THESIS

OBJECT AFFORDANCES IN YOUNG CHILDREN WITH DOWN SYNDROME

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ABSTRACT

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Young children with Down syndrome (DS) have limited exploration of their surroundings (Loveland, 1987). This may have long-term effects for the development of representations of object affordances in this population. This study aims to look at the relationship between developmental status and object affordance skills in young children with DS. The sample consisted of thirteen 1 to 4 year olds with DS. The Mullen Scales of Early learning served as the developmental measure, an object retrieval task and the Fewell play scales were used to assess object affordance skills. The results of the study indicate that a higher developmental status is highly correlated with increased exploration of objects. These results contribute to the overall field of information regarding DS, but specifically to interventions to aid in the development of object affordances.

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CHAPTER 1--INTRODUCTION

Infants gain knowledge about objects through active exploration (Landry, Miller-Loncar, & Swank, 1998; Schore, 1994). Active exploration involves mouthing an object, fingering it, and visually inspecting it (Rochat, 1983). Infants begin to form an understanding of objects by integrating the knowledge gained from these explorations (Corbetta, 1998). This information is later translated into practical manipulations of objects, such as taking food from a plate and bringing it to the mouth to eat. There is a normative pattern of acquisition for these cognitive and motor skills (Rochat, 1989; Sommerville, Hildebrand, & Crane, 2008). Disturbances in these foundational skills can lead to the atypical development of object awareness and cognitive representations of an object's properties, disturbances that can have implications for other skills such as the development of tool use and effective movement strategies (deCampos, Rocha, & Savelsbergh, 2009).

Individuals with Down Syndrome (DS) have shown delays in cognitive and motor development (Berger & Cunningham, 1981; Gilmore, Cuskelly, & Hayes, 2003; MacTurk & McQuiston, 1982; Vietze, McCarthy, McQuiston, MacTurk, & Yarrow, 1983). These delays are evident in infants' integration of information about exploration, in infants' motivation to explore objects, and in their persistence when exploring their environment (Loveland, 1987; Ruskin, Mundy, Kasari, & Sigman, 1994; Thombs & Sugden, 1991). These specific delays may have cascading effects for children with DS, specifically in their understanding the properties of an object and how they can interact with it. Skills such as these are critical in the development of early tool use and undoubtedly have an impact on a child's ability to plan movements (Fontanelle, Kahrs, Neal, Newton, & Lockman, 2007).

In this study, I used the concept of object affordances as a framework to examine the development of manipulation of objects in the DS population. The concept of object affordances was developed by E.J. Gibson, and states that humans use the exploration of objects to gain an understanding of the properties of the objects such as its density, weight, size, shape, and texture (E.J. Gibson, 1982). Further, infants learn about the properties of an object (e.g., a solid wall versus a screen door) through oral, haptic, and visual exploration (Lockman & McHale, 1989). Children integrate the knowledge gained through this multimodal exploration to achieve more effective manipulations of objects (E.J. Gibson). As children grow older, these explorations become more varied and increasingly specific based on the object. For instance, in order to pick up a foam ball, children must have the knowledge about the density of the ball to know how hard to squeeze and the roundness and size of the ball to know how to position their hand.

In order to understand the atypical trajectory associated with early development in DS, it is important to look at the typical trajectory to understand how other populations differ from the norm. I examined the development of object affordances in typically developing (TD) infants by looking at their exploration of objects and how this exploration develops an infant's cognitive representations of objects and contributes to motor planning. I also discuss how cognitive representations of objects are used in the development of tool use. Then I will describe the difference between DS and TD infants in cognitive and motor development by looking at their exploration of objects, motivation, and integration of information. I discuss how these differences lead to the atypical development of object awareness and cognitive representations of an object's properties. Finally, I will describe the proposed study and its implications for interventions and further research within the field of DS.

Development of Object Exploration in TD infants

Exploration of objects is at the heart of infants' quest for knowledge and understanding of their environment and surroundings. Piaget (1954) stated that infants' exploration of their surroundings is the basis for sensorimotor and cognitive development. Helmholtz (1885) argued that even the youngest infants are driven to interact with their surroundings in order to gain knowledge about digital stimuli or causes of sensations through exploration. The innate need to explore one's surroundings is the root of developing a robust knowledge base of the physical world (Rochat, 1989). This knowledge further translates into specific properties of objects and what they afford (E.J. Gibson, 1982). Through multimodal exploration—haptic, oral, auditory and visual—infants compile information about an object's properties (J.J. Gibson, 1979).

The development of infants' engagement with the physical world follows a normative pattern over the first two years of life. At one month, infants can recognize a shape based on its texture through oral exploration (Gibson & Walker, 1984; Meltzoff & Borton, 1979). At this early age, infants are able to visually distinguish objects by shape and texture that they could only explore orally before (E. J Gibson, 1984; Meltzoff & Borton, 1979). This is the most simplistic stage of exploration: There is no specific goal and the manipulation is not specific to the object. This stage is defined by simple handling and mouthing of an object (Belsky & Most, 1981; Rochat, 1989).

As children grow older, exploration is done using different methods, and movement becomes more specific to the object (Bourgeois, Khawar, Neal, & Lockman, 2005; E.J. Gibson, 1984; Gibson & Spelke, 1983). The first stage of undifferentiated exploration occurs when at 4 months hand and eye coordination develops and an infant can begin to systematically examine objects by holding the object in one hand and digitally exploring with the other hand (Rochat, 1989). At this point in development, infants will begin to reach for objects and bring them closer for visual inspection (Lockman & McHale, 1989; Rochat, 1989). This opens a new avenue for the exploration of objects: The visual input of an object enhances an infants' multimodal exploration of items (E.J. Gibson, 1982; Rochat, 1989). This fingering of objects is used in conjunction with the visual processing of the object.

The increase of visual processing of objects in conjunction with haptic exploration was demonstrated in a study by Rochat (1989), where children were observed exploring objects in a well lit room and a dark room. Infants were found to digitally explore an object more in a well-lit room as opposed to a dark room, which indicates the importance of the visual aspect of exploration at this point in development. This stage of exploration is multimodal and becomes increasingly intentional, where the infant tailors the manipulation of an object based on a specific object's properties (Bushnell & Boudreau, 1993; Lockman & McHale, 1989; Ruff, 1984; Weisler & McCall, 1976). Infants can now recognize objects through manual exploration, differentiating by texture, density, and shape. As this phase is more fully developed and honed, a third phase emerges and infants begin to use an object not simply for discovery of properties, but for a purposeful action (Weisler & McCall, 1976). This stage is similar to tool use, where one object influences another.

The evolution from undifferentiated exploration to the purposeful use of an object is the product of exploration and development of knowledge about objects and their properties (E.J. Gibson, 1982; Lockman et al., 1989). As knowledge of an object is developed, the goal of interaction is no longer the discovery of properties, but the integration of preexisting knowledge into manipulating objects (Belsky & Most, 1981). This integration of preexisting knowledge is enhanced by multimodal exploration, and allows infants to develop a sense of the attributes of the physical world.

