A Behavior Analytic Intervention to Teach Exploratory Motor Behavior to Infants with Down Syndrome

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A BEHAVIOR ANALYTIC INTERVENTION TO TEACH EXPLORATORY MOTOR BEHAVIOR TO INFANTS WITH DOWN SYNDROME

by

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ABSTRACT

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Exploratory Motor (EM) behavior refers to manipulating a toy in the hand(s). Infants with Down syndrome demonstrate significant impairments in the duration and frequency of EM behavior compared to their typically developing counterparts. A behavior analytic intervention involving multiple opportunities, prompting, and social reinforcement was used to teach three infants with Down syndrome between 4-9 months of age to emit EM behavior. Results indicate that all three infants with Down syndrome emitted the three EM target behaviors to mastery and demonstrated generalized responding across stimuli and other EM behaviors. The importance of these findings in addressing impairments in infants with Down syndrome, caregivers’ perceptions of intervention, and collateral changes in related skill areas are discussed.
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Infants with Down syndrome show significant impairments in reaching, grasping, and Exploratory Motor (EM) behavior (Cadoret & Beuter, 1994; DeFalco, Esposito, Venuti, & Bornstein, 2010; Landry & Chapieski, 1989; Loveland, 1987; MacTurk, Hunter, McCarthy, Vietze, & McQuiston, 1985). EM behavior refers to visually examining and manipulating an object the infant holds in his/her hand(s), all of which require the infant to reach and grasp the object first (Keogh & Sugden, 1985). For example, the infant may reach for a toy, grasp it, and then bang the toy on a surface, shake it back and forth, or drop it from his/her hand(s) onto a surface or the ground. Each of these is considered EM behavior.

Typically developing infants begin to engage in EM behavior at 4 to 5 months of age (Gibson, 1988). Infants with Down syndrome emit uncoordinated reaches (Thelen, Corbetta, & Spencer, 1996), tending to use an “open-hand” motion in which the fingers remain open when making contact with an object, rather than closing the fingers around the object as in a full grasp (Kearney & Gentile, 2002). Such reaches result in limited success in grasping the object, fewer natural object-related consequences, and fewer opportunities to engage in EM responses. Even when infants with Down syndrome do reach and grasp, their EM responses are less frequent and have shorter durations than those of typically developing infants (Bradley-Johnson, et al., 1981; Cadoret & Beuter, 1994; de Campos, da Costa, Savelsburgh, & Rocha, 2013; DeFalco et al., 2010; Landry & Chapieski, 1989; Loveland, 1987; MacTurk et al., 1985; Tudella, Periera, Basso, & Savelsburgh, 2011).
Motor skills such as EM behavior are of particular importance because, as infants reach for, grasp, and engage in EM behavior, they learn about objects in their environment. In fact, EM behavior may be related to other areas of development, particularly motor and cognitive development. Engagement in EM behavior with objects of different sizes, weights, and shapes develops muscle strength and fine motor movements (Gibson, 1988; von Hofsten, 1979), both part of motor development. EM behavior also facilitates problem solving, object affordances, causality, and planning, all part of cognitive development (Fidler, Hepburn, & Osaki, 2011; Needham, 2000).

Despite the importance of reaching, grasping, and EM behavior, there are no empirical demonstrations of interventions to address these impairments in individuals with Down syndrome and the only explanation for these impairments focuses on muscle weakness (Cadoret & Beuter, 1994; Davis & Kelso, 1982; MacTurk et al., 1985; Palisano, Walter, Russell, Rosenbaum, Gemus, Galuppi et al., 2001; Ulrich & Ulrich, 1993). Several early intervention curricula for infants with Down syndrome include suggestions to address EM behavior (e.g., Bruni, 2006; Dmitriev, 2001; Hanson, 1987). For example, in her manual for parents and professionals, Hanson (1987) suggests structured teaching activities in which the caregiver presents an EM opportunity and provides physical prompts and reinforcement (i.e., praise and continued access to the object) for reaching, grasping, and EM responses; but she did not systematically evaluate the EM intervention or report changes in EM behavior specifically.

The few demonstrations of interventions to address EM behavior with other populations may be useful in guiding intervention in Down syndrome. Needham, Barrett, and Peterman (2002) compared reaching, grasping, and EM behavior in 32 pre-reaching typically developing infants. Half of the infants were in the experimental group and wore “sticky mittens” on their
hands during intervention and the other half of the infants were in the control group and did not wear anything on their hands. The “sticky mittens” had strips of Velcro attached to them which allowed them to stick to toys that were dangled before the infant. Wearing these “sticky mittens” resulted in infants making many successful attempts at swiping for and engaging in EM behaviors with objects, compared to pre-reaching infants who did not wear sticky mittens. When the mittens were removed, infants who had previously worn the sticky mittens looked longer and swiped at the toys in front of them more than infants who had not worn the sticky mittens. This likely worked because wearing the “sticky mittens” increased reinforcement for grasping. Correa, Poulson, and Salzberg (1984) increased reaching and grasping in three 2-4 year old children with visual impairment and intellectual disability. Using a graduated prompting procedure involving a three-phase least-to-most prompting method, Correa et al. (1984) taught a reach-grasp response that generalized across objects.

Consistent with Hanson’s curriculum recommendations, Needham et al. (2002) and Correa et al. (1984) demonstrated the effect of prompting and reinforcement on EM behavior with infants and young children. To successfully apply these strategies with infants with Down syndrome, it is necessary to understand the variables that affect EM behavior in learners with Down syndrome. Muscle weakness and hypotonia are the primary explanations of impairments in EM behavior in infants with Down syndrome (Cadoret & Beuter, 1994; Davis & Kelso, 1982; MacTurk et al., 1985; Palisano, Walter, Russell, Rosenbaum, Gemus, Galuppi et al., 2001; Ulrich & Ulrich, 1993) and must be considered in developing intervention.

In addition to muscle weakness and hypotonia, Bauer and Jones (2014) proposed an etiology-based behavior analytic model of EM impairment that suggests other relevant variables related to EM impairments and strategies for intervention. Characteristics of Down syndrome
seem to change the value of certain consequences in the way that motivating operations (MOs) do. Specifically, characteristics of Down syndrome function as motivating operations to decrease the value of the natural object-related consequences resulting from engagement in EM behavior (Ruskin, Mundy, Kasari, & Sigman, 1994), and increase the value of social consequences (Loveland, 1987) when compared to typically developing infants. The effect is to decrease the likelihood of EM behavior that results in object related consequences. The pattern of heightened levels of socially interactive behavior in infants with Down syndrome compared to typically developing infants (Fidler, 2005; Fidler, Most, Booth-LaForce, & Kelly, 2008; Venuti, De Falco, Giusti, & Bronstein, 2008) means that for example, while an infant with Down syndrome plays with his mother and toys on the living room floor, he is likely to allocate more attention and engage more frequently in social interaction with his/her mother than in object interaction (Loveland, 1987). In terms of intervention, this means that social interaction should be limited prior to and during EM opportunities, and instead, provided as a consequence for engagement in EM behavior. Social consequences can also be paired with the naturally occurring object-related consequences for EM behavior. Providing social consequences only following an EM response and pairing with the naturally occurring object-related consequence may result in the natural, object-related consequence becoming a conditioned reinforcer.

Children with Down syndrome also seem to show behaviors that suggest a high value in escaping from a difficult EM task (Feeley & Jones, 2006). When faced with a difficult task, infants with Down syndrome often avoid the task by clapping hands, waving, turning away from the caregiver, making funny faces, or engaging in other socially oriented, charming behavior (termed “party tricks”) (Wishart, 1993). Weak muscles and low muscle tone increase the difficulty of EM behavior. The positions in which the infant with Down syndrome is stable
enough to engage in EM behavior and the infant’s overall ability to physically lift an object with his or her arms may be limited. Therefore, choice of position during intervention must limit stress on the body’s abdominal and back muscles and still allow the infant to freely move his/her arms to engage in EM behavior (Washington, Deitz, White, & Schwartz, 2002). Positioning supports may provide added stabilization. Furthermore, interventionists must carefully choose toys for intervention so that they are not too heavy or difficult to lift and are placed before the infant in such a way that the toys are easily graspable. In addition to minimizing muscle demands by object size and weight, EM responses can be broken down into small increments, beginning with reaching for and grasping the object and progressing to visually examining the object in the infant’s hand and forcefully dropping the object from the hand (or shaking, rolling, banging, etc.). Furthermore, the interventionist must provide prompts for each small step of the EM responses to assist the infant in engaging in EM behavior. Interventionists can begin by prompting EM responses using a most-to-least prompting procedure providing the most amount of physical guidance at the beginning of EM intervention and slowly fading to lesser amounts of physical guidance as the infant acquires the EM response and finally to no prompting at all. Each of these components of intervention serves to decrease the difficulty of EM behavior and minimize the effects of the increased value of escaping difficult tasks.

The purpose of the present study is to examine: (1) the effectiveness of the intervention procedures described in Bauer and Jones’ (2014) to teach three EM responses (i.e., reaching/grasping, visually examining a toy in hand, and dropping a toy from the hand(s), to young infants with Down syndrome, (2) spontaneous stimulus (toy, partner, and setting) and response generalization (shaking/banging behavior and an EM behavior chain), (3) collateral
changes in cognitive and motor development, and (4) social validity in the form of a questionnaire completed by caregivers to assess their perceptions of this type of intervention.

Method

Participants

Three infants with Down syndrome, Rachel, Ethan, and Chester, between 4 and 9 months of age (as this is the age range when typically developing infants begin to engage in EM behavior [Gibson, 1988]) participated. All infants had a diagnosis of Down syndrome as reported by a caregiver and showed a lack of reaching, grasping, and EM responses as confirmed by initial observations, a physical therapist’s (PT) assessment (described shortly), and baseline opportunities (described shortly). Caregivers provided informed consent. Exclusion criteria included medical complications prohibiting the appropriateness of working on motor behavior at the time of the study and classification as “Type 4” according to Dmitriev (2001)’s motor types (described shortly).

