minus (paper towels with spill minus paper towels without spill).

For the functional analysis, a second observer simultaneously but independently collected data during 41%, 35%, and 33%, of sessions for Mark, Irma (drinking), and Irma (eating), respectively. Interobserver agreement for acceptance was calculated by partitioning each session into 10-s intervals, dividing the number of intervals during which both observers agreed on the occurrence or nonoccurrence of acceptance by the total number of intervals, and converting this ratio to a percentage. Interobserver agreement for inappropriate behavior was calculated by dividing the number of exact agreements, defined as a 10-s interval in which both observers scored the same frequency of inappropriate behavior, by the number of intervals and converting this ratio to a percentage. Mean agreement for acceptance was 99% (range, 85% to 100%) for Mark and 100% for Irma (drinking and eating). Mean agreement for inappropriate behavior was 90% (range, 87% to 100%) for Mark, 92% (range, 97% to 100%) for Irma (drinking), and 99% (range, 95% to 100%) for Irma (eating).

During the treatment analysis, a second observer simultaneously but independently collected data during 26%, 34%, and 34% of sessions for Mark and Irma (drinking and eating), respectively. Mean agreement for acceptance was 95% (range, 81% to 100%) for Mark, 98% (range, 71% to 100%) for Irma (drinking), and 97% (range, 83% to 100%) for Irma (eating). Mean agreement for inappropriate behavior was 97% (range, 78% to 100%) for Mark, 99% (range, 90% to 100%) for Irma (drinking), and 99% (range, 89% to 100%) for Irma (eating).

Design

During Mark's functional analysis, we used a reversal design in which we randomly selected the order of test conditions (escape and attention) with a control phase following each phase of a test condition (Piazza, Fisher, et al., 2003). The order of conditions was attention, control, escape, control, escape. For Irma, we used a pairwise design (e.g., Bachmeyer et al., 2009) in which test and control conditions were alternated in each phase. We conducted separate analyses for eating and drinking, because different oral motor skills are required to be successful with eating and drinking, and because some children have different abilities with each skill.

During the treatment evaluation, we used an ABCBC design to compare levels of acceptance and rates of inappropriate behavior in the escape (A), escape plus sensory integration (B), and EE plus NCR (C) conditions.

General Procedure

A feeding therapist conducted meals five times a day with approximately 1 to 3 hr between the start of each meal (e.g., 9:00 a.m., 10:30 a.m., 12:00 p.m., 2:30 p.m., 4:00 p.m.). Each meal lasted approximately 30 to 45 min and consisted of approximately three to seven five-bite sessions, with 1- to 2-min breaks between sessions. During phases that included sensory integration, the therapist implemented the sensory integration protocol for 10 min prior to the scheduled meal.

During meals, the feeding therapist presented 3 cc of whole milk with Carnation Instant

Breakfast in a cut-out cup (a plastic cup with a section cut out in a U shape) to Mark and 8 cc of Lactaid milk thickened with baby oatmeal cereal in a cut-out cup to Irma. The OT recommended thickening Irma's liquids due to her inexperience as an oral feeder. The program dietitian recommended the liquids for each child based on the child's caloric and nutritional needs. Irma's parents identified 16 foods, four foods from each of the food groups of fruit, protein, starch, and vegetable, to present in sessions. The feeding therapist randomly selected four of the parent-identified foods (a fruit, protein, starch, and vegetable) to present to Irma in each session. The order of food presentation was randomly selected within the session. The foods were pureed texture (table food blended in a chopper until smooth). The feeding therapist presented Irma with a level bolus of food (the therapist filled the bowl of the spoon and scraped the bowl on the side of the dish to level the bolus) on a small maroon spoon. The OT selected the textures, bolus sizes, and utensils.

Across all feeding sessions, the feeding therapist presented the cup or spoon approximately 4 cm from the midline of the child's mouth accompanied by a verbal prompt to "take a drink [bite]" approximately every 30 s. The therapist delivered praise (e.g., "Good job taking a drink") following acceptance. The child's mouth was checked 30 s after the drink or bite entered the mouth to determine if the child had swallowed. The feeding therapist prompted the mouth check by instructing the child to "show me, ahhh" while modeling an open mouth. If the child did not open his or her mouth, the therapist inserted a rubber-coated baby spoon into the mouth and turned the spoon 90° to open the mouth. The feeding therapist delivered praise (e.g., "Good job swallowing your drink") if no liquids or solids larger than the size of a pea were in the child's mouth during the first check. No praise was delivered if the absence of liquids or solids at the 30-s check was due to expulsion. The therapist delivered a verbal prompt (e.g.,

"swallow your drink") if liquids or solids larger than the size of a pea were in the child's mouth at the check and repeated the prompt every 30 s until no liquids or solids larger than the size of a pea were visible. The therapist then presented the next drink or bite.