The synthesis of knowledge gained from exploration is further evidenced in a study conducted by Baillargeon (1994), who examined infants' reactions to plausible and implausible events. A box was placed on a table, a gloved hand pushed the box, and in the plausible event, the hand stopped pushing the box at the edge of the table. In the implausible event, the box is pushed over the edge of the table, and does not fall even when only 15% of the box is on the table. Baillargeon found that infants at 3 months of age only expected the box to fall if it did not retain any contact with the table; infants from 4.5 months of age to 5.5 months seem to be able to distinguish between the two events, noting that only the box in the former (plausible event) retains enough contact with the table to not fall. At 6.5 months, infants come to develop their knowledge of cause and effect even more, paying more attention to the amount of contact the box has with the table. These infants expect the box to fall when there is not a sufficient amount of contact between the table and the box. Here we can see that as children get older, the information gained through exploration is integrated into knowledge of real-life events. Children are gaining a sense of physics and properties of objects. These concepts continue to be more refined and more consistent with reality as more explorations are made and consequences witnessed (Baillargeon, 1994).

As children develop, a more advanced concept of constraints in the physical world is constructed through additional exploration. This is exemplified in a study conducted by Needham (2000), who examined the reactions of 3½-month-old infants when presented with two events involving naturally plausible and naturally implausible events with a box and cylinder. The first event, the "move apart" condition, is a naturally plausible event where a hand pushes the cylinder, the cylinder moves, and the box stays still. The second event is a naturally implausible event, called the "move together" event, in which a hand pushes the cylinder and both the box and the cylinder move. Infants designated as being "more active explorers" (as characterized by an increased amount of time manipulating objects both orally and haptically) showed more dishabituation in the "move apart" condition than in the "move together" event than infants who were labeled as "less active explorers."

Cognition and planning. As infants' cognitions of an event are integrated into everyday occurrences, the planning of movements toward a goal becomes more developed (Balliargeon, 1994). The development of strategy in goal-directed movements begins with exploration of the properties of an object (Bojczyk & Corbetta, 2004). These movements have been observed in object retrieval tasks where a desirable object is placed inside a transparent box and placed in front of a child (Bruner, 1970). Even when the properties of the box are discovered through exploration, children find it difficult to plan movements to find the opening to obtain the object. In a study conducted by Burner (1970), 6- to 17-month-old infants were observed engaged in the Object Retrieval Task. In this task children need to plan movements to lift the box's lid with one hand and reach for the object with the other.

Children from 6 to 8 months hit the top of the box and clawed at the surface, and infrequently obtained the toy from inside the box. At 9 to 11 months, infants began to lift the lid of the box, but only utilized one hand. This strategy was not optimal and presented problems in retrieving the object, but children in this age range obtained the object more frequently than younger children. At 12 to 14 months, infants began to use a two-handed strategy to open the lid and subsequently reach for the object. Infants in this age range experienced some trial and error in this strategy but eventually achieved their goal. Infants from 15 to 17 months were the first to show a flow and coordination to their strategy by using two hands in unison, lifting the lid of the box and reaching for the object without much trial and error. Through this study, a timeline was developed: Children use trial and error to gain understanding of a situation in the first year of life, and in the second year children begin to form strategy and implement the strategies motorically (Bruner, 1970).

The performance on the object retrieval task relates to the exploration of objects and development of object affordances discussed earlier. Children first build a base of knowledge about the properties of objects, and then proceed to planning effective strategies to manipulate objects to achieve a goal. Although much of object retrieval is based on development of muscles and refinement of gross and fine motor skills, there is a large cognitive component involved in the planning of movements (Baillargeon, 1987;

Bojczyk & Corbetta, 2004; Diamond, 1991). Children must take information they have gained through exploration of objects (e.g., hard, soft, round, square) and the physical properties of objects (e.g., gravity, cause and effect) and develop an efficient plan of action to reach a goal (Baillargeon, 1994; Munakata, McCelland, Johnson, & Siegler, 1997).

Exploration as an Avenue for Developing Representations of Object Affordances

As previously stated, infants use knowledge gained from exploration of objects to explore cause-and-effect relationships and gain information about physical properties. For example, visual processing of a doorknob gives the observer the understanding of roundness, and that the knob may be turned in order for the door to open and subsequently pulled. Using this information, people may position their hand in a fashion that allows them to accommodate the roundness of the knob as well as the need to turn the knob and pull. This information is built and grown in a one's mind from infancy on via explorations, as we grow and have more and more experiences with objects and their properties the better we can manipulate them in the most gainful ways (E.J. Gibson, 1982; Lockman et al., 1989).

The understanding of object affordances, according to Rochat (1987), begins in early infancy and is contingent on exploration of objects and their properties. In one study, Rochat (1987) examined newborns' responses when given a cylinder made of Lucite and a cylinder of the same shape and size made out of foam. The two objects were presented to the infants first via their hands and then to the infant's mouth. When the objects were presented to the infants via their hands, TD infants spent an average of 37 seconds squeezing the hard cylinder; conversely, infants only spent 3 seconds squeezing the cylinder made of foam. When the cylinders were presented to the infant's mouth, infants spent significantly more time sucking on the foam cylinder than the Lucite cylinder (average 135 seconds versus 89 seconds on the hard cylinder). This study presents evidence of infants' understanding of the affordances (hard versus soft, most advantageous to suck on versus grasp) of an object during the first months of life. Here, the differences between the time spent grasping and sucking the soft cylinder shows the increased tailoring of manipulation based on the object's properties. Infants' responses seem to be determined by the object's physical characteristics and the sensory system involved in the interaction; i.e., hands or mouth (Rochat, 1987).

The multimodal approach of exploration becomes more varied as infants age. At one month, this approach leads to the typical development of object awareness and cognitive representations of an object's properties: Oral exploration is the primary sense used to explore. Three to 5-month-old infants were observed manipulating objects first in a well-lit room and next in a dark room; the different environments allowed researchers to observe the difference in visual exploration of an object (Rochat, 1989). Results showed that fingering of objects greatly decreased across all age groups, which researchers attributed to the limitation of sight: Without being able to see the object, tactile exploration was less effective. As age increases, the interaction with an object becomes increasingly multimodal (e.g., the use of mouth, hands, and looking at the object instead of simply employing oral exploration or tactile exploration). At 2 and 3 months, infants are usually limited to oral and tactile contacts, whereas 4-month-old infants employ visual inspection of the object prior to oral exploration (Rochat, 1989). The progression of interaction from oral and haptic to a visual initiation may indicate that infants are planning their interactions with an object based on the visual understanding of the object. The knowledge base regarding objects has grown and therefore the interaction with an object becomes more planned and sophisticated. As age increases, the amount of haptic manipulation coupled with visual exploration increases and oral exploration decreases (McCall, 1974). From 6 to 12 months of age, fine motor manipulation of objects increases; specifically, fingering, rotating, and banging objects. These behaviors become increasingly dependent on the object and its affordances for action (Rochat, 1989; Ruff, 1984).