The author administered the Motor and Cognitive Subscales of the Bayley Scales of Infant and Toddler Development, Third Edition (Bayley-III) (Bayley, 2006) in each infant’s home at the same time that baseline sessions were conducted. The Bayley-III was used to describe each infant’s level of motor and cognitive development at the beginning of the study and as a means of assessing collateral changes in motor and cognitive development pre-to-post intervention.

A physical therapist (PT) assisting with this research also conducted an assessment to help determine and describe the optimal position of the infants and supports needed for intervention. This assessment included the Alberta Infant Motor Scale (AIMS) (Piper & Darrah,
which evaluated the infant’s overall motor development. The AIMS is a validated measure of motor skills in infants from birth to 18 months. The AIMS consists of 58 motor skills divided amongst four scales. Each of the four scales assesses a different postural position: prone (21 skills), supine (9 skills), sitting (12 skills) and standing (16 skills). Each positional scale depicts a sequence of motor skills described in terms of weight-bearing surface of the body, the posture necessary to achieve the skill, and the voluntary movement performed by the infant in the respective position. Motor behaviors performed by an infant during the assessment are classified as “observed” behaviors and all other behaviors as “not observed.” The least and most mature skills observed in a given position provide an overview of the infant’s possible motor repertoire in that position. Each “observed” skill is credited 1 point, and the sum of these points represents the infant’s positional score. To determine an infant’s total AIMS score, the scores for each of the four positional scales are summed.

The PT also classified the infants according to Dmitriev (2001)’s motor types, a specific classification system for infants with Down syndrome based on muscle tone and motor functioning. Type 1 (15%–25%) infants have good muscle tone and meet typical milestones such as head control, bearing weight on feet with support, and lifting the torso on extended arms by 4 months. Types 2 and 3 (50%–60%) infants, however, demonstrate a discrepancy between upper and lower body motor functioning. Type 2 infants have strong upper back, neck, shoulders, and arms, but have difficulty bearing weight on their legs. Conversely, Type 3 infants have strong legs and lower torso, but weaker upper torso, neck, head, shoulders, and arms. Type 4 babies (15%–25%) show muscle weakness throughout their bodies.

All infants received early intervention physical therapy services. Ethan also received occupational therapy. None of the infants was yet receiving intervention to specifically address
EM behavior. Early intervention services were conducted in the infants’ homes. Rachel also received services at a day care center. All three infants were classified as a Type 2 babies according to Dmitriev (2001)’s motor types.

Chronologically, Rachel was 7 months, 25 days old at the start of the study. However, she was born one month and 24 days prematurely. Therefore, after adjusting for prematurity, Rachel’s adjusted age at the beginning of the study was 6 months 4 days. Rachel was being raised by a legal guardian and was the only child in her home. At the onset of the study, Rachel’s caregiver reported that Rachel reached for and grasped toys in her hands only sporadically.

Ethan was 5 months old and the fourth child born to his family. According to caregiver report, at the start of the study, Ethan did not reach for or grasp toys. On occasion, he grasped a toy when placed in his hand, but quickly let go.

Chester was 4 months old at the start of the study and the 8th child born to his family. During the initial meeting, Chester’s caregiver noted Chester’s emerging reaching and grasping ability. Chester attempted to reach and grasp toys before him, but would not hold on to a toy for more than just a few seconds before it fell from his hand(s). On the AIMS, each infant received a total AIMS score between 7 and 9 pre-intervention. Table 1 and 2 show each child’s pre-and post-intervention scores on the Cognitive and Motor subscales, respectively, of the Bayley Scales of Infant and Toddler Development (Bayley-III).

**Setting and Interventionists**

Baseline, intervention, generalization, and follow-up sessions occurred in each infant’s home and in Rachel’s day care center. The licensed physical therapist who conducted the motor assessments for all infants had her Master’s degree in movement science and education (motor learning) and over 40 years of experience specializing in pediatric physical therapy. The author,
a doctoral candidate in psychology and licensed behavior analyst, served as the interventionist for Rachel and Ethan. Both the author and Chester’s mother served as the interventionists for Chester. Chester’s mother was available to conduct intervention sessions and willing to learn to implement intervention.

The author trained Chester’s mother to conduct baseline, intervention, and generalization sessions using behavioral skills training (Miles & Wilder, 2009) consisting of written instructions, modeling, rehearsal, and feedback. The author (acting as the interventionist) modelled procedures for baseline, intervention, and generalization sessions two times each. Chester’s mother then rehearsed with the author acting as the infant. During and following practice, the author provided feedback to Chester’s mother about her implementation of each procedure. This process of rehearsal and feedback continued until Chester’s mother conducted two consecutive sessions of baseline, intervention, and generalization with 100% accuracy. The author also provided ongoing feedback to Chester’s mother throughout intervention at regular weekly/biweekly meetings.

**Materials**

The author identified 30 small, lightweight (i.e., not exceeding 113 grams) toys with which young infants between 0-6 months of age typically play. Only lightweight, small toys were chosen so as not to exceed the motor and muscle limitations of the infants. All 30 toys produced noise (e.g., rattles, small musical toys) because these toys tend to result in more EM behavior in infants (Morgante & Keen, 2008). Consistent with other procedures to identify preferred toys for intervention with infants, parents chose 15 of the 30 toys they identified as likely to be preferred by their child (Thompson, Cotnoir-Bichelman, McKerchar, Tate, & Dancho, 2007). Of the 15, the author randomly assigned 10 toys to intervention and 5 to
generalization. A high chair with a tray, and infant bouncy seat were used as necessary for EM opportunities. Additionally, the PT recommended the use of a Snuggin Go infant positioner from BGR Juvenile Products, LLC for each infant. The Snuggin Go positioner is made of memory foam that provides seating and shoulder support that helps stabilize infants, and reduces slouching. The PT specifically recommended using this positioner with all infants because it also provides shoulder support which helps infants with Down syndrome stretch their arms further than they would if they had to also use their muscles to support their back and shoulders.

Data sheets were used to record infant EM behavior (see Appendices A-C). Caregivers completed a social validity scale (Appendix D) following intervention. The Bayley-III was administered by the author to evaluate the infants’ overall development, both pre-and-post intervention. The AIMS was administered by the trained PT pre-intervention to determine the optimal position for teaching EM behavior to each infant.

**Design**

To examine the effects of intervention based on Bauer and Jones’ (2014) model involving carefully chosen materials, positioning, a sequence of specific prompts, and high rates of social reinforcement on EM behaviors, a multiple baseline probe design across three different EM responses was conducted with probes for generalization across toys, partners, settings, and responses. In addition, pre and post assessments of infants’ motor and cognitive skills, (Bayley III) were conducted to investigate collateral changes in motor and cognitive development.

**Dependent Variables**

All baseline, intervention, and generalization sessions were video recorded. The author and trained undergraduate research assistants observed each video recorded session and scored all dependent variables across conditions.
**Exploratory Motor Behavior.** Target responses consisted of a reach/grasp response and two EM responses (visually examining a toy in hand and dropping).

*Reach-Grasp.* Consistent with Correa et al.’s (1984) definition, a reach-grasp response consisted of the infant extending his or her arm(s) to touch a toy simultaneously with his thumb and at least one other finger of the same hand. A reach-grasp response was counted once the infant reached for the toy, grasped it, and held the toy at least 2.5 centimeters in the air. For the reach-grasp response, opportunities began when a toy was placed within the infant’s arm reach and ended when the toy was released from the infant’s hand(s) and remained untouched for at least 5 s. The criterion duration of time the infant reach-grasped the toy was at least 1 s. Reach-grasp was measured and reported as the percentage of times the infant reach-grasped the toy for at least 1 s per 10-opportunity session.

*Visually Examine a Toy in Hand.* Visually examining a toy in hand consisted of the infant, with toy in hand, bringing the toy within 2.5 – 12.5 centimeters of the eyes with the infant’s eyes directed to the toy. Opportunities for visually examining a toy in hand began once the infant had already grasped the toy. Opportunities ended when the toy was released from the infant’s hand(s) and remained untouched for at least 5 s or the infant did not visually examine the toy for 5 s. The criterion duration of time the infant visually examined the toy in hand was at least 1 s. Visually examining a toy in hand was measured and reported as the percentage of times the infant visually examined the toy in hand for at least 1 s, per 10-opportunity session.

*Dropping.* Dropping consisted of releasing a toy from the hand(s) onto a surface or the ground by forcefully moving the hand in such a way so as to fling the toy from it. If the infant did not forcefully fling the toy from the hand(s), simply let go of the toy without any forceful movement, or the toy simply fell from the hand(s), this was not considered a dropping response.
As with visually examining a toy in hand, opportunities for dropping began once the infant had the toy in hand. Opportunities ended when the dropping response occurred. Dropping was measured and reported as the percentage of times the infant dropped the toy from the hand(s) per 10-opportunity session.

**Secondary Measures.** In addition to the three EM target behaviors, the author also measured generalization across two responses (shaking/banging and an EM behavior chain). The author also measured cognitive and motor development pre and post intervention using the Bayley III.