Functional Analysis

We conducted a functional analysis to identify the reinforcers for inappropriate behavior. During the functional analysis, the feeding therapist followed the general procedures described above in addition to the specific procedures for each condition described below. Across all conditions, the therapist held the cup or spoon at midline (the position in space in which the feeder presented the cup or spoon initially) if the child did not accept the drink or bite and provided no differential consequence for expulsion or vomiting.

During the control condition, the feeding therapist provided no differential consequence for inappropriate behavior and interacted with the child (e.g., sang) in the presence of toys on the tray throughout the session. During the escape condition, the therapist removed the cup or spoon for 30 s if the child engaged in inappropriate behavior and presented the next drink or bite after the 30-s interval. The therapist did not provide any other differential consequence following inappropriate behavior (e.g., the child was not reprimanded). Toys were not available. During the attention condition, the therapist provided 30 s of attention following inappropriate behavior (but the cup or spoon remained at midline). Toys were not available.

Sensory Integration Protocol Development and Training

The OT developed individualized sensory integration programs for each child. Because both children demonstrated high levels of inappropriate behavior during the presentation of food, the OT developed a sensory integration program outside of the mealtime (Case-Smith & Humphry, 2005). That is, rather than initiating therapy in an environment that

resulted in child distress, the OT initiated sensory activities in the context of play to establish a relationship of trust with the child (Case-Smith & Humphry, 2005). Not all of the sensory activities involved the mouth because, as indicated above, patients often prefer sensory input to the arms, legs, and back rather than the face (Koomar & Bundy, 2002). Because the sensory systems interact, stimulation of one sensory system will affect other sensory systems (Pruzansky & Farrington, 1999). The OT implemented the sensory integration procedure at regular intervals throughout the day according to a schedule (Wilbarger & Wilbarger, 1991). Regular delivery of an individually prescribed sensory diet is hypothesized to promote changes in the CNS that will result in alterations in end-product behavior (e.g., improved feeding). The OT then trained the feeding staff to implement the sensory integration procedure. Consultation and caregiver training are common methods of delivering regularly scheduled sensory activities, because most OTs are not available to provide therapy throughout the day for multiple consecutive days with a single child (Kimball et al., 2007; Wilbarger & Wilbarger, 1991).

First, the OT described the protocol verbally, and a written protocol was developed based on her instructions. Next, the OT approved the written protocol and demonstrated the protocol to the feeding therapists. She then observed the feeding therapists implementing the protocol with the child and provided feedback until the feeding therapists implemented the protocol correctly. Next, the treatment evaluation began. The OT periodically observed each feeding therapist implementing the sensory integration protocol to ensure correct implementation throughout the study and provided corrective feedback, if necessary; however, she did not collect data on the integrity of protocol implementation. In addition, the OT periodically implemented the protocol herself.

During the sensory integration protocol, the therapist interacted with the child by prompting activities as described below; providing positive comments about the activity (e.g., "the

bug feels great") or other topics (e.g., "what a beautiful day"); providing periodic, noncontingent praise (e.g., "you are doing a great job") in an upbeat, enthusiastic tone of voice; and smiling and laughing periodically. We attempted to balance child directedness (i.e., allowing the child to determine the type and timing of the activities rather than specifying the activities in advance), which is a hallmark of sensory integration, in the context of developing a procedure that was technological. To that end, the OT recommended a sequence of sensory integration activities, but the sequence could change if the child demonstrated interest in (e.g., pointed to, crawled toward) an alternative activity. If the child changed activities, the therapist followed the child to the alternative activity and implemented that activity according to the protocol (see below). For example, if the child was bouncing on the ball and then left the ball and began crawling through the tunnel, the therapist went to the tunnel with the child and followed the tunnel protocol. However, we did not collect data on how often the therapist followed the recommended routine and how often the child initiated an alternative activity. The recommended sequence of sensory integration activities were vibrating bug, tunnel, therapeutic brush, joint compression, ball, and ARK toys for Mark; vibrating bug (lips and cheeks only) and ARK toys for Irma (drinking); and vibrating bug, bubbles, and ball for Irma (eating). (ARK toys are resin-covered plastic toys in the shape of animals that vibrate in response to pressure that are used for oral stimulation during oral motor and sensory integration therapy.)