To further illustrate the increase of specification of behaviors on objects, Gibson and Walker (1984) presented 12-month-old infants with a battery of hard and soft objects. The infants spent considerably longer banging the hard objects versus squeezing the soft objects. This shows the integration of object affordances into the manipulation of objects and subsequently appropriately using the object to create an effect (Gibson & Walker, 1984). As infants begin to learn about the properties of different objects, they also learn about the cause-and-effect nature that objects can produce.

In a study conducted by Bourgeois et al. (2005), infants were presented with either a hard or soft cube and varying tabletop surfaces--liquid, discontinuous (i.e. a net), flexible or inflexible--in an effort to observe if the type of surface made a difference in the interaction an infant had with the surface. Videotapes were coded based on three classes: object, surface, and object-surface exploration. Coding involved looking at the frequency of behaviors for each class. For object exploration, coding included squeezing, pressing, or scratching the object. For surface exploration the number of times an infant was observed slapping or pressing the surface was coded. For object-surface exploration the frequency of the interactions the infant caused between the object and the surface were measured.   Analyses showed infants at each age level squeezed soft objects more frequently than hard objects, but the frequency of squeezing increased with age. Similarly, infants scratched the hard object more frequently than the soft cube. These results indicate, again, that infants tailor their manipulation of objects based on their properties. Moreover, in the surface exploration analyses, researchers found that as the age of the infant increased, so did the adaptation of movements depending on type of object. This further illustrates that the increased exploration of objects and surroundings increases the knowledge about their properties, which is further integrated into manipulations of the object.

As infants gain more motor capabilities, a new mode of exploration is available: Just as the enhancement of hand-eye coordination at 4 months changes infants' ability to integrate haptic exploration, crawling and cruising expands infants' cognition of properties. This is new mode of exploration and its implication for a development of object affordances is evidenced in a study conducted by Campos, Bertenthal, and Kermoian (1992). They examined the reactions of crawling and precrawling infants to the visual cliff. Crawling infants were found to have a fear reaction to the visual cliff versus the precrawling infants who did not show a response to the visual cliff. The crawling infants have experienced, through exploration, the affordances of a solid surface, whereas the precrawling infants have not had experience to formulate the difference between a solid and nonsolid surface.

To further show the development and integration of physical properties via exploration, researchers conducted a study with precrawling infants. Half of the group was placed in a walker to simulate walking daily. These infants were then exposed to the visual cliff again. Infants who had used the walker showed a fear response to the visual cliff that was similar to the crawling group in the previous experiment. Here the experience in the walker expanded the infants' knowledge about the physical world and the consequences of the cliff (Campos et al., 1992). This research shows the effect that exploration has on children's recognition of physical boundaries and characteristics.

Each developmental stage brings with it new abilities and experiences. Exploration of objects and properties enhance infants' knowledge regarding object affordances and the way to manipulate objects. This knowledge base created in infancy is the root of older children's complex understanding of object relational skills (Baillargeon, 2004; E.J. Gibson, 1985). By learning how to exploit and use the physical properties of objects, infants create a useful concept of an object. By looking at these studies of how infants develop affordances of both objects and the physical world, we can see how exploration of objects, and their properties, contributes to infants' understanding of objects. With this information, infants can now plan a strategy of manipulation of objects based on experiential knowledge.

Tool Use in TD Infants

Tool use is a new stage in object affordances. Infants can integrate the knowledge gained through exploration and use this knowledge to manipulate objects in a more specific way (Lockman, 2000). As stated previously, infants at 9 months will bang hard objects more frequently than soft objects, and feel textured surfaces more frequently than smooth ones; this is thought to be the way in which infants discover objects properties and create a product, such as noise. Through active experience and exploration infants begin to understand the interaction between objects (Klatzky, Lederman, & Mankinen, 2005; Lockman, 2000; Sommerville et al., 2008). This then leads to tool use, using one object to create an effect on another object, which requires an infant to learn not only the affordances of one object but the relations between objects and their effect (Lockman, 2000). As early as 6 months, infants can use an intermediary objects as an apparatus toward a desired goal (Sommerville et al., 2008). At 8 months, TD infants show a simplistic understanding of tool use, as evidenced in a study by Cralley, Ellman, and Lockman (1999) wherein infants were given hammer-like objects that were comprised of a handle attached to a cube, and the density of the cube varied from soft to hard. Eight-month-old infants were more likely to bang the hard cube by holding the handle than the soft cube. Holding the handle of the hammer displays an important component of proper and effective tool use (Cralley et al., 1999).

More sophisticated tool use requires manipulation of objects to obtain the most effective strategy. In a longitudinal study, Lockman and Wright (1989) observed infants' interactions with cubes that were composed half of wood and half of sponge. There were two ways infants could elicit noise from the cubes: The first was to bang the block on the hard surface of the table, and the second was to turn the blocks so that both wood sides faced each other and then bang them together. Researchers found that infants between 6 and 10 month of age only performed the first form of banging but not the more sophisticated second form (Lockman &Wright, 1989). Here we can see that prior to 10 months of age infants do not have the experiential knowledge to effectively manipulate objects to produce an outcome (Lockman & Wright). Mastery of tool use continues through infancy and into childhood, and through increased experimentation and integration of experience children hone and develop tool use (Lockman, 2000).

Through this compilation of research, we can see the advantages of exploration and its effects on cognitive development and the development of object affordances in infants and children. Similarly, we can also see how limiting exploration could have negative outcomes for children's object affordance skills. By not completing the aforementioned skills of mouthing object, fingering, and visually processing objects, infants can miss critical stages in the development of object affordances, which can have consequences later in life when tool use emerges (Lockman, 2000).

DS and Development

Children with DS generally demonstrate pronounced delays in exploration (Wishart, 2000). The consequences of these delays may become evident in difficulties formulating cognitive representations about objects in the physical world. There is a great deal of variability in the levels of cognitive achievement and motor development in the DS population (Wishart, 1998). However, almost all will experience a level of difficulty in development of cognition. Although individuals with DS in most cases will reach many motor milestones, it is at a slower rate than in TD children.

The cause of DS is attributed to an extra copy of chromosome 21 in 95% of all cases (Prescott, 1988). This chromosomal abnormality in DS is associated with a number of cognitive and physical characteristics (Harris & Shea, 1991; Parker & James, 1985). For the purposes of this research, the instance of hypotonia, or low muscle tone in this population, is of particular interest. This low muscle tone is evident in the first few weeks of life. How this affects the motor functions in infants is not clear but, it has been posited that motor reflexes, deceleration of motor development, abnormal movement patterns and strategies, and overall strength are among the areas affected by hypotonia (Block, 1991; Cowie, 1970; Cunningham, 1979; Hazett, Hammer, Hooper, & Kamphas, 2011; Moss & Hogg, 1988). Additionally, these delays may be attributed to differences between DS and TD children in the integration of reflexes and postural reactions. Postural reactions include the tonic neck reflex, where if an infant's head in turned the arm and leg on the side that he is looking toward to extend or straighten, while his or her other arm and leg will flex.