**Shaking/Banging.** Shaking consisted of holding a toy in one or both hands and moving it either back, forth, up, or down in the air at least one time. Each back, forth, up, or down movement was considered a shaking response. Banging consisted of holding a toy in one or both hands and bringing it into contact with a surface (i.e., table top, floor, another toy, etc.). Each contact that the toy made with a surface was considered one banging response. Since typically developing infants who are shaking a toy often uninterruptedly bang the toy into some object or surface nearby, shaking and/or banging behavior was combined. That is, if an infant shook the toy upward once, and then brought the toy back down and it made contact with a surface, that would be counted as one shake and one bang. Shaking/banging was measured as the number of times the toy was either moved in the air and/or made contact with a surface during an EM opportunity. Opportunities for shaking/banging began once the infant had the toy in hand. Opportunities ended when the toy was released from the infant’s hand(s) and remained untouched for at least 5 s, or the infant did not make contact with or manipulate the toy for 5 s. The number of shake/bang responses was totaled following intervention for all target responses and reported as the cumulative number of shake/bang responses.
**EM Behavior Chain.** The EM behavior chain was a chain or bout of EM responding that reflected a varied order and duration of EM behavior (as seen in typically developing infants). The chain or bout of EM responding began when the infant reached-grasped the toy and ended when the toy was released from the hand(s) and remained untouched for at least 5 s, or the infant did not engage in any EM behavior with the toy for 5 s. The chain or bout of EM responding consisted of various sequences beginning with a reach-grasp response and proceeding with some combination of at least 2 more EM behaviors (e.g., visually examining a toy in hand, dropping, and/or shaking/banging responses), to closely resemble what EM behavior looks like in typically developing infants. Therefore, the EM behavior chain could include a variable sequence of EM responding that may have included all of the EM behaviors that were taught or just one or some of the EM behavior, and could include repeated demonstrations of some or all EM responses. The EM behavior chain was measured and reported as the number of times the infant engaged in a bout of EM behavior during an EM opportunity. After the infant engaged in the target EM response, the interventionist did not remove the toy from the infant’s hand(s) so as not to interrupt the EM behavior chain. An EM behavior chain ended only if the infant did not make contact with the toy or did not manipulate the toy at all after 5 s elapsed. The number of EM behavior chains was totaled following intervention for all target responses and reported as the cumulative number of EM behavior chains emitted.

**Cognitive and Motor Development.** The Bayley-III was administered pre-and post-intervention. The Bayley-III measures cognition, language, motor, social-emotional skills, and adaptive behavior in children from birth to 42 months. On the Bayley-III, infants begin to be assessed with items that fall into a specific age range that is approximately within 1-2 months of their chronological age. For example, if an infant is 4 months, 0 days old at the time of testing,
he/she receives items meant for infants between 3 months, 16 days – 4 months, 15 days, as he/she chronologically falls within that age range. At pre-intervention, all infants were between 4 months, 0 days to 6 months, 4 days old. At post-intervention, all of the infants were between 7 months, 28 days to 10 months, 23 days old.

**Procedure**

Prior to intervention, the author and PT administered pre-assessments to determine each infant’s overall level of development and the optimal position for intervention. The author also conducted an arm reach assessment to determine the appropriate distance to place a toy in front of an infant for him/her to reach-grasp. Then, baseline probes were administered, intervention was implemented, and generalization and follow-up probes were conducted. Following mastery of all EM responses, the author re-administered the Bayley-III.

**Pre-Assessments.** To examine each infant’s overall development, the Bayley-III was administered in the infant’s home prior to intervention (during baseline). The Bayley-III was administered by the author. The PT administered the AIMS to evaluate the infant’s motor skills and help determine the optimal position for each infant’s engagement in EM behavior. Positional scores and recommendations from the PT who conducted the AIMS assessment were used to identify a position (i.e., supine, prone, or seated) and any necessary positioning supports for each infant for use in intervention. On the AIMS, each infant received a total AIMS score between 7 and 9 pre-intervention. The PT who conducted the AIMS assessment suggested that all 3 infants be placed in a seated position (in their highchairs with the high chair tray attached) along with the Snuggin Go infant positioner from BGR Juvenile Products, LLC placed behind them. Therefore, all infants experienced baseline, intervention, generalization, and follow up sessions in the seated position with these supports.
**Arm Reach Assessment.** Arm reach was determined before baseline. However, because reaching is impaired in infants with Down syndrome, infants tended not to extend their arms on their own to reach for an object to allow for the length of their arm reach to be measured. To determine the arm reach distance for each infant, the interventionist placed the infant in the seated position that would be used for intervention and gently pulled the infant’s arm so that it was extended in such a way that the elbow was only slightly bent (e.g., bent at approximately a 120 degree angle). Then, the interventionist measured the distance from the front of the infant’s shoulder to the base of the infant’s palm. The interventionist repeated this procedure three times with the infant’s left and right arms separately and calculated the average of the six distances (three distances from each arm) to determine the infant’s overall average arm reach. Then, when presenting EM opportunities to an infant in the seated position, the interventionist placed the toy in front of the infant, anywhere within the determined average arm reach (which was indicated by small pieces of tape on the highchair tray), either directly in front of the infant or to the left or right at approximately a 45 degree angle. All of the infants had similar overall average arm reach values. Rachel’s average arm reach was 15.5 centimeters, Ethan’s was 16.25 centimeters, and Chester’s was 16 centimeters distance from the front of the shoulder to the base of the palm.

**Baseline.** All baseline opportunities began when the toy was activated or shaken and placed before the infant and ended when the toy was released from the infant’s hand(s) and remained untouched for a duration of at least 5 s, or when the infant did not engage in reaching-grasping, visually examining the toy in hand, dropping, or shaking/banging for 5 s. During baseline sessions, the interventionist chose one of the 10 toys designated for intervention and the infant was placed in his/her high chair or infant seat. Six initial baseline sessions were conducted
within two weeks, (before intervention began for the first target response) with three sessions occurring each week; each session consisted of 5 opportunities.

Once intervention was implemented with the first EM target response, baseline probe sessions continued to be presented after a variable number of intervention sessions (approximately 1 probe each week) for the remaining target responses until intervention was introduced for each target response. The interventionist conducted a baseline probe session immediately prior to introducing intervention for each target response (Appendix A).

The interventionist sat approximately half a meter across from the infant and ensured that the infant looked at the toy by activating the toy or shaking it in front of the infant. Then the interventionist held or placed the preferred toy on the tray before the infant, at the distance determined by the arm reach assessment. If the toy fell from the infants hand(s) during a baseline opportunity, the interventionist immediately retrieved it and re-presented it to the infant. Any EM behavior resulted in natural EM behavior consequences including whatever the toy did (e.g., made noise, lit up, activated and moved around, etc.), but no contrived consequences were delivered.

**Intervention.** Interventionists provided the intended intensity of intervention to each infant. The intended intensity of intervention consisted of two to three intervention sessions, containing 10 opportunities each, per week. Intervention opportunities began in the same manner as baseline opportunities. The interventionist sat across from the infant and presented one of the toys to the child. The interventionist then implemented the prompting procedure. Prompts for each response were faded using a most-to-least prompt fading hierarchy and time delay once the infant reached the mastery criterion of 80% correct responses across 2 sessions and 2 days. Full prompts involved hand-over-hand prompting. Partial prompts included a light tap to the infant’s
arm or hand. Details about prompts are described next. During time delay, the interventionist waited 8 s for the infant to begin to respond independently. If the infant did not respond independently, the interventionist immediately reverted to the partial prompt to guide the infant to complete the target response. The mastery criterion was 80% independent correct responses across 2 sessions and 2 days in time delay. Following a correct response, the interventionist delivered social reinforcement in the form of verbal praise and tickles and did not immediately remove the toy from the infant’s hands, but allowed the infant to continue to hold the toy to allow for possible further EM responding. Following an incorrect response, the interventionist implemented an error correction procedure in which she said, “Uh, uh, try again,” removed the toy, and immediately represented it, to provide the infant with a new opportunity to respond.

**Reach-Grasp.** For the reach-grasp response, once the toy was presented to the infant (either on a table or high chair tray), the interventionist immediately introduced a full prompt in which she physically held the infant’s arm, moved it toward the toy, wrapped the infant’s hand around the toy, and raised the toy at least 2.5 centimeters above the table/tray for at least 1 s. For a partial prompt, the interventionist slightly tapped on the infant’s arm to prompt the infant to reach toward the toy. Once the infant reached for the toy, the interventionist then held the infant’s hand to prompt the infant to continue grasping the toy at least 2.5 centimeters above the table/tray for at least 1 s.

**Visually Examine a Toy in Hand.** Once the infant reach-grasped the toy, full prompts for visually examining a toy in hand involved the interventionist physically prompting the infant by placing her hand(s) on the hand of the infant and moving the infant’s hand toward the infant’s eyes to ensure that the infant held the toy within 2.5 – 12.5 centimeters of his/her eyes for at least
A partial prompt consisted of the interventionist slightly tapping on the infant’s arm to prompt him/her to bring the toy within 2.5 – 12.5 centimeters of the infant’s eyes for at least 1 s.

**Dropping.** The prompting procedure for the dropping response followed the same format as for the other two responses. After being presented with the toy and reaching-grasping, the interventionist provided a full prompt in which the interventionist placed her hand(s) on the infant’s hand and physically guided the infant to drop the toy. A partial prompt included less intrusive physical guidance (i.e., gently tapping the infant’s arm toward a dropping response).

**Follow up.** Follow-up probe sessions were conducted for each target response one month after mastery of the final target response to determine maintenance of skill acquisition. Follow-up probe sessions were conducted in the same manner as baseline sessions.

**Generalization.** Stimulus generalization was assessed pre- and post-intervention. Generalization probes were administered following the six initial baseline probes conducted for each EM behavior, again immediately after mastery of each target response, and once more, one-month post intervention. Response generalization was examined over the course of the study.