The sensory integration activities were implemented as follows. The therapist placed a vibrating bug (a soft, cloth-covered toy shaped like a bug that vibrated in response to pressure) sequentially on the child's feet, legs, hands, arms, stomach, back, cheeks, and lips for about 2 to 3 s each. The therapist verbally prompted the child to crawl through a vinyl tunnel that was approximately 150 cm in length and 46 cm

in diameter. The therapist could use a variety of strategies to motivate the child to crawl through the tunnel such as verbal encouragement (e.g., saying, "you can do it"), the mirror (e.g., placing the mirror at the end of the tunnel), crawling through the tunnel with the child, or physically assisting the child to crawl through the tunnel. The child was encouraged to crawl through the tunnel three or four times. The therapist stroked the child's hands, legs, feet, and back four times each with a therapeutic brush with firm pressure. (A therapeutic brush is a plastic brush with soft, dense bristles designed specifically to provide sensory stimulation.) During joint compression, the therapist sequentially supported and provided firm compression to each joint (elbow, shoulders, knees, and hip) 10 times. The therapist held a bubble wand in front of the child and prompted him or her to blow bubbles. If the child did not blow, the therapist modeled the response, and the trial ended if the child did not blow. The therapist prompted the child to blow bubbles approximately once every 20 s for a total of about 3 min. The therapist placed the child prone on his or her stomach on a 45-cm therapy ball and rolled the ball forward until the child's hands touched the ground. The ball-rolling sequence was repeated approximately four times. The surface of the ARK toy has grooves and textures to provide different types of sensory stimulation to the mouth. The therapist (a) placed an ARK toy into the child's mouth near the molars (alternating from one side of the mouth to the other) and prompted the child to bite down 10 times; (b) pushed laterally on the child's tongue three times and then moved the ARK toy to the child's cheek, alternating from one cheek to the other; and (c) rotated the ARK toy across the child's lips in a circular motion three times. The therapist and child sat on a mat on the floor during the stationary activities. The sequence of activities was repeated with each child for approximately 10 min prior to the escape with sensory integration feeding sessions (described below).

Treatment Evaluation

Escape. Procedures were identical to the escape condition of the functional analysis.

Escape plus sensory integration. During the escape plus sensory integration phase, a feeding therapist or the OT implemented the sensory integration protocol described above for 10 min before each meal. After implementation of the protocol, the feeding therapist immediately brought the child from the sensory integration room to the feeding room and began the feeding sessions. The procedures during the feeding sessions were identical to the escape condition of the functional analysis and the escape baseline. The only difference between the escape baseline and the escape plus sensory integration condition was that the child experienced one 10-min period of sensory integration prior to participating in each 30- to 45-min meal. That is, the child experienced one 10-min period of sensory integration followed by approximately three to seven five-bite feeding sessions. We used escape baseline contingencies during the sensory integration intervention to maintain a trusting relationship with the child. Case-Smith and Humphry (2005) note that a child will not trust an adult who attempts to place food in his or her mouth. They highlight the importance of responding to the child's physical cues of discomfort by withdrawing the oral stimulus. Therefore, when the child turned his or her head or batted at the cup or spoon, the therapist responded to the child's cue by removing the cup or spoon.

Escape extinction with NCR. The results of the functional analyses for both children suggested that escape from cup or spoon presentations maintained inappropriate behavior. Therefore, we used EE during treatment. Both parents requested that we interact with their children during the session. Therefore, we added NCR to EE.

The feeding therapist conducted a mini-choice assessment (Roane, Vollmer, Ringdahl, & Marcus, 1998) prior to the meal in which she presented the child with the three most

highly preferred toys identified during a stimulus preference assessment (Fisher et al., 1992). The chosen toy was available throughout the meal. The therapist also provided attention throughout the meal.

The therapist held the cup or spoon at the child's lips and deposited the drink or bite when the child opened his or her mouth. The therapist re-presented (i.e., scooped up the liquid or solid from the child's face or bib with the cup or spoon and placed the drink or bite into the child's mouth) expelled drinks or bites and provided no differential consequence for inappropriate behavior. The session ended when the child had no liquid or solid larger than the size of a pea in his or her mouth following the fifth drink or bite entering the child's mouth, except when the absence of liquid or solid at the 30-s check was a result of expulsion. No differential consequence was provided for gagging, coughing, or vomiting.