Research has shown a strong relationship between postural reactions and the attainment of certain motor milestones. Infants with DS tend to be delayed in reaching these motor milestones that are influenced by postural reactions (Haley, 1986). Once these infants acquire specific postural reactions, the related motor milestones follow. This indicates that delays in attainment of motor skills are closely related to delays in postural reactions (Haley, 1990). The lag in development of reflexes has a cascading effect for the exploration of objects and an individual's surroundings.

Furthermore, MRI scans show differences in the size and weight of the brain as well as abnormalities in the synapses of neurons in individuals with DS (Hazlett et al., 2011). The most affected area of the brain seems to be the cerebral cortex. There appears to be an immaturity of the frontal and temporal lobe as well as a reduction in size of the hippocampus; in addition, there are fewer neurons in this region, which affects cognition and learning processes such as attention, information processing and integration, and language skills (Pennington, Moon, Edgin, Stedron, & Nadel, 2003; Uecker, Mangan, Obrzut & Nadel, 1993).

Extra chromosomal material found in DS children also contributes to sensory differences in this population, especially in visual, auditory, kinesthetic and timing areas (Block, 1991; Uecker et al., 1993). Additionally, problems with proprioception have been detected in the DS population; without proper understanding of one's body in space and time, it can be difficult to plan and complete reaching strategies effectively (Haywood, 1986; Schmidt, 1988). These differences can affect exploration of objects in this population such as the type of interaction that they have with an object.

Motor Development in DS

In children with DS, there seems to be a stagnation of motor development from 1½ to 10 months. After this phase, most of the typical motor milestones are achieved, only at a slower pace than TD children (Carr, 1970; Cowie, 1970; Cunningham, 1979). There has been some debate over the emergence of delays in infants with DS. Some studies suggest that delays are only evident after 6 months of age when TD infants, of a similar age, begin to roll over and sit up (Carr, 1970). The delays become even more evident as TD infants are standing up and attempting to walk (Carr, 1970; Cowie, 1970; Fishler, Share, & Koch, 1964). Other researchers indicate that delays are apparent prior to 6 months for reaching skills and object manipulation (Rast & Harris, 1985). Whatever the age of emergence, infants with DS have been documented as being delayed in the development of gross motor skills, such as reaching for objects, crawling, standing, walking, and in fine-motor skills that involve hand manipulation of objects that are characterized by abnormal movement patterns (Cowie, 1970; Latash, 2007; Sugden, 1998). These motor delays may be attributed to hypotonia (low muscle tone) and hyperflexiblity, which is found in a majority of the DS population (Chen & Woolley, 1978; Dunst, 1988; Harris & Shea, 1991). Through this lag in motor development, children with DS fall behind TD in terms of exploration of surroundings. This deficiency of exploration can lead to a less developed understanding and internalization of object affordances (Moss, 1988).

Motivation in Children with DS

Motivation to explore surroundings and objects is intrinsic to most humans; curiosity and inquiry are the driving force behind the attainment of knowledge (Morgan, Harmon, & Glicken, 1984; White, 1959). Furthermore, there is motivation to effectively interact with an environment, eliciting cause and effect or reaching for and obtaining an object (Ruskin et al., 1994). Lack of motivation to explore can lead to deceleration of object affordance skills and tool use (Bradley-Johnson, Friedrich, & Wyrembelski, 1981). Young children with DS tend to have less motivation to explore their surroundings in the same way that TD children do, and this lack of motivation may be attributed to motor differences (MacTurk et al., 1985; Ruskin et al., 1994). Cunningham (1979) observed the reaching skills of 12 infants with DS and 12 TD infants from 2 to 4 weeks after birth. Infants with DS were observed to be slow to develop accurate reaching and rarely made hand adjustments based on the size and shape of the object. Moreover, once infants with DS reached the object, infants explored the object less (Cunningham, 1979). When infants were presented with a novel toy, TD infants immediately reached for the toy, infants with DS did not immediately reach for the new toy. These children did not reach for the toy for 6 sessions (Cunningham, 1979). This demonstrates limited motivation in infants with DS, and their more limited interest in novel objects and exploration.

The reduced motivation to explore carries over to familiar toys. Bradley-Johnson et al. (1981) observed the duration and the modality of exploration with objects, comparing the actions of TD infants and infants with DS. DS infants spent less time manipulating objects over three trials (less time on trial 2 than 1, less time on 3 than 2), but TD infants did not decrease in manipulation over the trials. Similar studies examining DS infants and duration of exploration with novel objects have yielded the same results (Morss, 1983; Wishart & Duffy, 1990).

In another study, MacTurk et al. (1985) compared mental age matched 6-month-old infants with 9-month-old DS infants. The latter population showed significant differences in exploratory behaviors. The researchers divided tasks into six categories: Look, explore, persist, success, social, and off-task. Children were videotaped in free play sessions and then videos were coded based on the categories. The results indicate that there were no significant differences between the total amounts of behavior, but there was significant variation in the distribution of the behavior. TD infants moved between the "look" action category and "persist:" These behaviors were followed by high level of task involvement. The DS sample tended to move from the "look" category to "social" or "off-task." This may show that DS infants require more looking time, possibly for visual processing, than TD infants, who spent more time interacting directly with the objects rather than looking at them. At the same time, the infants in the TD sample showed more instances of pounding, shaking, examining, and dropping objects compared to the DS infants. Infants with DS spent notably more time looking at the objects without interacting with them than the TD infants. Similar results have been found in other studies (Bradley-Johnson et al., 1981; Loveland, 1987).

Infants with DS have shown less motivation to manipulate and explore objects even once the objects are obtained (Thombs & Sugden, 1991). As stated before, object mastery in typically developing children is inspired intrinsically, but in infants with DS, it seems to be more socially motivated (Vlachou & Farrell, 2000). In a study conducted by Loveland (1987), TD children and children with DS were tested on the mirror task developed by Gallup (1970). Children with DS lost interest in the mirror and the task when there was no social incentive or when there was no motivating stimulus. Similarly, de Falco et al. (2008) tested children with DS and their interactions with their fathers. During this task, children increased their exploratory play when their father was present and decreased when their father left the room. Both of these studies demonstrate a decrease in the intrinsic motivation in children with DS during their interactions with objects and highlight the social motivation in this population.

Integration of Information and Visual Processing in DS

This difference in motivation in children with DS is thought to stem from problems integrating adult-supported, goal-directed activities, or scaffolding, into their own independent play. Landry et al. (1998) observed the independent play of DS and TD children before and after play sessions with a parent. In the initial play sessions, children in both groups showed similar levels of goal-directed activity. For the joint play sessions, parents were instructed to show children a more effective play strategy then leave the room again. In the last play session without the parent, TD children again showed high levels of goal-directed play with the addition of lessons learned by his or her parent. Children with DS failed to benefit and integrate higher levels of goal-directed play demonstrated by the parent and returned to the baseline independent play displayed in the first session of play. This illustrates the difficulties that children with DS have in integrating new information into already established forms of play. We can see that this may cause problems for the evolution of play into more sophisticated methods.