**Stimulus generalization.** Generalization was assessed across toys, partners, and settings for each EM response and conducted in the same manner as baseline and follow-up sessions. Separate generalization sessions were conducted across toys, partners, and settings. The interventionist examined generalization across toys with the five extra toys provided by the author, but not used for intervention. A caregiver who did not implement intervention (e.g., grandmother, sister) conducted sessions to assess generalization across people. Generalization across settings was studied using generalization sessions conducted by the interventionist in a novel setting (i.e., a different room from the one in which intervention sessions were conducted). As in baseline sessions, during generalization sessions, no prompting procedures were conducted.
and only natural consequences (i.e., toy-related consequences) were delivered for correct responses.

**Response generalization.** Data on response generalization were collected from all baseline, intervention, and stimulus generalization sessions. Since EM behavior includes multiple forms of engaging with a toy and often sequences of different EM responses, spontaneous generalization to shaking/banging and to an EM behavior chain (both defined previously) was also assessed. As in baseline sessions, during generalization sessions, the interventionist did not prompt, and only provided natural consequences (i.e., toy-related consequences) for correct responses.

**Post-Assessments.** To examine collateral changes in each infant’s overall development, the Bayley-III was re-administered post-intervention.

**Social Validity.** Social validity was assessed by asking caregivers to complete a questionnaire. Post-intervention, the infants’ primary caregivers responded to several questions on a 7-point scale rating their perception of this intervention (Appendix D).

**Interobserver Agreement**

Interobserver agreement (IOA) was examined for 50% of sessions for each infant with Down syndrome, for each response, across each condition. That is, IOA was examined for 50% of baseline, 50% of intervention, and 50% of generalization sessions. Baseline, intervention, and generalization sessions chosen for IOA examination were identified using a random numbers generator. IOA observers were trained undergraduate research assistants who rated the video recordings of sessions after the sessions were completed. The author trained all IOA observers by viewing and discussing actual video recordings of baseline, intervention and generalization sessions not included in the IOA calculations. The IOA observer used the same data collection
sheet used to collect baseline, intervention, generalization, and observation data, respectively (Appendices A, B, C, and D) to score IOA observations.

Agreements occurred when both the interventionist and the IOA observer independently recorded a given response as independent, prompted, or incorrect. Disagreements occurred when either the interventionist or IOA observer recorded a response as independent, prompted, or incorrect, and the other did not record the same performance. The author calculated the percentage of IOA by summing all response opportunities and dividing the number of agreements by total agreements plus disagreements multiplied by 100. Overall, IOA results for infants with Down syndrome showed an average of 94% (range, 92%-95%) agreement for all independent, prompted and incorrect responses across baseline, intervention and generalization. IOA was 92% (range, 80%-100%), 95% (range, 92%-100%), and 95% (range, 90%-100%) for Rachel, Ethan, and Chester respectively.

**Intervention Integrity**

To ensure that intervention was conducted as intended, we examined the specific intervention procedures during each intervention session as well as adherence to the intended intensity of intervention. The same research assistant who examined IOA also recorded intervention integrity data for the same 50% of sessions. Intervention integrity ratings were recorded on a separate data sheet (Appendix E). Each intervention opportunity was examined for the accurate presentation of each component of intervention (i.e., presentation of the SD, prompting procedures, and delivery of appropriate consequences). The number of times the interventionist correctly presented each instructional component was divided by the total number of correct plus incorrect presentations of that component, multiplied by 100, to obtain the percentage of correctly implemented intervention procedures.
For all infants, interventionists correctly presented opportunities to emit an EM response 100% of the time. For Rachel, overall intervention integrity for prompting procedures and consequences was 97% and 98%, respectively. For Ethan, overall intervention integrity was 98% for prompting procedures and 96% (range, 92%-99%) for consequences. For Chester, overall intervention integrity for prompting procedures and consequences was 100% and 85% (range, 80%-89%) respectively.

Intensity refers to the “amount of intervention” or, in this case, the number of opportunities provided to a learner (Warren, Fey, & Yoder, 2007). To examine adherence to the intensity with which intervention was intended to be provided, the research assistant also scored whether the infant received the intended number of intervention sessions and opportunities described. The intended intensity of intervention consisted of 10 opportunities per session with two to three sessions of intervention conducted each week.

Access to the intended intensity of intervention was calculated by examining the number of sessions per week and the number of opportunities per session for each infant for each response form. For each infant, the number of weeks the interventionist conducted the required number of intervention sessions was divided by the total number of weeks that intervention sessions were conducted, multiplied by 100, to obtain the percentage of weeks with the intended number of intervention sessions conducted. This same procedure was used to calculate the percentage of sessions with accurate number of opportunities provided for intervention.

Rachel, Ethan, and Chester, received the intended intensity of intervention sessions across 80%, 64%, 80% of the weeks of intervention, respectively. Ethan’s low treatment intensity percentage for number of intervention sessions was due to scheduling conflicts. The interventionist implemented fewer sessions of intervention per week than initially prescribed,
because of the family’s vacation schedule. Therefore, Ethan sometimes received only 1 session per week of intervention. For the number of opportunities per intervention session, Rachel, Ethan, and Chester all received the intended number of opportunities per session across 89%, 93%, and 97% of opportunities per intervention session.

**Results**

**EM Performance**

Figures 1-3 illustrate EM performance (percentage of correct responses) across sessions for baseline, intervention, and follow-up. For each figure, the top panel depicts reach-grasp performance, the middle panel performance of visually examining a toy in hand, and the bottom panel dropping performance. All correct responses are depicted as filled in circles. Full prompt, partial prompt, and time delay are indicated as FP, PP, and TD, respectively. Performance during stimulus generalization probe sessions is also depicted (by an “x”, open square, and open circle to depict stimulus generalization across toy, people, and setting, respectively) and will be discussed shortly.

Figure 1 depicts EM performance for Rachel. During baseline, Rachel emitted 0-20% independent correct responses. Once intervention began, Rachel mastered reaching-grasping within 13 sessions, visually examining within 6 sessions, and dropping within 9 sessions. She completed intervention within 10 weeks. The one month follow-up probe indicated that Rachel’s performance maintained at 80% or above for all target responses with the interventionist.

Figure 2 illustrates EM performance for Ethan. Like Rachel, Ethan emitted 0-20% independent correct responses during baseline, mastered reaching-grasping within 11 sessions, visually examining within 9 sessions, and dropping within 7 sessions. Ethan completed
intervention within 11 weeks. At the one month follow-up probe, Ethan emitted all responses at 100% with the interventionist.

Figure 3 depicts EM performance for Chester. During baseline, Chester emitted 0-40% independent correct responses. Chester mastered reaching-grasping within 6 sessions, visually examining within 18 sessions, and dropping within only 5 sessions. During intervention for dropping, Chester began to emit independent correct responses at mastery levels during the first session in the partial prompt phase. Therefore, Figure 3 depicts only one data point within the partial prompt phase for the dropping response; the interventionist did not conduct a second session with a partial prompt, but moved immediately to the time delay phase. Chester completed intervention within 10 weeks. The follow-up probe indicated that Chester’s performance maintained at 80% or above for all target responses.

Generalization

Stimulus Generalization. Figures 1-3 also show infants’ generalization performance across toys, people, and settings. Stimulus generalization data are depicted on each Figure with an “X” indicating performance with different toys, an open square indicating performance with different people, and an open circle indicating performance in a different setting. Rachel (Figure 1) did not demonstrate any of the target EM responses across toys, people, or settings during baseline. However, immediately following intervention, Rachel generalized across toy and setting for each EM target response, but did not generalize across partner. At the follow-up probe opportunity, Rachel generalized across toy, setting, and partner at mastery levels.

Ethan’s (Figure 2) performance during generalization probes across toys, people and settings at baseline was low. Following intervention for each EM response, Ethan’s performance increased to mastery levels except for dropping across partner. Ethan’s performance remained
higher than baseline for all responses; however, at the follow up probe, his performance decreased and he showed some lower than mastery levels of performance.

Chester’s (Figure 3) generalization responding depicts low performance for all EM responses across toy and setting at baseline, but higher levels of responding across partner. Following intervention, Chester generalized across toy, partner, and setting. However, due to scheduling conflicts, generalization across partner was not conducted following dropping intervention. At the follow-up probe, Chester generalized across toy, partner, and setting at mastery levels across the reach/grasp and dropping responses, but at lower levels across partner for visually examining a toy in hand.

**Response Generalization.** Figures 4 and 5 depict response generalization for shake/bang and the EM behavior chain, respectively. Both figures illustrate cumulative correct responses for each infant across the duration of the study. The top, middle, and bottom panels depict response generalization performance for Rachel, Ethan, and Chester, respectively. Dotted lines indicate when intervention occurred for each of the three target EM responses. During baseline, only Chester showed some shaking/banging, but none of the infants engaged in the EM behavior chain.

**Shake/Bang.** Rachel (top panel of Figure 4) began to show response generalization in the form of shake/bang within two sessions of intervention for reach-grasp. That is, once the interventionist began prompting Rachel with a full prompt to reach-grasp, she also began to shake/bang the toy, showing 48 shake/bang responses by the second session of intervention for reach-grasp. Rachel’s rate of shake/bang responses increased from 0 to 200 over the course of intervention for reach-grasp, but did not increase at the same rate (only by approximately 50 cumulative responses) during intervention for visually examining a toy in hand and dropping.
Rachel’s level of shake/bang responding plateaued following intervention for dropping; this is likely because, at the onset of intervention for dropping, the interventionist immediately prompted her to fling the toy from her hand, eliminating the possibility of shaking/banging it. Following intervention for the last target response (i.e., dropping), at the 1-month follow-up probe, the cumulative number of correct shake/bang responses reached 287.