RESULTS

The results of the functional analyses (Figure 1) suggested that inappropriate behavior was maintained by escape from drink or bite presentations for Mark and Irma (drinking and eating). For Mark, mean inappropriate behavior was 5.8 responses per minute in the attention condition, 3.4 responses per minute in the two phases of the control condition, and 9.1 responses per minute in the two phases of the escape condition. For Irma (drinking), mean inappropriate behavior was 0.1 and 0.3 responses per minute in the pairwise comparison of attention and control, respectively, and 3 and 0.2 responses per minute in the pairwise comparison of escape and control, respectively. For Irma (eating), mean inappropriate behavior was 7 and 2 responses per minute in the pairwise comparison of escape and control, respectively, and 1 and 0.4 in the pairwise comparison of attention and control, respectively.

For Mark, levels of acceptance (Figure 2, top) were low ($M = 39\%$), and mean inappropriate behavior (Figure 2, second panel) was 11 responses per minute during the initial escape baseline. During escape plus sensory integration, mean levels of acceptance ($M = 41\%$) and rates of inappropriate behavior ($M = 11$) were equivalent to baseline. Levels of acceptance increased ($M = 94\%$), and rates of inappropriate behavior decreased ($M = 2$) during EE plus NCR. During the return to escape plus sensory integration, levels of acceptance ($M = 64\%$) were slightly higher and rates of inappropriate behavior were slightly lower than during the initial escape plus sensory integration phase ($M = 4$), but lower (acceptance) and higher (inappropriate behavior) than during EE plus NCR. During the reintroduction of EE plus NCR, mean acceptance increased to 100%, and mean inappropriate behavior decreased to 0.5 responses per minute. Mean grams consumed were 4 during baseline, 7.5 during escape plus sensory integration, and 23 during EE plus NCR. These data suggest that the biggest increase in grams consumed occurred during the EE plus NCR condition.