In addition to problems integrating new information into old routines, children with DS have difficulty processing information given regarding a task, and in turn are delayed in executing a motor-based task. This could contribute to slow reaction time and a slow reaching movement (Hogg & Moss, 1988). Slower movement in individuals with DS has not been fully explained, but it is thought to be an adaptive strategy to allow the individual enough time to process and correct strategies (Kearney & Gentile, 2002). Children with DS have also been found to have poor visual perception, which may lead to slower movements. In a study performed by Kearney and Gentile (2002), the success and timing of reaching and grasping wooden dowels in children with DS was tested. Researchers found that children with DS required contact with an object before they would begin the process of gripping the object; in contrast, normally developing children initiated the grip before contact with the object. Children with DS also required more time to lift the dowel than their TD counterparts. This may also indicate that contact with the dowel was required before the grip was initiated.

Exploration in Young Children with DS

All of these motor deficits have implications for exploratory play in children with DS. Because these children reach and crawl later than their typically developing counterparts, there is already a lag in the exploration process (Block, 1991; Dunst, 1990). Also, once children with DS begin to explore their world, it may be at a slower pace, with slower neural processing of the objects and their interactions on those objects. When infants touch and explore objects haptically, they learn about an object's properties and use this information to manipulate the object in the future (Corbetta & Snapp-Childs, 2009).

When exploratory play begins for children with DS, the way in which they interact with objects is markedly different than typically developing children. Due to the slower reactions times and neural processing, these infants interact with objects in a more repetitive manner (Loveland, 1987; Polastri & Barela, 2005). They tend to mouth or throw the object repeatedly, more so than their TD counterparts. Although mouthing and throwing objects are important aspects of understanding properties and limitations, children with DS seem to linger in this stage longer, not internalizing the results of their actions (Loveland, 1987; Moss, 1988). Repeating the same movements and explorations with the same object allows them to interact with the object for longer and obtain object mastery. In a study by de Campos, Francisco, Savelsbergh and Ferreira Rocha (2010), the movements of infants with DS were compared to the movements of TD infants. Researchers found marked differences between the two populations. Infants with DS had fewer reach attempts overall than TD infants (159 reaches to 239). Infants with DS also showed less effective strategies when reaching for objects; for instance, hitting the object repeatedly before initiating a grasp. Infants with DS have different interactions with objects because of differences in motor and cognitive development. Strategies such as hitting an object prior to grasping are adaptive and allow contact with the object without monitoring the speed of the movement as would be required with a intentional grasp movement (de Campos et al., 2010). In addition to the differences in haptic movements children with DS make, there is a difference in their overall behavior with objects compared to TD children.

In a study conducted by Ruskin et al. (1994), children with DS were observed in a laboratory setting interacting with several groups of toys. Children with DS were observed to have shorter strings of continuous exploratory behavior than the TD sample. This suggests than children with DS have a lack of motivation needed to pursue a specific task, and have may have difficulties linking actions together in order to explore a toy.

Children with DS have been found to use less effective means to manipulate objects (MacTurk et al., 1985; Vietze et. at, 1983). Children in this population tend to display problems with “coincidence timing” (Sudgen & Keogh, 1990) where individuals have difficulty initiating movements in relation to external events. Cunningham (1979) suggested that there is a discrepancy between the motor and visual systems in children with DS, which leads to impairment in the infant’s ability to process visual feedback when attempting to make eye-hand contact with an object. This difficulty may contribute to problems using hands to manipulate objects in a meaningful way as well as exploration of objects. Rochat (1989) stated that visual inspection is integral to an infant learning affordances and properties about that object. With the diminished visual processing, children with DS may have an additional hindrance in the exploration of objects (Hogg & Moss, 1983). Fidler, Hepburn, Mankin, and Rogers (2005) examined children with DS performing an object retrieval task, similar to that in Bruner’s (1970) study with TD infants; children with DS in this study utilized less effective strategies than MA-matched TD children. In this study, children with DS did not appear to use perceptual information to plan reaching strategies as effectively as TD children (Fidler et al., 2005). This further demonstrates a deficit in the integration of visual and haptic cues into the planning of movements in the DS population.

A compounding factor to the overall deficit in motivation is the general avoidance of tasks that has become apparent in the DS phenotype (Wishart, 2001, 1996). Similar avoidance strategies have been employed not only by young children with DS, but adolescents with DS as well. These methods include both positive and negative behaviors such as, crying and yelling when the child is young, and can develop into a more sophisticated strategy of involving others in off-task social behaviors. These "party trick" behaviors include clapping hands, making faces, or blowing raspberries to distract from the task at hand (Pitcairn & Wishart, 1994; Wishart, 1996). These are thought to be adaptive strategies to avoid completing the task at hand and may develop in reaction to past failures in successful accomplishment of tasks (Wishart, 2001). These avoidance behaviors may contribute to the deceleration in the development of cognitive skills in subsequent years.

Moreover, as children with DS develop, reliance on others for the completion of tasks grows, even if help is not needed. This leads to a decrease in willingness to initiate problem-solving tasks (Wishart, 1994). Lack of motivation in conjunction with refusal to attempt tasks contributes to the impediment of exercising more effective strategies.

Summary

Through exploration, children develop a sense of an object's properties, and through cause-and-effect actions, children develop an understanding of the properties of the physical world. Through these observations, children learn the implications of actions and further develop the use of tools (Baillargeon, 1994; Cralley et al., 1999; E.J. Gibson, 1985; Lockman, 2000; Morss, 1993). All of these milestones are required in order to develop skills related to purposeful, goal-directed actions on objects. These stages come in a sequence (Belsky & Most, 1981). It is critical to understand what occurs when there is a disruption to the sequence of obtaining these skills. The cognitive and motoric implications of DS create such a disruption. Through hypotonia, hyperflexiblity, atypical movement strategies and patterns, young children with DS are faced with physical interruptions to the development of gross motor skills (Block, 1991; Hazlett et al., 2011; Wishart, 2000). At the same time, deficits in motivation, divergent neural processing, and problems with integration and visual processing create cognitive barriers in the DS population (Wishart, 2000).

This difference in developmental course may lead to difficulty formulating representations of object affordances. Thus, without a complete understanding of the properties of objects and the most advantageous way to interact with objects, individuals with DS may be less effective in organizing actions to manipulate objects later in life. Similarly, by internalizing these incomplete understandings of objects and their limitations, individuals with DS may show marked differences in execution of goal-directed behavior with objects.