Ethan (middle panel of Figure 4) began to shake/bang at the very end of the partial prompt phase during intervention for reach-grasp. Ethan’s rate of shake/bang responses increased from 0 to 133 responses over the course of intervention for reach-grasp, then increased by almost another 200 responses during intervention for visually examining a toy in hand, and then increased by almost 400 more responses during dropping intervention. This is different from Rachel as his rate of responding increased most during the dropping intervention. Ethan’s level of shake/bang responding plateaued following implementation of the full prompt and partial prompt phases of intervention for the dropping response, but jumped up once time delay was introduced. At the 1-month follow-up probe, the cumulative number of correct shake/bang responses increased to over 846.

Chester (bottom panel of Figure 4) began to shake/bang at the very end of baseline, demonstrating 29 cumulative shake/bang responses by the final baseline probe before implementing intervention. Shaking/banging responses then increased dramatically during reach-grasp intervention, increasing to over 400 responses. Chester’s cumulative shake/bang responses then jumped by another 500 responses, to almost 1000 responses, during intervention for visually examining a toy in hand, but increased very little during dropping intervention. Like the other infants, Chester’s level of shake/bang responding plateaued slightly (i.e., for 2 sessions) following implementation of the full prompt phase of intervention for the dropping response, but
slowly increased once the partial prompt phase and time delay were introduced. By the end of intervention for the final target response, at the follow-up probe, the cumulative number of correct shake/bang responses increased to 1093.

**EM Behavior Chain.** The EM behavior chain required the infant to emit the reach-grasp response followed by at least two other EM behaviors. Therefore, the infant would not be expected to emit an EM behavior chain until he/she had learned to reach-grasp and at least visually examine. For Rachel (top panel of Figure 5), once intervention began for visually examining a toy in hand, Rachel’s EM chain responses increased to 7 cumulative responses (she emitted sequences of reach-grasp, visually examining a toy in hand, and shake-bang). By the end of intervention for all three target responses, at the follow-up probe, EM behavior chain responses increased to 21 cumulative chains. The rate of EM behavior chain responses increased most toward the end of dropping intervention, during time delay.

Like Rachel, Ethan (middle panel of Figure 5) began to emit the EM behavior chain upon implementation of intervention for visually examining a toy in hand, with 5 cumulative EM behavior chain responses. Following mastery of the final target response (i.e., dropping), Ethan’s rate of EM chains increased to 23 and further increased at the 1-month follow up to 32. Again, similar to Rachel, Ethan’s rate of EM behavior chains increased most toward the end of dropping intervention, during time delay.

Chester (bottom panel of Figure 5) also began to emit EM behavior chain responses once intervention for visually examining a toy in hand began in the full prompt phase. At this point in intervention (7 sessions following the onset of intervention), Chester’s cumulative number of correct EM chains was 5 and, following intervention for the dropping response, increased to 13
at the follow-up. Chester demonstrated relatively rapid increases in rates of EM behavior chains across intervention for all target responses.

**Collateral Changes**

Tables 1 and 2 depict performance pre- and post-intervention for the Cognitive and Motor subscales of the Bayley-III, respectively. These are the most relevant subscales to EM behavior. Each table shows both the overall composite scores for the subscale as well as performance on individual items related to EM behavior. The individual item analysis allows the interventionist to examine changes on the items most related to EM behavior, whereas the composite score reflects a wide range of items, most of which are not directly related to EM behavior (e.g., Inspects Own Hands, Responds to Surroundings Series: Awareness of Novelty, Sits with Support Series: Briefly, and Rolls from Back to Sides). For the individual items related to EM behavior, the author indicated the age ranges at which those items could potentially be passed based on normative data. All infants were presented with specific items that were administered to them within 1-2 months of their chronological age. For example, if an infant was 4 months, 0 days old at the time of testing, the interventionist would administer items meant for infants between 3 months, 16 days – 4 months, 15 days, as he/she chronologically fell within that age range.

At pre-intervention, all infants were between 4 months, 0 days to 6 months, 4 days old (this was the adjusted age for Rachel). At post-intervention, all of the infants were between 7 months, 28 days to 10 months, 23 days old. In examining the items passed and failed it is important to consider the age of the infants and the age range for the individual items.

On the Cognitive subscale (Table 1), each infant received composite scores between 60 to 90 on the pre-intervention assessment, and composite scores between 60 to 95 for the post-
intervention assessment. Cognitive composite scores remained the same for Rachel and Ethan and increased slightly for Chester.

On individual items, Rachel completed items in the 5 month, 16 day - 8 month, 30 day age range post-intervention, but continued to have difficulty with items at her post-intervention adjusted chronological age of 10 months, 23 days, only mastering one item in the 9 month, 0 day -10 month, 30 day range, the same item she mastered pre-intervention.

Ethan, at 9 months, 18 days old post-intervention, mastered all of the items in the 5 month, 16 day - 8 month, 30 day ranges, but also demonstrated difficulty with items at his post-intervention chronological age, only mastering one item in the 9 month, 0 day -10 month, 30 day range and one item in the 11 month, 0 day -13 month, 15 day age range.

Chester, at 7 months, 28 days old post-intervention, not only mastered all of the items in the 5 month, 16 day - 8 month, 30 day ranges, but at his post-intervention chronological age, he showed success with more advanced items, mastering 3 items in the 9 month, 0 day - 10 month, 30 day range, and one item in the 11 month, 0 day - 13 month, 15 day age range. Table 2 illustrates performance pre-and post-intervention for the Motor subscale of the Bayley-III. On the Motor subscale, each infant received composite scores between 49 to 88 on the pre-intervention assessment, and composite scores between 58 to 76 for the post-intervention assessment. Motor composite scores decreased for Ethan and Chester and increased for Rachel.

At her post-intervention adjusted chronological age of 10 months, 23 days, Rachel demonstrated success with all items in the 4 month, 16 day - 10 month, 30 day ranges and even one item in the 11 month, 0 day - 13 month, 15 day age range. Post-intervention, at his chronological age of 9 months, 18 days old, Ethan mastered all items in the 4 month, 0 day - 8 month, 30 days ranges, but did not demonstrate mastery of many of the items in his
chronological age range, only mastering two items in the 9 month, 0 day - 10 month, 30 day range, and one item in the 11 month, 0 day - 13 month, 15 day ranges. At his post-intervention chronological age of 7 months, 28 days old, Chester mastered all of the items in the 4 month, 16 day - 6 month, 15 day ranges, and 3 of the 4 items in the 6 month, 16 day-8 month, 30 day range. Interestingly, although he did not master any items in the 9 month, 0 day - 10 month, 30 day range, he did master one item in the 11 month, 0 day -13 month, 15 day range.

Social Validity

Each caregiver completed a questionnaire intended to assess social validity following intervention. Caregivers rated five questions about the importance of engaging in EM behavior, the effectiveness of the intervention in increasing EM behavior, satisfaction with the intervention, appropriateness of intervention, and intention to continue to implement the intervention as needed. Each question was rated on a scale from 1 to 7 with higher numbers indicating more positive perceptions of the intervention. Each caregiver rated all 5 questions seven out of seven post-intervention.

Discussion

Specific prompts and social reinforcement were effective to teach young infants with Down syndrome to emit EM responses including reach-grasp, visually examine, and drop. This is the first demonstration of intervention to teach EM behavior to infants with Down syndrome of which the author is aware. Intervention lasted 10-11 weeks for each infant and resulted in EM performance at mastery levels during follow-up and most generalizations sessions. EM performance generalized across toys, settings, and partners, indicating that this intervention yielded externally valid results. Infants also demonstrated generalization across responses, spontaneously beginning to shake/bang the toys as intervention progressed. Standardized
assessment of cognitive and motor development showed some improvements. Finally, caregivers’ responses on the social validity measure indicated that intervention procedures were highly appropriate and that they will use this intervention in the future as needed.

**Etiology-Based Behavior Analytic Intervention**

Bauer and Jones (2014) proposed a model of EM behavior that considers a number of variables that may impact EM behavior specifically in infants with Down syndrome. This model further suggests intervention strategies to address weaknesses in EM behavior. As suggested by leading researchers in the field of Down syndrome (e.g., Hodapp & Fidler, 1999; Fidler & Nadel, 2007; Fidler, 2005), etiology based interventions that address phenotypic weaknesses (e.g., EM behavior) by building on phenotypic strengths may be particularly powerful interventions. Such interventions use an already present strength to target an area in which infants need improvement. In this case, we used social interest, a phenotypic strength associated with Down syndrome, as a consequence for engaging in EM behavior. Intervention involved multiple repeated opportunities (10 opportunities), each of two sessions per week. On each opportunity, the interventionist prompted and provided reinforcement for correct EM behavior. The author provided social reinforcement to build on this phenotypic strength. This is a behavior analytic approach to intervention, which has been suggested by Fidler (2005; Fidler used the term operant conditioning), Buckley (2008; Buckley used the term behavior modification), and Jones and Feeley, (2011). Several recent studies also support the effectiveness of behavior analytic interventions to address the needs of infants and children with Down syndrome (e.g., Poulson, 1988; Mace, Hock, Lalli, West, Belfiore, Pinter, et al., 1988; Dodd, McCormack, & Woodyatt, 1994; Drash, Raver, Murrin, & Tudor, 1989; Bauer, Jones, & Feeley, 2014; Feeley, Jones, Blackburn, & Bauer, 2011). For example, Bauer and Jones (2015) used a behavior analytic
approach focusing on phenotypic weaknesses in communication skills and the strength in social skills (as a reinforcer) to teach verbal imitation and requesting to 5 toddlers with Down syndrome. Despite the successful results of the present study and previous studies mentioned, the packaged nature of the intervention bears mention. That is, the present intervention was a package of components/strategies. It is difficult to conclude what components are necessary or if all components/strategies are necessary to improve EM behavior. Future research might explore the various components of the intervention package separately (i.e., prompting, and social reinforcement).