For Irma (drinking), levels of acceptance (Figure 2, third panel) were zero during the escape and escape plus sensory integration phases. Rates of inappropriate behavior (Figure 2, bottom) were high during the escape ($M = 33$) and escape plus sensory integration ($M = 25$) phases. Levels of acceptance increased ($M = 94\%$) and rates of inappropriate behavior decreased ($M = 1$) during EE plus NCR. Levels of acceptance decreased and rates of inappropriate behavior increased during the reversal to escape plus sensory integration. Levels of acceptance increased ($M = 93\%$) and rates of inappropriate behaviors decreased ($M = 0.7$) during the reintroduction of EE plus NCR. Mean grams consumed were 0 during escape and escape plus sensory integration conditions and 38 during EE plus NCR. Thus, intake was
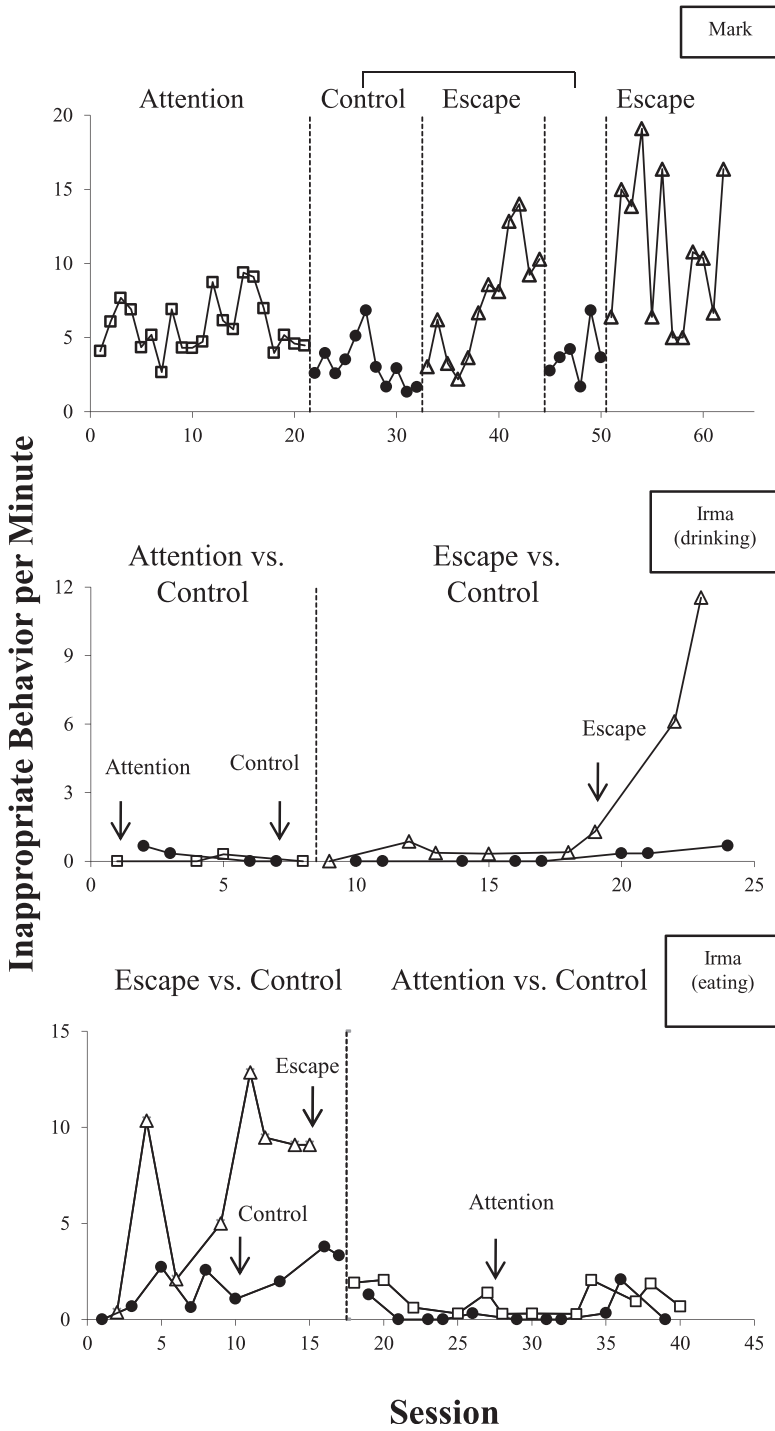
Figure 1.   Inappropriate behavior per minute for Mark (top), Irma (drinking, middle), and Irma (eating, bottom).
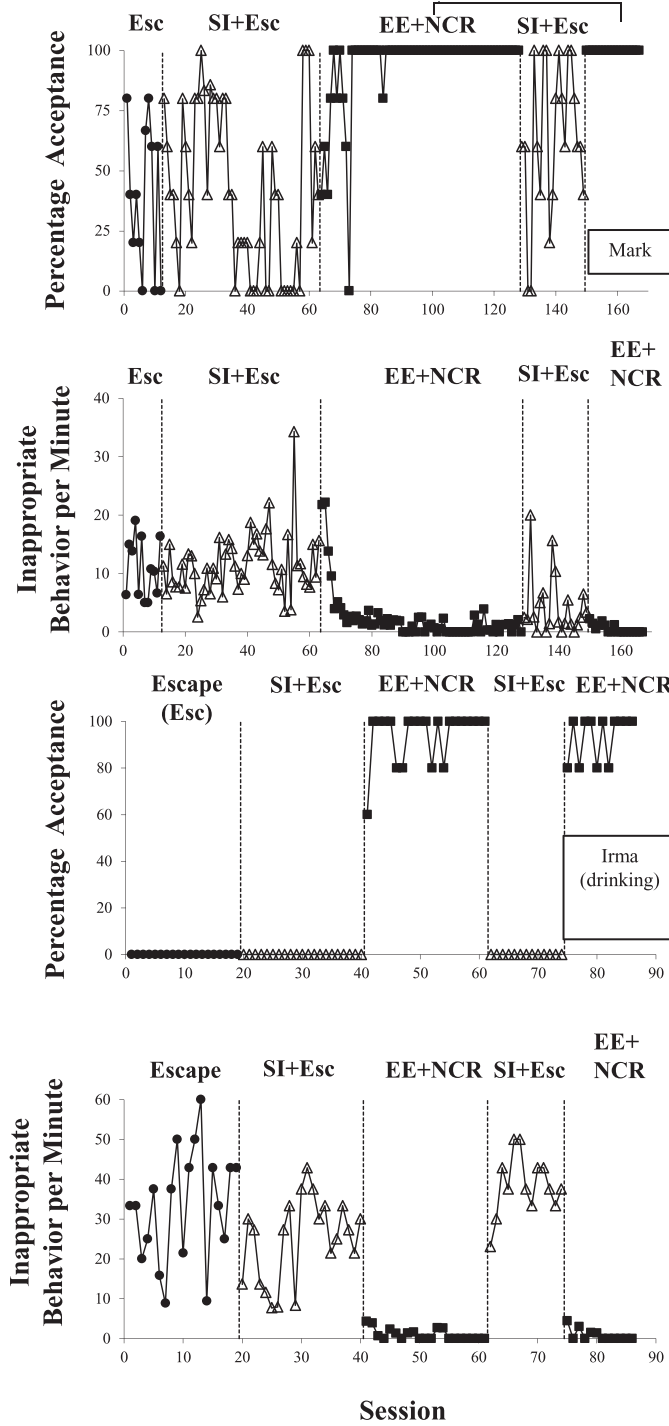
Figure 2. Percentage acceptance and inappropriate behavior per minute during Mark's and Irma's drinking treatment evaluation.
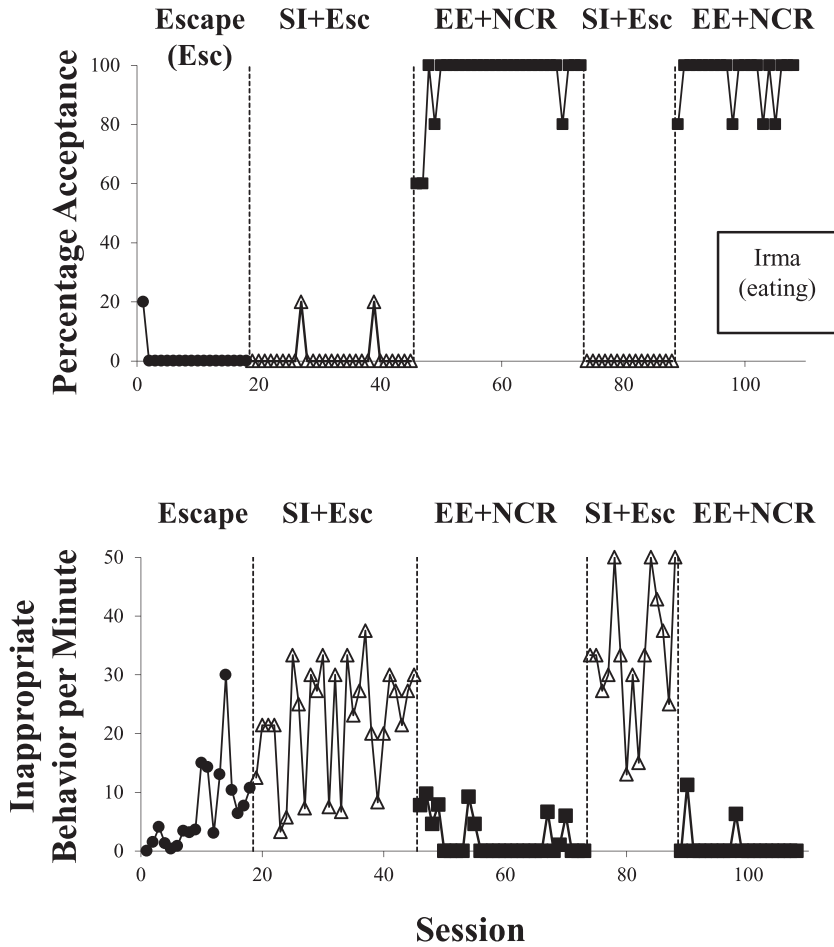
Figure 3.   Percentage acceptance (top) and inappropriate behavior per minute (bottom) during Irma's eating treatment evaluation.

substantially higher during EE plus NCR than during escape with sensory integration.

Figure 3 shows the results of Irma's eating treatment analysis. Mean acceptance (top) was 1% and mean inappropriate behavior (bottom) was 7 responses per minute during the initial escape baseline. During escape plus sensory integration, mean levels of acceptance were equivalent to baseline ($M = 1\%$), and rates of inappropriate behavior increased ($M = 22$). Levels of acceptance increased ($M = 96\%$) and rates of inappropriate behavior decreased ($M = 2$) during EE plus NCR. During the return to escape plus sensory integration, levels of acceptance decreased ($M = 0\%$), and rates of

inappropriate behavior increased. During the reintroduction of EE plus NCR, mean acceptance increased to 96%, and mean inappropriate behavior decreased to 0.9 responses per minute. Mean grams consumed were 0.3 during escape, 0.1 during escape plus sensory integration, and 6.7 during EE plus NCR. Thus, intake was substantially higher during EE plus NCR than during escape with sensory integration.

DISCUSSION

In the current investigation, we implemented a sensory integration intervention for two

children who had been diagnosed by an OT with a sensory-based feeding disorder. The OT, who had extensive training and experience in sensory integration, developed the procedures, trained the therapists, and participated in implementation of the sensory integration therapy. The results showed that the sensory integration intervention did not produce stable or lasting increases in acceptance and grams consumed or decreases in inappropriate behavior for either child.

There are a variety of potential reasons why the sensory integration procedures were not effective. One challenge we encountered in development of the procedures is that sensory integration interventions are supposed to emerge "dynamically" through therapist–child collaboration (L. D. Parham et al., 2007). In fact, Parham et al. (2007) noted that we cannot be confident about the results of many existing studies on sensory integration because therapists implemented the procedures in a prescribed sequence (e.g., Humphries, Wright, McDougall, & Vertes, 1990) or for a specified period of time. Parham et al. also criticized studies that attempted to isolate effective components of treatment by minimizing the overlap between sensory integration and the alternative procedures in comparison studies (see below; e.g., Mason & Iwata, 1990). Parham et al.'s concerns offer a challenge to the scientist who is interested in testing the efficacy of sensory integration. That is, how do we develop procedures that are technologically precise and studies that are well controlled while still adhering to the constructs of sensory integration? Presumably, too much technological precision and control may contradict the tenets of sensory integration and too little technological precision and control may lead to a scientifically inadequate experiment.

This dilemma is exemplified in a study by Mason and Iwata (1990), who tested the effects of sensory integration therapy on the self-injurious behavior (SIB) of three participants whose SIB was maintained by automatic

reinforcement, attention, and escape from demands, respectively. One component of the sensory integration program involved exposing the individuals to automated physiological stimulation (e.g., lights, music) in the absence of adult attention. Mason and Iwata used automated stimulation to assess the effects of physiological stimulation in the absence of the confounding effects of attention. That is, if the therapist delivered attention, it would not be clear whether the observed effects were a function of sensory stimulation, adult attention, or both. L. D. Parham et al. (2007) criticized Mason and Iwata, stating,

> The research design of this study did not permit therapist–child interaction as a therapeutic strategy. The therapist was present in the room to monitor the child's safety but did not otherwise interact with the child, to allow the child to have continuous access to sensory stimulation without the confounding effect of "social stimulation" (p. 364). Apparently, the researchers assumed that sensory integration intervention consisted of sensory stimulation only and that the therapist–child relationship was not intrinsic to the intervention. (p. 221)

The counterpoint to L. D. Parham et al.'s (2007) criticism, as pointed out by Mason and Iwata (1990), is that there may be components of sensory integration that have functional effects on behavior. For example, the SIB of one of the participants in the Mason and Iwata study was maintained by attention. For this participant, the therapist conducted sensory integration with and without adult attention. SIB was low when adult attention was present but not when it was absent, which would be expected based on the results of the functional analysis. Mason and Iwata concluded that the lower levels of SIB during sensory integration with adult attention were an artifact of the presence of adult attention rather than an effect of sensory integration per se.

In the current investigation, we specified a sequence of activities through which the therapist prompted the child such that the study was sufficiently technological, but the child also had the opportunity to change or

redirect the activities such that the study was consistent with the parameters of sensory integration. Our experience was that specification of the sequence and timing of the activities provided information necessary for replication and the structure for the sensory integration session if the child did not initiate activities on his or her own, which often did not happen. It also was necessary to time the sensory integration therapy such that it occurred immediately before the meal, which is a recommended method of implementing this type of therapy (Case-Smith & Humphry, 2005; Glass & Wolf, 1998). That is, the focus of sensory integration therapy is to alter the child's sensory processing capabilities through a regularly scheduled sequence of sensory-organizing stimulation.

Although the sensory integration intervention was not effective for the participants in the current investigation, some features of sensory integration as described in the literature may address the functional components of feeding problems for other children. For example, Case-Smith and Humphry (2005) recommended interaction during meals to distract the child and "looks of delight" and meal termination as a reward for appropriate eating. These recommendations could be conceptualized in the behavior-analytic literature as noncontingent positive (Reed et al., 2004), differential positive (Piazza, Patel, et al., 2003), and differential negative (Lalli et al., 1999; LaRue et al., 2011) reinforcement, respectively, and would be appropriate components of treatment for children whose inappropriate mealtime behavior was maintained by positive (noncontingent and differential positive reinforcement) and negative (differential negative reinforcement) reinforcement. By contrast, other components of sensory integration (e.g., acknowledging the child's physical cues by withdrawal of the oral stimulus; Case-Smith & Humphry, 2005) may actually worsen feeding behavior if inappropriate behavior is maintained by negative reinforcement (Piazza, Fisher, et al., 2003). This

might explain the results of DeGangi, Sickel, Wiener, and Kaplan (1996), who found that premature infants who received sensory integration had more feeding problems at follow-up than a control group who did not receive sensory integration. DeGangi et al. randomly assigned premature infants who did not have reported feeding problems at the start of the study to either a sensory integration or a control group, and they followed the two groups over time to evaluate the effects of the sensory integration intervention on a variety of outcomes. It is not clear from the study how caregivers implemented the sensory integration activities. If the caregiver removed the feeding utensil or terminated the meal, as recommended in some sensory integration interventions (e.g., Case-Smith & Humphry, 2005), it is possible that the inappropriate behavior of the children in the sensory integration group may have worsened over time if inappropriate behavior was maintained by escape.

In the current investigation, when the child's physical cues of head turning and batting at the spoon were followed by removal of the drink or bite, inappropriate behavior was high and acceptance was unchanged during the escape and the escape plus sensory integration conditions. By contrast, when inappropriate behavior no longer produced escape during EE plus NCR, inappropriate behavior decreased and acceptance increased. These results are consistent with those of Reed et al. (2004) and others that have shown that EE in conjunction with positive reinforcement is an effective treatment for feeding disorders (Ahearn et al., 1996; Bachmeyer et al., 2009; Cooper et al., 1995; Piazza, Patel, et al., 2003).

Although EE plus NCR was effective, these findings are limited because sensory integration was always the first intervention and EE plus NCR always followed sensory integration. It is possible that sensory integration did have a positive effect on behavior that was not observed until the EE plus NCR phase (i.e., the effects of sensory integration were delayed).

This explanation seems unlikely because responding returned to baseline levels during the reversals to escape with sensory integration. Nevertheless, future studies should correct this limitation.

Another potential limitation of the current investigation is that toys and therapist attention were available in EE plus NCR and not in escape plus sensory integration. It was important to examine sensory integration independent of other treatment components such as NCR because this is the first study to our knowledge that systematically examined the effects of sensory integration as treatment for children with feeding disorders. If we had added NCR to escape plus sensory integration, the individual effects of sensory integration on the feeding behaviors would be unclear. Also, it is unlikely that NCR was the reason that EE plus NCR was an effective treatment and sensory integration was not. Previous research has shown that NCR alone is not an effective treatment for children with feeding disorders and that EE is necessary to increase acceptance and decrease inappropriate behavior (Reed et al., 2004). In the current investigation, we added NCR to EE per parental request and because the data from Reed et al. (2004) showed that NCR had some beneficial effects for some participants when combined with EE. It is possible that NCR contributed to the treatment effects during EE plus NCR for the children in the current investigation. Future research could examine the effects of NCR during feeding sessions following sensory integration therapy.

Another limitation of the current investigation is that it included only two children. It is possible that the feeding behavior of these children was not representative of the feeding behavior of children who are commonly treated with sensory integration. In addition, the popularity of sensory integration among first-line clinicians of feeding disorders (e.g., OTs) should provide an incentive for further investigation, particularly collaborative efforts between experts in sensory integration and behavior analysis. Such a collaboration would ensure that therapists implement both sensory integration and behavior-analytic treatments with high fidelity. The lack of treatment fidelity data for the sensory integration and behavior-analytic treatments is an additional limitation of the current study. Documentation of the fidelity with which treatments are implemented would increase the confidence in the findings, which is important as debate continues as to the effectiveness of sensory integration (Case-Smith & Arbesman, 2008; Gresham, Beebe-Frankenberger, & MacMillan, 1999; Hoehn & Baumeister, 1994; May-Benson & Koomar, 2010; Schechtman, 2007).

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