Present Study

In an effort to better understand young children with DS and object affordance skills, I examined the relationship between performance on an object retrieval planning task and affordance use during the Fewell Play Scales in young children with DS. I believe the lag in exploration coupled with differences in cognitive development have a negative effect on the development of object affordance skills in young children with DS. For this study I had three hypotheses:

1. It was hypothesized that a positive relationship would be observed between participants' Fewell Play scale score and their object retrieval score.
2. A positive relationship would be observed between developmental status and score on both the object retrieval task and the Fewell Play scale score.
3. A negative relationship would be observed between developmental status and off-task behavior.

I hypothesized that a positive relationship between participants' scores on the Fewell Play Scales and the object retrieval task would be observed. The object retrieval task is a measure that is made up of a number of different variables. The original object retrieval task uses a rubric for each child's reach strategy. Strategy is rated 0 through 4, zero being the lowest score and four being the most efficient highest score (see appendix A for coding rubric). To further enhance this measure I added an observational scoring component that looks at the specific interactions each child had with the box (see appendix B to see observational coding). It is important to look at the movements that children in this population use to obtain the prize. These two forms of coding were used to examine each child's performance on the object retrieval task. If children have more robust interactions with the toys (i.e., more instances of spontaneous play), as indicated in high Fewell play scale scores, their understanding of objects should be more developed, thus scoring higher on the object retrieval task. Further, I expected to observe a positive relationship between developmental status and scores on both the object retrieval task and the Fewell Play scales. If a child has a higher developmental status, for instance more developed gross motor skills evidenced by a higher score on the Mullen Scales of early learning, that child may have had more experience in the exploration of objects. This increased exploration may then translate into more developed understanding of object affordances, and possibly higher scores on the object affordances measures, the Fewell play scale and the object retrieval task.

My third hypothesis looks at the influence off-task behavior seems to have on persistence on tasks and elicitation of help for the completion of tasks. I expected to find with an increase instance of off-task behavior (both social and non social) a lower developmental status as indicated by the Mullen Scale of Early Learning. If a participant is eliciting help from others to avoid completing the task, or distracting others from completely the task, that participant will have fewer opportunities to develop skills.

Research in this area is pertinent because when deficits in motor skills, cognitive skills, and motivation to explore are present, children will fall further behind their cohort in terms of development. This lag eventually will affect other aspects of life such as language development, fine and gross motor skills, and social understandings (Landry et al., 1998).

CHAPTER 2--METHOD

Participants

Participants for this study were recruited through the Mile High Down Syndrome Association. A total of 15 participants were recruited. All of the children had a previous diagnosis of DS (Trisomy 21). Participants had a mean age of 2 years (range 1 to 4 years); of the sample studied, 8 were male and 6 female. All participants lived with their families. Participants were predominantly White and came from middle class families. After the purpose of the study was described along with known risks and benefits, consent was obtained from the parents; verbal assent was used for the children when possible. Compensation in the form of $15 was awarded to parents following each session.

Measures

Mullen Scales of Early Learning (MSEL; Mullen, 1995). The MSEL is a developmental test that has been standardized for children from 3 to 68 months. The scale is made up of five subscales: receptive language, expressive language, gross motor skills, fine motor skills, and visual reception. For this study I used only the nonverbal portion of the scale. Individuals with DS have pronounced delays in language development (Wishart, 2001). Thus, using only the nonverbal portion provided the most accurate reading of developmental status. The MSEL was standardized on a nationally representative sample of children and has strong concurrent validity with other developmental tests such as the Bayley Scales of Infant Development, Peabody Developmental Motor Scales, and the Birth to Three Scale. All of the items on the MSEL are performance based and are designed to pose a challenge only in the skill being assessed. Interpretation of scores is based on T scores (*M* = 50

Fewell Play Scales (Fewell, 1984). The participant was seated in a booster seat facing the task administrator. Each child was observed in his or her interactions with toys. The first set of toys included a toy car, truck, helicopter, and a small figurine that could be placed inside the car, truck, and helicopter. The second set of toys included a set of four brightly colored plastic plates with corresponding spoons and mugs, a plastic teapot, and a baby doll. The last set of toys included a play telephone, mirror, brush, and book. The task was videotaped for coding. Participants were coded based on the number of spontaneous interactions they had with the toys. A higher score indicates more purposeful actions with the toys. For instance "uses toy with appropriate action" (i.e., places man in truck, brushes hair, feeds baby doll). If one of these actions is preformed the participant receives a point. Total number of actions is added up which equals the participant's score. The Fewell play scales measures how well a participant understands object affordances and further, how object interact with each other. A higher score indicates more purposeful actions with toys, thus, a more developed understanding of object affordances.

Object retrieval. This task uses two (one small, one large) clear boxes specially made with one side or top missing. Each child participated in 15 trials of the clear box task. This task is designed to measure children's problem-solving skills, inhibition, cause-and-effect understanding, and motoric reach strategies. A clear box is placed in front of the participant and a toy or treat is placed under the box. The child must find the missing side in order to retrieve the toy of treat. The administrator changes the orientation of the box in order to vary the placement of the open side (front, left, right). The trials were administered in ascending order from the easiest task (e.g., opening of the box in the front) to hardest (opening of the box on left or right side). The object retrieval task was used in this study because it is a good task to measure object affordance skills. If a child uses more efficacious movements on this task, it is likely that more cognitive representations of objects have been developed. These representations have been integrated into the planning of movements and can be coded through observations of behaviors and strategies.

If, during the object retrieval task, the participant became agitated or frustrated with the task or the environment, the experimenter first offered help, by displaying the proper way to obtain the treat through the clear box. If the agitation persisted, the task was stopped. Reach scores within this task assess the acuity and accuracy of the child's reach strategy (i.e., exploring box with hands before finding the opening, or simply looking at the box for the opening before interacting with the box to find the opening.) Reach scores range from 1 to 3, where 3 indicated a high efficiency in reaching. The help scores were calculated after each set of the opening placement (i.e., front opening, right side opening, or left side opening.) The help score ranged from 0 to 4.5, with a higher score indicating less help from the experimenter.

In addition to the original object retrieval task protocol, an additional coding was added to look at the specific interactions that each participant had with the clear box. This coding scheme was developed specifically for this study, and included observational variables such as: off-task non-social behavior, off-task social behavior, touching the box prior to finding the opening, switching hands from right to left or left to right when the opening switched sides (for more information see appendix B). These questions were answered with Yes or No. If a participant engaged in one of these behaviors during the trial Yes was recorded, and No if the action was absent. Each trial was recorded separately for actions.

This coding scheme was utilized to give more insight into the strategies participants were using, and how they were interacting with the box. Because of the small sample size, once data were collected and entered variables looking at the same action were combined to create a summated scale score. For example, the action of a participant touching the Plexiglas box prior to finding the opening of the box was recorded as present or absent for each trial of the Object Retrieval task. These scores were then combined for each participant to create the haptic exploration variable across trials, score ranged from 7 to 13. Combining variables gave the variables more statistical power and allowed for analyses between variables. Summed scores were also created for Object Retrieval score, off task social and non social behavior in the same fashion as stated above.