Future research may also involve chaining some components of intervention. For example, for the error correction procedure, upon an incorrect response, the interventionist responded with “Uh, uh, try again” and then immediately presented another opportunity to the infant. However, the interventionist did not turn her head away and, therefore, did not fully remove social engagement following an incorrect response, but simply did not provide social praise. A question for future research is whether this change may make social interaction and engagement an even more effective reinforcer for correct responding and improve learning.

Since this is but one study investigating the impact of behavior analytic interventions to address EM Behavior in infants with Down syndrome, future research is warranted to replicate these findings with additional infants with Down syndrome. All three infants were classified as Type 2 babies according to Dmitriev (2001)’s motor types; they showed stronger upper back, neck, shoulder, and arm muscles, but difficulty bearing weight on their legs. Type 1 (15%–25%) infants have good muscle tone and meet typical milestones such as head control, bearing weight on feet with support, and lifting the torso on extended arms by 4 months; the author would probably expect infants showing Type 1 motor development to respond similarly or even more
quickly to this intervention. However, Type 3 babies have strong legs and lower torso, but weaker upper torso, neck, head, shoulders, and arms and Type 4 babies (15%–25%) show muscle weakness throughout their bodies. Given the focus in this intervention on upper body, both Types 3 and 4 babies may not respond in the same way to intervention, perhaps requiring longer intervention durations or increased number of opportunities or sessions per week in order to master the target responses due to their particular upper body muscle weakness. Future research might explore additional upper body positioning supports along with increasing certain aspects of intervention including the number of opportunities, sessions per week, and/or duration to help Types 3 and 4 babies master EM behavior.

The multiple baseline across responses design allows for the conclusion that the present intervention was successful across 3 responses and 3 infants between 4-9 months of age. However, the age average of all three infants was right around the age at which EM behavior typically emerges for infants with Down syndrome (Cadoret & Beuter, 1994). Thus, it could be that intervention facilitated EM behavior, but the infants may have begun to show EM behavior at nearly the same time even without this intervention. Changing the design such as with a multiple baseline across infants and/or following a small group of infants with Down syndrome at the same age who do not receive this intervention would provide further information about the role of maturation in this intervention.

**Stimulus and Response Generalization**

Not only did infants acquire target EM responses pretty quickly, they also showed generalization of those responses to novel toys and settings as in the Needham et al. (2002) study; however, generalization across partner varied, with low levels of correct responding occurring at least once across all infants. The poorer generalization performance across partners
may relate to one component of intervention— withholding social interaction before opportunities so that it would only be used as a reinforcing consequence for correct EM responding. In implementing intervention with each infant, the interventionist created a clear contingency such that social interaction was only delivered as a reinforcing consequence. However, partners who participated in generalization probes were the infants’ mothers, grandmothers, and siblings. Despite the interventionist’s instructions, the generalization partners still tended to respond to the infants’ social behavior with social interaction before EM behavior occurred. Further, during generalization probes across partner, the interventionist was present throughout and provided feedback to the novel partner as he/she presented opportunities to the infants. This too may have impacted generalization results across partner because the interventionist had a history of stimulus control over the EM behaviors emitted by each infant so merely the presence of the interventionist may have influenced performance. Future researchers might consider simply having the novel caregivers conduct generalization probes when the interventionist is not present in order to resolve this potential limitation.

In addition to stimulus generalization, infants also demonstrated response generalization across shake/bang and an EM behavior chain. Within just 10-11 weeks of intervention, infants spontaneously emitted shake/bang responses without training. Chester and Rachel showed similar patterns of responding for shake/bang; once intervention began for reach-grasp, both infants showed increases in the rate of shake/bang responding and then demonstrated a slowing in the rate of shake/bang responding once intervention for visually examining a toy in hand was introduced. Interestingly however, Ethan’s rate of shake/bang responding increased slowly during intervention for reach-grasp and visually examining a toy in hand, but then increased dramatically during the partial prompt and time delay phases of the dropping response. For all
three infants, the level of shake/bang responding initially plateaued during the full prompt phase of intervention for the dropping response. This is likely because, at the onset of the full prompt phase of intervention for dropping, the interventionist immediately prompted the infants to fling the toy from their hand(s), thus making it impossible to engage in any further shake/bang responses.

Infants also began to emit EM behavior chain responses following implementation of intervention for the second target EM response of visually examining a toy in hand. Once this second target response was taught, infants could combine reach-grasp with shake-bang (that they had begun to emit spontaneously) and visually examining a toy in hand. Although increases in EM behavior chain responses as this point in intervention were slight, once intervention was completed for the final target response (i.e., dropping) and at follow-up probes, all infants showed increases in EM behavior chains. Nonetheless, the cumulative number of EM chains was not very high, certainly not as high as the cumulative number of shake/bang responses. The author might suggest that this is due to the fact that the interventionist began teaching infants to simply engage in single EM behaviors. Once infants learned to engage in at least two EM behaviors, they then began to tentatively emit EM chains (as can be seen in Figure 5).

Presumably, now that intervention is complete and infants continue to emit more EM chains, this will result in natural consequences, from the object and caregiver, and then those chains will continue to increase (as can be inferred from Figure 5). In future research, investigators might consider adding an additional 3-month post intervention follow-up probe to determine if EM chains will increase even more following intervention. Further, perhaps as infants learn more and more EM responses, they will begin to emit more EM chains. Or perhaps it may be that in order to increase the occurrence of EM chains, interventionists need to directly reinforce the chain.
Finally, future researchers might investigate teaching many EM responses to infants with Down syndrome and simultaneously measure EM chain responding.

In this study we focused on the initial reach-grasp response necessary for EM behavior and three early emerging EM behaviors (visually examining a toy in hand, dropping, and shaking/banging). There are other EM behaviors such as pushing or rolling a toy. As typically developing infants master the early developing EM behaviors taught here, they begin to explore different objects in different ways, showing what Fidler (2005) referred to as object generativity or what we might describe as generalization. We could teach all of the EM responses but object generativity involves engaging in familiar EM behaviors with novel objects (stimulus generalization), novel EM behaviors with familiar objects (response generalization), or even novel EM responses with novel objects. In the present study, we showed the beginning of object generativity by demonstrating response generalization in the form of shaking/banging (novel action with familiar object) and stimulus generalization across toys (familiar action with novel objects). Future research might expand upon this and teach infants to engage in familiar EM behaviors, but with a much larger range of novel objects, providing multiple exemplars of toys to increase the likelihood of generalization and demonstration of object generativity in the form of familiar actions on novel objects. We could also carefully teach select combinations of EM behaviors and objects that might result in generalization in different combinations. We could combine various EM behaviors and objects in a matrix and then teach the action-object combinations along the diagonal of the matrix while probing for generalization to other combinations of actions and objects; this is referred to as matrix training (Goldstein, 1983). For example, if we teach an infant to fly an airplane, push a train, and drop a ball, the infant may demonstrate recombinative generalization by pushing and dropping the airplane, flying and
dropping the train, and flying and pushing the ball; that is, the infant recombines the different EM behaviors and objects he/she has learned into different combinations of EM behaviors-objects. The EM behavior-object combinations along the diagonal of the matrix are taught, while others may emerge without direct intervention, consistent with Fidler’s concept of object generativity.

Collateral Changes

Bauer and Jones (2014) also proposed that early changes in the EM behavior patterns of infants with Down syndrome may be related to changes in further motor and cognitive development. For example, engaging in EM behavior helps to develop muscle strength and fine motor movements (Gibson, 1988) and benefits cognitive skills such as problem solving and planning (Fidler, et al., 2011). The present study assessed related changes in cognitive and motor skills using the Bayley-III. On the Bayley, Motor composite scores increased from pre-to-post-test only for Rachel, and Cognitive composite scores increased only for Chester, though all infants showed improvements on individual items most related to EM behavior.

Bayley-III scores may not be the best measure of infant cognitive and motor skills. For example, on the Bayley-III, there was just one assessment opportunity for reaching and grasping. One probe opportunity may not be sufficient to accurately measure reaching and grasping. Thus, the infants’ Bayley-III performance may have looked more or less advanced compared to their baseline performance involving multiple opportunities across several session and days.

The Bayley-III and other similar measures provide a global assessment of skills that may not be sensitive enough to detect the kind of changes we are likely to see after only 10-11 weeks of intervention (and the passage of 3-4 months from pre-assessment to post-intervention assessment). This is consistent with our careful examination of individual items on each of the
subscales. Infants’ performance improved on the items evaluating the behaviors targeted in this study, demonstrating that the infants did develop some skills at a rate that was similar to typically developing infants of the same chronological age, especially on the Cognitive Subscale, and did not fall further behind, but no collateral changes on other motor or cognitive skills were observed.

The Bayley was included as part of the examination of EM behavior as a pivotal skill. Pivotal behaviors are those that provide the opportunity for corresponding changes in other adaptive untrained behaviors (Cooper, Heron, & Heward, 2002). Though I did not see extensive response generalization on the Bayley, I did on the measure of response generalization to shake/bang and the EM behavior chain. The spontaneously emitted shake/bang and EM behavior chain responses suggest that learning to emit three EM behaviors in intervention resulted in changes in similar EM responses that were not specifically taught.

Perhaps future research might use other developmental tests that evaluate more specific cognitive and motor skills. For example, problem-solving may relate to EM behavior and reflects a specific area of cognitive development. The Ages and Stages Questionnaire, Third Edition (ASQ-3) (Squires & Bricker, 2009) is a screening questionnaire covering 5 developmental areas, one of which is problem solving. It may also be that teaching other or additional EM behaviors, especially the EM behavior chain (as discussed previously), may be necessary to see more global changes in cognitive and motor functioning.