Procedures

Parent and child were invited to the Colorado State University Developmental Disabilities Laboratory where a table and two chairs were set up. The child was seated in a booster seat with his or her back facing the two-way mirror; the table was placed in front of the child and the task administer was seated on the other side of the table facing the child. Parents were invited to observe the tasks, but it was not required. A video camera was placed in full view of the participant to the right hand side of the task administrator. All tasks were videotaped. The completion of all tasks took about 1 hour.

Coding of Videotapes. Coding of observations was conducted by two trained coders (two undergraduate students from the Human Development and Family Studies Department). Both coders were naive to the research questions for the study, and used their own judgment when assigning scores to participants. The coders coded for the quality and manipulation strategies employed by participants during play sessions, the quality of retrieval strategy, and hand and arm use on the Object Retrieval Task. Reach scores described the quality of the participants' reach; an ordinal scale from 0 to 3 was used, with higher scores denoting more efficient reach strategies (see Appendix for details). Each coder was be given instructions about the coding system and was able to ask questions about the coding to increase reliability. To ensure inter-rater reliability, the tapes of the first participant were coded together. Once completed, the data were compiled and entered into SPSS. Inter-rater reliability for object retrieval task was kappa = .91, p < 001, indicating a high level of coder agreement. The Fewell play scales and the Mullen Scales of Early Learning were previously coded by a Graduate Research assistant from the Developmental disabilities research lab.

CHAPTER 3--RESULTS

The subsequent sections look at the analyses that addressed the study hypotheses. The small sample size limits the significance of these relationships; significance was reported in order to give the reader an understanding of the relationship of the variable. These results should be viewed as preliminary and an exploratory to look at the relationships between the variables in the DS population.

Hypothesis 1—Positive relationship between Fewell Play Scale scores and Object Retrieval scores.

Hypothesis 1 stated that there would be a positive relationship between the Fewell Play Scale scores and the Object Retrieval scores. It was thought that if a child has a more developed understanding of how an object interacts with another object, then they will have a more developed sense of object affordances, as evidenced by an increase in Fewell Play Scale scores. This would then translate into higher Object Retrieval scores. Correlations were preformed between Fewell Play Scale Scores and Object retrieval scores. Object Retrieval Scores were derived from both the original Object Retrieval protocol and the additional observational coding. A negative relationship between Fewell Play Scale score and the Object retrieval score from the original Object Retrieval protocol was observed, $r(8) = -.44, p < .24$. This result does not support my original hypothesis of a positive relationship between these two variables.

To further expand upon these findings, correlations were peformed between Fewell Play Scale scores and the observational coding of the Object Retrieval task (touch box prior to finding the opening). This analysis looks more specifically at the haptic exploration of the box in relation to Fewell Play Scale scores; haptic exploration of the box is not an effective strategy according to the original Object Retrieval protocol, but taps into the amount of exploration each participant is motivated to engage in. Haptic exploration scores were strongly correlated with participants' Fewell play scores $r(12) = .54$, $p < .05$, indicating that an increased haptic exploration is associated with more instances of purposeful actions with toys, as evidenced by a higher Fewell Play Scale score (Cohen, 1988).

In summary, my first hypothesis was not supported. Fewell Play Scale scores are not positively related to Object Retrieval scores, further analyses using the observational Object Retrieval coding shows that there is a positive relationship between the haptic exploration and Fewell Play Scale scores. Haptic exploration of the box was not the most efficient strategy for obtaining the prize inside the box, thus, participants who utilized this strategy scored lower on the Object Retrieval task according to the original protocol. Even though the first hypothesis was not supported these analyses gain interesting insight into the possible link between haptic exploration and development of object affordances.

Hypothesis 2—Positive relationship between developmental status and object retrieval scores and Fewell Play Scale scores.

The second hypothesis was addressed by performing correlations first between MSEL age equivalent gross and fine motor scores and the Fewell Play Scale scores; between MSEL age equivalent gross and fine motor scores and the Object Retrieval scores derived from the original protocol; and the MSEL age equivalent gross and fine motor scores and haptic exploration variable from the observational Object retrieval scores. Statistical significance was only found for correlations between MSEL age equivalent gross motor scores and haptic exploration, where a positive association was found between the two variables, $r(8) = .88, p < .009$. This indicates that similar to the findings in the previous paragraph we can see that an increase in exploration is positively associated with an increase in other measures.

In summary, the hypothesis of a positive relationship between developmental status and Object Retrieval scores and Fewell Play Scale scores was not supported. But in looking at observational Object retrieval data we can see a positive association between the developmental status of a participant in terms of gross motor skills and their haptic exploration. This may indicate that these participants have had more experience exploring, thus, increasing their gross motor skills, or, gross motor skills were more developed so exploring was more available.

Exploratory analyses—Fewell Play Scale scores and off-task non social behavior.

Children with DS have shown limited persistence when completing a task, instead relying on distractions and elicitations of help from others to complete a task. In order to look at this behavioral characteristic correlations were preformed between off-task non social and social behaviors that were coded for in the observational Object Retrieval coding and the Fewell Play Scale scores. Only correlations between off task non-social and Fewell Play Scale scores yielded significant results, $r(10) = .78, p < .008$. This is an interesting result because it was expected that on task behavior would produce higher scores on the Fewell Play Scale, but the opposite was found.

CHAPTER 4--DISCUSSION

The development of object affordances is influenced by a number of factors, but exploration remains an integral part of the development of a child's understanding the properties (Corbetta, 1998; Gibson, 1982; Rochat, 1989; Sommerville, Hildebrand, & Crane, 2008). Exploration of objects allows children to examine an object's properties, and build a mental representation of an object's affordances. Limited exploration may cause children to fall behind in the development of object affordances (Gibson, 1982; Lockman, 2000; Rochat, 1989). Past research on individuals with DS indicates that this population shows delays in gross and fine motor development, as well as deficits in motivation to explore surroundings (Loveland, 1987; Ruskin, Mundy, Kasari, & Sigman, 1994; Thombs & Sugden, 1991). These characteristics create a disruption in the path of typical development (deCampos, Rocha, & Savelsbergh, 2009).

The aim of this study was to take a closer look at how these differences describe the way young children with DS interact with objects. This was done by examining developmental status using the MSEL. Developmental status was compared to other measures examining object affordance development, and correlations between these measures gave insight into the link between developmental status and mental representations of objects. The object retrieval task assessed aspects of the development of object affordances, the strategies that a child used to obtain the prize relates to the exploration of objects and development of object affordances (Burner, 1970). The Fewell

Play Scales assessed the way that participants played with toys; this displayed their understanding of how objects interact with one another.