Conclusion

The present study demonstrated that Bauer and Jones’ (2014) model of intervention using specific toys, positions, prompting, and social reinforcement procedures was effective to teach EM behavior to infants with Down syndrome. The current study targeted very young infants in
an effort to prevent or alleviate some of the motor and cognitive impairments generally observed in individuals with Down syndrome. Ultimately, this approach has the potential to minimize early EM deficits and further minimize/prevent associated negative consequences.
### Responses | Definitions
--- | ---
1. Reach/Grasp | Raising and moving one or both arms toward the toy (Reach) and immediately closing all of the fingers of at least one hand around a part of the toy, or the entire toy (Grasp)
2. Visually examine | Bringing the toy within 2.5 – 12.5 centimeters of the eyes with infant’s eyes directed to the toy
3. Shake or bang | Shaking - holding a toy in one or both hands and moving it back or forth in the air at least one time. Banging - holding a toy in one or both hands and bringing it into contact with a surface (i.e., table top, floor, another toy, etc.).
4. EM Behavior Chain | EM chains will begin with a reach/grasp, and proceed to a randomly selected sequence of at least two more EM responses including visually examining a toy in hand and shaking/banging.

**Directions:**
1. Sit across from your child and present toy within arm’s reach (as determined)
2. Ensure your child is looking at the toy by shaking it/activating it.
3. Wait 8 s for a response (try NOT to interact with your child during the 8 second opportunity).
4. If your child reaches for, grasps, visually examines, shakes/bangs, or even drops the toy, you may smile slightly and make casual comments about the toy.
5. If your child makes no response, DO NOT say anything, keep a straight face.
6. Circle a “+” if your child emits a correct response or a “-” if your child emits an incorrect response.

<table>
<thead>
<tr>
<th>Target Response: <strong>REACH/GRASP</strong></th>
<th>Target Response: <strong>VISUALLY EXAMINE</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Date:</strong></td>
<td><strong>Date:</strong></td>
</tr>
<tr>
<td><strong>Trial #</strong></td>
<td><strong>Correct/Incorrect</strong></td>
</tr>
<tr>
<td>1.</td>
<td>+ −</td>
</tr>
<tr>
<td>2.</td>
<td>+ −</td>
</tr>
<tr>
<td>3.</td>
<td>+ −</td>
</tr>
<tr>
<td>4.</td>
<td>+ −</td>
</tr>
<tr>
<td>5.</td>
<td>+ −</td>
</tr>
<tr>
<td>6.</td>
<td>+ −</td>
</tr>
<tr>
<td>7.</td>
<td>+ −</td>
</tr>
<tr>
<td>8.</td>
<td>+ −</td>
</tr>
<tr>
<td>9.</td>
<td>+ −</td>
</tr>
<tr>
<td>10.</td>
<td>+ −</td>
</tr>
<tr>
<td>%</td>
<td></td>
</tr>
</tbody>
</table>

Initials

*Appendix A*

IOA: Y/N
Observer: 

**EM Baseline Data Sheet**
Child’s Name: 

---

39
<table>
<thead>
<tr>
<th>Trial #</th>
<th>Correct/Incorrect</th>
<th># of Drops/ # of EM Chains</th>
</tr>
</thead>
<tbody>
<tr>
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<td>+ −</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>+ −</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>+ −</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>+ −</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>+ −</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>+ −</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>+ −</td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>+ −</td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td>+ −</td>
<td></td>
</tr>
<tr>
<td>10.</td>
<td>+ −</td>
<td></td>
</tr>
</tbody>
</table>

% Initials
**EM Intervention Data Sheet**

<table>
<thead>
<tr>
<th>Responses</th>
<th>Definitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Reach/Grasp</td>
<td>Raising and moving one or both arms toward the toy (Reach) and immediately closing all of the fingers of at least one hand around a part of the toy, or the entire toy (Grasp)</td>
</tr>
<tr>
<td>2. Visually examine</td>
<td>Bringing the toy within 2.5 – 12.5 centimeters of the eyes with infant’s eyes directed to the toy</td>
</tr>
<tr>
<td>3. Shake or bang</td>
<td>Shaking - holding a toy in one or both hands and moving it back or forth in the air at least one time. Banging - holding a toy in one or both hands and bringing it into contact with a surface (i.e., table top, floor, another toy, etc.).</td>
</tr>
<tr>
<td>4. EM Behavior Chain</td>
<td>EM chains will begin with a reach/grasp, and proceed to a randomly selected sequence of at least two more EM responses including visually examining a toy in hand and shaking/banging.</td>
</tr>
</tbody>
</table>

**Directions:**
1. Sit across from your child and present toy within arm reach (as determined)
2. Ensure your child is looking at the toy by shaking it/activating it.
3. Use appropriate prompt (or no prompt) to help your child emit an EM response.
4. Circle a “+” if your child emits a correct response and provide lots of social reinforcement (praise, smiles, tickles, etc.)
5. Circle a “-” if your child does NOT emit a correct response.

Child’s Name: ______________

**FP = Full prompt**  
**PP = Partial prompt**  
**TD = Time Delay (No prompt)**

**Target Response:** ______________________  
**Interventionist:** _____________________

**FOR EM CHAIN ONLY:** Circle Sequence Used:
1. Visually Examine -> Shake/Bang  
2. Visually Examine -> Visually Examine  
3. Shake/Bang -> Visually Examine  
4. Shake/Bang -> Shake/Bang

<table>
<thead>
<tr>
<th>Date:</th>
<th>Trial #</th>
<th>Correct/Incorrect</th>
<th>Prompt</th>
<th># of shake/bangs</th>
<th># of EM Chains (Indicate Sequence &amp; Duration)</th>
<th>Trial #</th>
<th>Correct/Incorrect</th>
<th>Prompt</th>
<th># of shake/bangs</th>
<th># of EM Chains (Indicate Sequence &amp; Duration)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.</td>
<td>+ –</td>
<td></td>
<td></td>
<td></td>
<td>1.</td>
<td>+ –</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.</td>
<td>+ –</td>
<td></td>
<td></td>
<td></td>
<td>2.</td>
<td>+ –</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.</td>
<td>+ –</td>
<td></td>
<td></td>
<td></td>
<td>3.</td>
<td>+ –</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4.</td>
<td>+ –</td>
<td></td>
<td></td>
<td></td>
<td>4.</td>
<td>+ –</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>5</td>
<td>+</td>
<td>−</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>+</td>
<td>−</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>+</td>
<td>−</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>+</td>
<td>−</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>+</td>
<td>−</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>+</td>
<td>−</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
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<tr>
<td>%</td>
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</tbody>
</table>
### Stimulus Generalization Data Sheet

<table>
<thead>
<tr>
<th>Responses</th>
<th>Definitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Reach/Grasp</td>
<td>Raising and moving one or both arms toward the toy (Reach) and immediately</td>
</tr>
<tr>
<td></td>
<td>closing all of the fingers of at least one hand around a part of the toy, or</td>
</tr>
<tr>
<td></td>
<td>the entire toy (Grasp)</td>
</tr>
<tr>
<td>2. Visually examine</td>
<td>Bringing the toy within 2.5 – 12.5 centimeters of the eyes with infant’s</td>
</tr>
<tr>
<td></td>
<td>eyes directed to the toy</td>
</tr>
<tr>
<td>3. Shake or bang</td>
<td>Shaking - holding a toy in one or both hands and moving it back or forth in</td>
</tr>
<tr>
<td></td>
<td>the air at least one time. Banging - holding a toy in one or both hands and</td>
</tr>
<tr>
<td></td>
<td>bringing it into contact with a surface (i.e., table top, floor, another</td>
</tr>
<tr>
<td></td>
<td>toy, etc.).</td>
</tr>
<tr>
<td>4. EM Behavior Chain</td>
<td>EM chains will begin with a reach/grasp, and proceed to a randomly selected</td>
</tr>
<tr>
<td></td>
<td>sequence of at least two more EM responses including visually examining a</td>
</tr>
<tr>
<td></td>
<td>toy in hand and shaking/banging.</td>
</tr>
</tbody>
</table>

**Directions:**
1. Sit across from your child and present toy within arm reach (as determined)
2. Ensure your child is looking at the toy by shaking it/activating it.
3. Wait 5 s for a response (try NOT to interact with your child during the 5-s opportunity).
4. If your child reaches for, grasps, visually examines, shakes/bangs, or even drops the toy, you may smile slightly and make casual comments about the toy.
5. If your child makes no response, DO NOT say anything, keep a straight face.
6. Circle a “+” if your child emits a correct response or a “−” if your child emits an incorrect response.

---

**Generalization Across (Circle one):**

<table>
<thead>
<tr>
<th>TOYS</th>
<th>PARTNERS</th>
<th>SETTINGS</th>
</tr>
</thead>
</table>

**Target Response:**

<table>
<thead>
<tr>
<th>Date:</th>
<th>Correct/Incorrect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trial #</td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>+ –</td>
</tr>
<tr>
<td>2.</td>
<td>+ –</td>
</tr>
<tr>
<td>3.</td>
<td>+ –</td>
</tr>
<tr>
<td>4.</td>
<td>+ –</td>
</tr>
<tr>
<td>5.</td>
<td>+ –</td>
</tr>
<tr>
<td>%</td>
<td></td>
</tr>
</tbody>
</table>

Initials
## Appendix D

### Social Validity Likert scale – Appropriateness of Intervention

1. **Is it important that infants engage in EM behavior?**
   
<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Not successful.</td>
<td>Somewhat successful.</td>
<td>Very successful.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. **Overall, How successful was the intervention in increasing your child's Exploratory Motor (EM) behaviors (i.e. reach/grasp, visually examining a toy in hand, and shaking/banging)?**
   
<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intervention procedures were not appropriate.</td>
<td>Intervention procedures were somewhat appropriate.</td>
<td>Intervention procedures were very appropriate.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. **How satisfied are you with this intervention?**
   
<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
</table>

4. **We taught your child EM behavior using lightweight toys, specific positioning, prompting, and reinforcement. Was this an appropriate way to teach your child?**
   
<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>No, never.</td>
<td>Maybe, at times.</td>
<td>Yes, definitely.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5. **Will you continue to implement intervention as needed?**
   
<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>No, not at all.</td>
<td>Somewhat.</td>
<td>Yes, Definitely.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix E

Treatment Integrity Instruction & Data Sheet

Name __________
Program: ________________

Instruction: 1. Analyze interventionist procedure during each trial and indicate if interventionist

<table>
<thead>
<tr>
<th>Procedures</th>
<th>Did the interventionist:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sd</td>
<td>A) Deliver Sd: present toy</td>
</tr>
<tr>
<td>Prompting</td>
<td>B) Present appropriate toy, place infant in correct position, and present appropriate</td>
</tr>
<tr>
<td></td>
<td>physical prompt/no prompt during time delay</td>
</tr>
<tr>
<td>Reinforcement/</td>
<td>C) Reinforce correct response by providing social praise (e.g., “yay!”), tickles,</td>
</tr>
<tr>
<td>No consequence</td>
<td>laughs, etc.)</td>
</tr>
<tr>
<td></td>
<td>D) Not deliver any consequence upon incorrect response/no response</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Date</th>
<th>Target Response</th>
<th>Prompt</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Trial 1</th>
<th>Y/N</th>
<th>Trial 2</th>
<th>Y/N</th>
<th>Trial 3</th>
<th>Y/N</th>
<th>Trial 4</th>
<th>Y/N</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
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<td>A</td>
<td></td>
<td>A</td>
<td>A</td>
<td></td>
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</tr>
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<td>C</td>
<td>C</td>
<td></td>
<td>C</td>
<td>C</td>
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</tr>
<tr>
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<td>D</td>
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</table>

<table>
<thead>
<tr>
<th>Trial 5</th>
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<th>Trial 6</th>
<th>Y/N</th>
<th>Trial 7</th>
<th>Y/N</th>
<th>Trial 8</th>
<th>Y/N</th>
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</thead>
<tbody>
<tr>
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<td>A</td>
<td>A</td>
<td></td>
<td>A</td>
<td>A</td>
<td></td>
<td></td>
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<td>C</td>
<td>C</td>
<td></td>
<td>C</td>
<td>C</td>
<td></td>
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</tr>
<tr>
<td>D</td>
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<td></td>
<td>D</td>
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</table>

<table>
<thead>
<tr>
<th>Trial 9</th>
<th>Y/N</th>
<th>Trial 10</th>
<th>Y/N</th>
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<tbody>
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<td>A</td>
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<td>A</td>
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<td>B</td>
<td>B</td>
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<td>C</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td></td>
<td>D</td>
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</tr>
</tbody>
</table>
Figure 1. The three graphs represent percentage of correct EM responses during baseline, intervention, generalization, and follow up sessions for Rachel. Full prompt, partial prompt, and times delay are indicated by FP, PP, and TD, respectively. During baseline, generalization, and TD sessions, performance reflects percentage of correct independent responses only. During FP and PP, correct responses are independent or prompted.
Figure 2. The three graphs represent percentage of correct EM responses during baseline, intervention, generalization, and follow up sessions for Ethan. Full prompt, partial prompt, and times delay are indicated by FP, PP, and TD, respectively. During baseline, generalization, and TD sessions, performance reflects percentage of correct independent responses only. During FP and PP, correct responses are independent or prompted.
Figure 3. The three graphs represent percentage of correct EM responses during baseline, intervention, generalization, and follow up sessions for Chester. Full prompt, partial prompt, and times delay are indicated by FP, PP, and TD, respectively. During baseline, generalization, and TD sessions, performance reflects percentage of correct independent responses only. During FP and PP, correct responses are independent or prompted.
Figure 4. The three graphs represent the cumulative number of correct shake/bang responses over the course of the study for Rachel, Ethan, and Chester. Reach-grasp, visually examining a toy in hand, and dropping EM behaviors are depicted to indicate rate of shake/bang responses during intervention for each target response.
Figure 5. The three graphs represent the cumulative number of EM behavior chains emitted over the course of the study for Rachel, Ethan, and Chester. Reach-grasp, visually examining a toy in hand, and dropping EM behaviors are depicted to indicate rate of EM behavior chains during intervention for each target response.
Table 1

Pre-and Post-Intervention Scores and Confidence Intervals on the Cognitive Subscale of the Bayley Scales of Infant and Toddler Development (Bayley-III) and Participant Correct (+) or Incorrect (-) Responses to the Relevant Individual Items on the Cognitive Subscale Pre and Post Intervention, Separated According to Age Range.

<table>
<thead>
<tr>
<th>Ages (months-days)</th>
<th>Rachel Pre</th>
<th>Rachel Post</th>
<th>Ethan Pre</th>
<th>Ethan Post</th>
<th>Chester Pre</th>
<th>Chester Post</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6 - 4</td>
<td>10 - 23</td>
<td>4 - 6</td>
<td>9 - 18</td>
<td>4 - 0</td>
<td>7 - 28</td>
</tr>
<tr>
<td>Cognitive Composite</td>
<td>60</td>
<td>60</td>
<td>65</td>
<td>65</td>
<td>90</td>
<td>95</td>
</tr>
<tr>
<td>95% Confidence Interval</td>
<td>(56-72)</td>
<td>(56-72)</td>
<td>(60-)</td>
<td>(60-)</td>
<td>(83-)</td>
<td>(87-)</td>
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<td></td>
<td>76</td>
<td>76</td>
<td>99</td>
<td>103</td>
<td></td>
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</table>

Cognitive Subscale Items

<table>
<thead>
<tr>
<th>5 month, 16 days - 6 months, 15 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Persistent Reach</td>
</tr>
<tr>
<td>-</td>
</tr>
<tr>
<td>+</td>
</tr>
<tr>
<td>+</td>
</tr>
<tr>
<td>+</td>
</tr>
<tr>
<td>-</td>
</tr>
<tr>
<td>+</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>6 months, 16 days – 8 months, 30 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plays with String</td>
</tr>
<tr>
<td>-</td>
</tr>
<tr>
<td>+</td>
</tr>
<tr>
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<table>
<thead>
<tr>
<th>9 months, 0 days – 10 months, 30 days</th>
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<tbody>
<tr>
<td>Bell series: Manipulates</td>
</tr>
<tr>
<td>+</td>
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<tr>
<td>+</td>
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<td>+</td>
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<table>
<thead>
<tr>
<th>Reaches for Second Block</th>
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<tbody>
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<table>
<thead>
<tr>
<th>Pulls Cloth to Obtain Object</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
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<table>
<thead>
<tr>
<th>Pulls String Adaptively</th>
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</thead>
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<tr>
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<table>
<thead>
<tr>
<th>Retains both Blocks</th>
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<tr>
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<td>-</td>
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</table>

<table>
<thead>
<tr>
<th>11 months, 0 days – 13 months, 15 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rings Bell Purposefully</td>
</tr>
<tr>
<td>-</td>
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<td>-</td>
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Table 2

*Pre-and Post-Intervention Scores and Confidence Intervals on the Motor Subscale of the Bayley Scales of Infant and Toddler Development (Bayley-III) and Participant Correct (+) or Incorrect (-) Responses to the Relevant Individual Items on the Motor Subscale Pre and Post Intervention, Separated According to Age Range.*

<table>
<thead>
<tr>
<th>Ages (months–days)</th>
<th>Rachel</th>
<th>Ethan</th>
<th>Chester</th>
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<tbody>
<tr>
<td>Pre</td>
<td>Post</td>
<td>Pre</td>
<td>Post</td>
</tr>
<tr>
<td>6 - 4</td>
<td>10 - 23</td>
<td>4 - 6</td>
<td>9 - 18</td>
</tr>
<tr>
<td>Motor Composite</td>
<td>49</td>
<td>58</td>
<td>82</td>
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<tr>
<td>95% Confidence Interval</td>
<td>(45-61)</td>
<td>(54-69)</td>
<td>(76-91)</td>
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<tr>
<td>Motor Subscale Items</td>
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<tr>
<td>4 months, 16 days – 5 months, 15 days</td>
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<tr>
<td>Grasps Suspended Ring</td>
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<td>+</td>
<td>+</td>
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<tr>
<td>5 months, 16 days – 6 months, 15 days</td>
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<tr>
<td>Reaches for Block</td>
<td>-</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Touches Block</td>
<td>-</td>
<td>+</td>
<td>-</td>
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<tr>
<td>6 months, 16 days – 8 months, 30 days</td>
<td></td>
<td></td>
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<tr>
<td>Whole Hand Grasp</td>
<td>-</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Reaches Unilaterally</td>
<td>-</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Raking Grasp</td>
<td>-</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Partial Thumb</td>
<td>-</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Opposition</td>
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<tr>
<td>9 months, 0 days – 10 months, 30 days</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Transfers Ring</td>
<td>-</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Whole Hand Grasp</td>
<td>-</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Transfers Block</td>
<td>-</td>
<td>-</td>
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</tr>
<tr>
<td>11 months, 0 days – 13 months, 15 days</td>
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<td></td>
</tr>
<tr>
<td>Thumb-Fingertip Grasp</td>
<td>-</td>
<td>+</td>
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</tr>
<tr>
<td>Partial Thumb</td>
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<tr>
<td>Opposition</td>
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<tr>
<td>Lifts cup by Handle</td>
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</table>
References


Hanson, M. J. (1987). *Teaching the infant with Down syndrome: A guide for parents and professionals* (2nd ed.). Austin, TX: Pro-Ed.