It was hypothesized that young children with DS with higher scores on the developmental assessment would demonstrate higher scores on the Fewell Play Scales and the object retrieval task but the opposite was found, participants with higher. By looking at the typical trajectory of the development of object affordances, we can see that haptic exploration of objects is integral (Gibson, 1982; Rochat, 1999). Infants use haptic information to manipulate objects, information gained through exploration regarding the density, size, and shape of an object allows a child to effectively interact with that object (Gibson, 1982). An increase in haptic exploration increases the amount of knowledge children have about objects and their affordances (Baillargeon, 1994; Klasky, Lederman, & Mankinen, 2005). Young children with DS have shown marked differences in their haptic exploration of objects (Wishart, 2001). This difference may lead to a delay in the development of object affordance skills. It is important to understand the implications for haptic exploration and the influences it has on development in this population.

A strong association was observed between MSEL age equivalent gross motor scores and total haptic exploration scores. Children who touched the Plexiglas box prior to finding the opening had more developed gross motor skills. Touching the box prior to finding the opening is not the most effective strategy for obtaining the prize. But, participants who utilized this strategy demonstrated that they explore their surroundings more, the increase in exploration may have an effect on developmental status, which is indicated in their developmental scores. The interaction between object exploration and development of gross motor skills displays. This finding was not expected, and does not support my hypothesis of a positive relationship between developmental status and object retrieval scores. This is an interesting finding overall because these results were not expected, however, they do represent the importance of exploration in the development of object affordances in this population.

This study also examined how the development of object affordances translates into play. The Fewell Play Scales were used to look at the participants' understanding of objects and how they interact with each other, for instance, placing the toy man into the toy car. In order to understand interactions between objects a foundation of object affordances must be established. Children must first learn the properties of an object and how it can be used before they can understand interactions between objects (Gibson, 1982; Lockman, 2000). Correlations showed that an increase in exploration of the box and touching the box prior to finding the opening was associated with higher scores on the Fewell play scale. These results indicate that an increase in haptic exploration may positively influence the understanding of objects and how they work together in a play setting. These findings demonstrate the importance of exploration in development.

Results from correlations of MSEL developmental scores gross and fine motor and less than optimal reach scores indicate that participants used strategies that were rated less efficient despite higher scores on the Mullen developmental assessment. These findings may relate to the exploration of the box prior to engaging in reaching for the prize inside. A reach score of 1 is given to a participant who touches the top of the box prior to finding the opening of the box. This action demonstrates an increased haptic exploration of the box, which is needed to increase understanding of the affordances of the box. Similarly, the reach score of 1.5 is given to a participant who leans to look through the opening of the box, then reaches for the prize, instead of using the most efficient strategy of looking through the top of the box while reaching into the opening of the box. This indicates that these children are employing their knowledge of object affordances to obtain the prize. These results were surprising, because they are contrary to the original Object Retrieval scoring protocol. In this protocol, participants who used more effective strategies (i.e., not touching the box prior to finding the opening) seemed to be more developed. But these results indicate something different for the DS population, touching the box may allow the participant to gain knowledge about the box. These results are in line with the overall trend that children with DS with higher developmental score explore the box more than participants with lower developmental scores. Similar results have been found using typically developing samples: Early exploratory behaviors were an important precursor to later competence in children (Klasky, Lederman, & Mankinen, 2005). Given that children with DS have been noted to explore their surroundings less than typically developing children, an increase in exploration may allow for the development of more robust motor skills.

This study also examined off-task behavior in relation to MSEL age equivalent gross motor scores. A significant association was observed between MSEL age equivalent gross motor scores and off-task non social behavior, as participants with more off-task nonsocial behavior showed more developed gross motor skills than those children who had fewer off-task nonsocial behaviors. This finding may be related to a reduction of the social “party tricks” that have been used in this population to avoid completing tasks (Wishart, 2001). If children display fewer of these distractions, they may demonstrate greater task persistence. Persistence allows for practice with a task.

Correlations between the off-task social behaviors support this theory: Children with more off-task social behavior tended to have lower MSEL age equivalent gross motor scores. This indicates that these children may use social interaction as a diversion to completing a task on their own (Wishart, 2001). Less developed motor skills leads to fewer effective motor strategies, this may influence children to use social distraction as a way to avoid completing the task.

There are several limitations to this study. The small sample size utilized in this study demonstrates the need for replication of the study with more participants. More participants in the study would give us more information about this population and their specific development of object affordances. Additionally, missing data further reduced the amount of useable data. These data came from a study conducted in 2003, any missing data could not be replaced and because of the small sample size, missing data affected the overall analysis of the data significantly. The lack of a comparison group also limited the results of the study. Without a comparison group comprised of participants with other developmental disabilities there is no way to tell if these patterns were unique to young children with DS, or whether they are associated with intellectual disability in general. Research on TD children served as a baseline for development, but the addition of a comparison group comprised of children with developmental disabilities to the data analysis would strengthen the results of the study and contribute to a better understanding of the differences between populations. Future research on the topic using a larger sample size and a longitudinal design would enhance the understanding of the DS developmental trajectory in this area.

Despite these issues, the results of this study indicate that young children with DS with higher developmental status tend to explore their surroundings more. This finding should contribute to current knowledge regarding the phenotype of children with DS, and how the differences in this population contribute to the overall development. Knowing more about the early developmental trajectory of this population, and by understanding what contributes to poor development of object affordances, more effective interventions can be designed to mitigate some of the detrimental effects of this genetic disorder.

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APPENDIX A

Appendix A

Each score relates to how the child reaches for the treat/toy.

1 point= Child tries to reach through the top of the box. The participant bangs the top of the box. After initial attempt at the top of the box the participant may search for the opening of the box. Child lifts or moves the box to obtain the prize.

1.5 points= Child leans to one side or the other to look for the opening of the box. Then reaches for the treat/toy while looking through the opening of the box.

2 points= Child leans to look through the opening f the box, finds the opening, straightens, then reaches through the opening to obtain the prize.

3 points= Participant does not lean from one side to the other to locate the opening of the box. Child reaches through the opening to obtain the prize while looking through the top of the box.

APPENDIX B

Appendix B

Coder:
Subject # 1 on Disc 1

FRONT
Trial #1 attempt

Child touches box prior to finding opening: (y/n)
Elicits help from parent or experimenter: (y/n)
Off task social behavior:(y/n)
Off task non-social behavior: (y/n)
Use of both hands: (y/n)
Uses one hand: (y/n)
Uses corresponding hand when opening: (y/n)
Pulled/lifted box to try and obtain prize: (y/n)
Did the child switch hands with side switch: (y/n)
Reach Score:
Help Score for Set:
Total Reach Score:

Subject # 2 on disc 1

FRONT

Child touches box prior to finding opening: (y/n)
Elicits help from parent or experimenter: (y/n)
Off task social behavior:(y/n)
Off task non-social behavior: (y/n)
Uses of both hands: (y/n)
Uses one hand: (y/n)
Uses corresponding hand when opening: (y/n)
Pulled/lifted box to try and obtain prize: (y/n)
Did the child switch hands with side switch: (y/n)
Reach Score:
Help Score for Set:
Total Reach Score: