A LION OR A SHOE: 17-MONTH-OLDS OBSERVING VS. ACTING ON AN OBJECT IN AN OBJECT INDIVIDUATION TASK

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The Supervisory Committee certifies that this ***disquisition*** complies with North Dakota State University's regulations and meets the accepted standards for the degree of

MASTER OF SCIENCE

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ABSTRACT

Object individuation, the ability to distinguish an object that is currently perceived from one that was previously perceived, is an important cognitive ability used in everyday life. In the current study, we assessed the influence of self-action on infants' ability to individuate objects. Using a manual search task, we tested eighteen 17- to 18-month-old infants' ability to individuate objects. Infants either observed as an experimenter hid an object in a covered bucket or they hid the object themselves. The rationale was that if infants perceived the retrieved object as a distinct object from the one hidden, they would continue searching in the bucket for the yet-to-be-retrieved object. These results indicate that infants successfully individuated only when they were able to hide the object themselves. This outcome provides evidence that, similar to other types of object processing, object individuation is enhanced when infants are given the ability to act on objects.

Keywords: object individuation, manual search task, violation of expectations

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DEDICATION

To my husband Andrew and my father Chad. I could not have done it without either of you.

Thank you for believing in me and for all your support, love and encouragement along the way.

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CHAPTER ONE. INTRODUCTION

Object individuation is a perceptual and cognitive ability in which the viewer mentally represents and keeps track of objects across time and distance (Carey & Xu, 2001). More specifically, object individuation is the ability to distinguish whether an object that was previously experienced is the same as or different from an object experienced later (Xu & Baker, 2005; Kingo & Krøjgaard, 2012; Johnson & Woods, 2016; Van de Walle, Carey, & Prevor, 2000). For example, if a green car pulls into a carwash and then a black car emerges we would conclude that there had been two cars in the carwash (Figure 1).

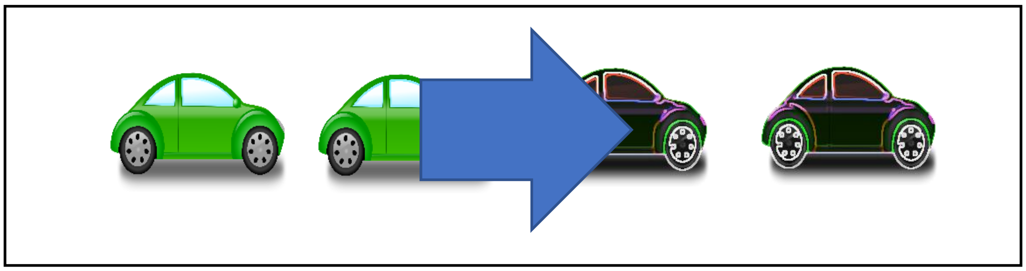

Figure 1. Pictorial representation of object individuation

Object individuation is important for accurate interactions with the environment. It provides a foundation for learning about categorization, tool use, and even social interactions (Barrett, Davis & Needham, 2007). Without the ability to individuate objects, we would consider every object we experienced as novel. We would not be able to recognize objects or learn about them across encounters. As a result, we would not be able to act on objects in ways that require extensive learning and practice, such as driving a car.

The ability to track an object across times relies on the capacity to remember the object. This memory is known as an object concept and is a type of mental representation. (Lewis & Mitchell, 1994; Streri, de Hevia, Izard, & Coubart, 2013; Zosh & Feigenson, 2012). In order to individuate, the object concept needs to contain sufficient information about the object to make the distinction between it and another object (Krøjgaard, 2007). However, it does not require a complete, highly detailed mental representation.

Jean Piaget

The development of the object concept is the cornerstone of Jean Piaget's first stage of cognitive development, the sensorimotor stage (Piaget, 1954). Piaget frequently referred to object representations in terms of object permanence (Charles & Rivera, 2009). Object permanence is the ability to maintain a mental representation of an object, even when the object is no longer in view (or perceived via any other sense) (Keen, Berthier, Sylvia, et al., 2008; Krøjgaard, 2004; Piaget & Cook, 1954; Shinskey, 2008). Piaget's theory states that it is during the sensorimotor stage (i.e., the first two years of life), that the ability to form object representations develops (Streri et al., 2013). However, recent research suggests that this ability develops at much earlier ages than Piaget theorized (Zelnick & Buchholz, 1990).

According to Piaget, basic object permanence develops around eight to nine months of age and the ability continues to improve until fully developed between eighteen to twenty-four months (Keen et al., 2008; Carey, & Xu, 2001; Streri et al., 2013; Piaget & Cook, 1954). To assess object representations in infants, Piaget typically utilized manual search tasks (Keen et al., 2008). Search tasks, including those used by Piaget, require infants to retrieve an object that is hidden by a visible occluder (e.g., screen or blanket) or by darkness (Keen et al., 2008; Piaget, 1954). In the first phase of a search task, an object is hidden while the infant watches. Because the object is no longer visible, the infant must hold a representation of the object and its location to initiate a search. When an object is hidden by a visible occluder, infants first succeed at search tasks at 8 months, suggesting they have at least a rudimentary object representation (Piaget, 1954).

Looking-time tasks have also been used to assess object representations (Munakata, McClelland, Johnson, & Siegler, 1997). Looking-time tasks involve measuring how long an infant watches a specific event (Carrico, 2013; Hauf, Paulus & Baillargeon, 2012). Many looking-time tasks utilize “violation-of-expectation” procedures. Violation-of-expectations experiments capitalize on the well-documented tendency for infants to look longer at an event that is surprising to them (Dunn & Bremner, 2016; Kingo & Krøjgaard, 2012; Yott & Poulin-Dubois, 2012). If infants understand the physical world as adults do, they will look longer when their expectations are violated (e.g., seeing a ball being hidden under a blanket and then watching as a box is retrieved) compared to when no expectations are violated (e.g., seeing a ball being hidden and then seeing the same ball being retrieved). When violation-of-expectations looking-time tasks are used to assess object representations, infants typically succeed at younger ages relative to when a search task is used (Keen et al., 2008; Shinskey, 2008). These studies suggest that infants may be capable of object representations at much earlier ages than Piaget proposed (Streri et al., 2013).

This discrepancy in age begs the question, why do different methods of assessment result in different outcomes (Cheries, Wynn, & Scholl, 2006; Christie & Slaughter, 2009)? One possibility is that infants’ failure to succeed at manual search tasks may not be due to an inability to represent objects, but to other factors, such as cognitive load and limited motor skills (Frick & Wang, 2014; Shinskey, 2008). For example, manual search tasks like the ones used by Piaget require more attentional resources than looking time tasks (Carrico, 2013; Keen et al., 2008). There is evidence to suggest that when attentional load is decreased, infants succeed at manual tasks (Feigenson, & Carey, 2003). For example, having infants search for items hidden by darkness, rather than by a physical occluder requires fewer attentional resources because an occluder itself acts as an object and therefore distracts attention from the hidden object. By eliminating the visible occluder, those resources can be used to maintain the object representation and allow infants to succeed at the task as early as five to seven months (Shinskey, 2002, 2008). Similar results are obtained when the manual search task is simplified by making object retrieval a one-step process (i.e., removing a cloth to reveal an occluded object; Bojczyk & Corbetta, 2004) or when demands on motor skills are reduced (i.e., knocking over an occluder screen; Shinskey, 2008). Infants succeed at these simplified tasks at about seven or eight months. As individuals grow older, their developing cognitive structures contribute to increasingly elaborate mental representations (Zelnick, & Buchholz, 1990). These robust mental representations allow infants to succeed at more challenging manual search tasks (Cruz, Jang, & Park, 2016).

Object Individuation

While the demanding manual search tasks require a somewhat sturdy object representation, some abilities require only an elementary object representation. Object individuation is one such ability. To individuate objects, the representation needs to include only the qualities essential for distinguishing the objects. These essential qualities can include spatiotemporal information (e.g., one object cannot be in two places at the same time), property information (e.g., shape, color), or kind information (e.g., lion, shoe). Many studies suggest spatiotemporal cues are the first source of information that infants use to individuate objects (Van de Walle, Carey, & Prevor, 2000).While young infants can reliably analyze spatiotemporal information when individuating one or two objects, older infants (e.g., 12-month-olds) also take into account other sources of information (Kingo & Krøjgaard, 2012; Van de Walle et al., 2000; Wagner & Carey, 2003). That is, there appears to an age-based progression in the types of information included in infants' object representations, with location and timing of appearance preceding object features and classifications.

The types of information that infants can use to successfully individuate is determined by their age. Wagner and Carey (2003) found that if only property or kind information is available, twelve-month old infants may be expected to fail at an object individuation when a manual search task is used. However, if spatiotemporal information is available, twelve-month old infants are expected to succeed at individuating objects when assessed using a manual search task (Wanger & Carey, 2003). In contrast, Van de Walle and colleagues (200) found that when comparing ten-month-old infants to twelve-month-old infants, both groups succeed if only spatiotemporal information is given but, only the latter group succeeds if they must individuate objects based solely on spatiotemporal information. The success of the twelve-month-old infants could be attributed to their ability to efficiently act on an object to gain information from it.

Similar to studies focusing on object permanence, when looking-time tasks are used, infants show evidence of the ability to individuate objects earlier than when manual search tasks are used (Keen et al., 2008; Shinskey, 2008). Like studies investigating object permanence, this difference is likely due to demands on attention. However, looking time tasks often break down when used with older infants, likely because by the time they are toddlers, they are no longer satisfied with passively watching an event (Keen, 2003). This poses a problem to researchers investigating developmental changes in object concepts. The easier looking-time tasks can no longer be used, so researchers switch to manual search tasks that better engage toddlers. However, manual search tasks are more cognitively demanding, which makes it more challenging for toddlers to demonstrate the ability to individuate objects to the same level that younger infants do with looking-time tasks. As a result, it appears that toddlers have 'lost' the ability to individuate objects However, the failure is likely not due to toddlers' inability to individuate, but due to the greater demands of the assessment method used.

Given that infants are capable of individuating but seem incapable when assessed using a manual search task, infants may need a more complete object representation to successfully individuate. Additionally, allowing infants to play with an object may give them more information about the objects than when they passively observe. While acting on an object may not decrease the overall demands of the task, it may increase infants' attention to the object.

Acting on Objects

Infants' ability to act on objects (e.g. grasp, rotate, or play with objects) directly affects object processing (Streri et al., 2013). There is evidence to suggest that when infants have an opportunity to act on objects (e.g., manually explore or use objects as tools) rather than passively viewing them, they learn more about the properties and affordances objects and form more complete and robust object representations (Johnson & Woods, 2016; Markson & Spelke, 2006). For example, being able to haptically explore objects enhances infants' ability to segregate, individuate, and mentally rotate objects and to detect violations in the physical properties of objects (Libertus & Needham, 2010; Johnson & Woods, 2016; Slone, Moore & Johnson, 2018; Soska, Adolph & Johnson, 2010). The importance of action on learning is evidenced by studies on augmented or enhanced object-related actions (Johnson & Woods, 2016; Libertus & Needham, 2010; Woods & Wilcox, 2013). Needham, Barrett, and Peterman (2002) used Velcro "Sticky Mittens" that allowed infants to hold objects that they would otherwise not be able to hold. They found that infants who explored the objects using the mittens were more engaged (sustained visual attention) than infants who did not wear the mittens. This study suggested that wearing the mittens aids the learning process because not only do they assist in more successful object manipulation, but they also increase engagement (i.e., focused attention). Other augmented motor skills have been shown to similarly enhance object processing. For example, object individuation has been enhanced by an object exploration phase in which infants sat supported (Johnson & Woods, 2016; Woods & Wilcox, 2013). In both cases, augmenting infants' motor skills enhanced their learning about objects. However, what is it about object-related actions that enhances learning? Advantages may be due to several differences between active versus passive experiences with objects. Active experiences typically involve processing objects via multiple sensory modalities, such as both vision and touch. The result is that more information is perceived. Active experiences also involve a sense of control over the fate of the object which can help focus attention (Gerson, Schiavia, Timmers & Hunnius, 2015). Furthermore, acting on and actively controlling objects adds a sense of play in which the infant is self-motivated to learn about the object for no other reason than enjoyment.

Multisensory Learning

Multiple sensory modalities (e.g., combined visual and tactile information) are used when acting on objects. When an infant is using both tactile and visual information, a link is formed across modalities (Bahrick & Pickens, 1994) and the senses merge to form one representation of an object (Baumgartner & Oakes, 2013). Having a single representation based on multiple modalities forms a more robust object representation, increasing the likelihood of individuation (Johnson & Woods, 2016; Wilcox, Woods, Chapa, & McCurry, 2007; Woods & Wilcox, 2013). As a result, multimodal experiences enhance object perception and learning.

Control Over an Object

Having control over an object's fate may enhance infants' focused attention to the object (Kochanska & Murray, 2000; Rothbart, 1989). The perception of control over the environment is related to a sense of agency—intentionality and control over one's actions from the initiation to completion of the action (Oishi, Tanaka, & Watanabe, 2018). This sense requires an understanding of the relationship between cause and effect, which is evident in infants from birth (Deans, McIlwain, & Geeves, 2015). Having control over objects and other elements of the environment is linked to the maturation of attention mechanisms (Rothbart, 1989). Control and infants' ability to sustain attention have been shown to have a positively predictive relationship. Kochanska & Murray (2000) found that at 9 months of age, better focus and greater control were significantly linked.

The act of hiding an object could be influencing object learning and the overall demand on attention through the multiple modalities utilized. Through self-directed action on an object, infants engage in self-guided multisensory exploration. This self-directed multi-modal perceptual opportunity provides infants with additional information (Fagan & Pisoni, 2009). When infants are allowed to hide an object, infants' hands are going into the hiding place, giving them proprioceptive experience with the hiding location. As a result, infants may have the opportunity to track the object to the new object location. This opportunity allows infants to gain knowledge of the object due to the experience of hiding the object and the physical location of the hidden object. There may be the added experience of "knowing" the place where the object resides for infants who hide and act on an object compared to infants who watched the object being hidden.

Additionally, the act of hiding the object may trigger enhanced object tracking due the added learning experiences available (Schaub, Bertin, & Cacchione, 2013). The difference may be that gaining experience with the hiding place of the objects gives infants enhanced information about the location of the object. Not only do infants experience the location twice but, the purpose of the experience with the location is different. The information about the "hiding place" may be different than the information infants receive from the "finding place."

Elements of Play

Play directly influences attention in a way separate from the multi-sensory experience (Kannass & Oakes, 2008). Intrinsic motivation is a self-generated desire that requires persistence to attain mastery or competence of a task (Vig, 2007). Play involves active participation, making motivation and engagement imperative to play. Motivation to play with and explore an object concurrently relies on attention to the object.

Play has been shown to influence attention and overall maintenance of attention to an object over time (Kannass & Oakes, 2008). Attention is a required cognitive function to engage in object play because in order to play with a toy, one must first focus on the toy. During a period of play throughout the day there are multiple toys and objects competing for the infant's attention. During object exploration changes in attention occur (Ruff, 1986). A child must decide to focus on one object and ignore the others or distribute attention to multiple objects.

There are various explanations for why engaging in play with an object may influence infant's attention to the object. Acting on an object may allow an infant to be more engaged due to the tactile experience available (Needham, Joh, Wiesen, & Williams, 2014). The experience may increase infants' understanding of object affordances. The increase in knowledge may stem from the act of hiding the object which may illicit a feeling of play from the infant (Dekker & Mareschal, 2013). The multiple types of experiences available when hiding an object leads to an increase in the number of objects that infants have knowledge of. Not only is there an opportunity to engage the object, but also the location the object will be hidden. There could potentially be a difference in how the infants engage with the object and if the engagement takes the form of play.

Allowing infants to act on an object provides a self-directed, multisensory action that may enhance attention to the object and may assist in object tracking. Both control and multisensory learning provide additional information that allow infants to form more robust mental representations (Wilcox, Woods, Chapa, & McCurry, 2007). Previous research has shown that more robust mental representations are needed to successfully individuate objects when using a manual search task (Keen et al., 2008) Additionally, the act of hiding the object may assist in object tracking. Providing infants an opportunity to explore objects has been shown to enhance learning (Johnson & Woods, 2016; Libertus & Needham, 2010; Woods & Wilcox, 2013). Therefore, exploring the object and the object location may give infants more knowledge of both.

Selective Attention

Another possibility is that individuation can be aided by guiding infants' attention to a specific object feature that can be used as a basis for individuation. For example, one feature of an object could be highly salient, such as a flashing light. Drawing attention to a single feature may reduce the overall cognitive load required to perform a manual assessment task by reducing attention to competing, irrelevant information. It is known that attention directly influences perception, and therefore object representations, from an early age. The relationship between attention and perceptual abilities is believed to occur by either enhancing the processing of target stimuli or by diminishing distracting information present in a scene (Johnson & Proctor, 2004). The ability to selectively attend to objects (i.e., the ability to focus on certain stimuli and filter out or ignore irrelevant stimuli) improves with maturation (Richards, 1998).

Lavie's perceptual load theory of selective attention suggests that selective attention is directly influenced by overall perceptual load (Lavie, Hirst, de Fockert, & Viding, 2004; Couperus, 2011). The more complex an object is or the more stimuli there are in a visual scene, the greater the demand placed on attention. As an object or scene becomes more complex, there is an increase in perceptual load. This increase leads to overall attention being divided over multiple features. For example, if a scene contains ten objects, attention to any single object will be decreased because attention is divided among the multiple objects. Consequently, infants are less likely to form detailed object representations. Due the cognitive abilities of older infants, they are able to handle increases in perceptual load that are associated with additional features. Attentional selection is key to successfully individuating objects in the current manual search task. If infants are able to select the features they attend to, they should succeed at the task.

If making one feature highly salient successfully draws infant's attention to that feature, it could increase the strength of representation. Strengthening mental representations could potentially aid in object individuation by reducing the cognitive load. Attention to selected features can reduce cognitive load because there could be less features competing in the mental representation.

Current Study

Mental representations are essential for successful object individuation. We hypothesize that strengthening representations through improving object presentation or increasing attention to an object features will aid in object individuation. The present study assesses the degree to which acting on objects influences infants' ability to individuate those same objects. Infants aged 17- to 18- months were tested using a manual search task in which an object is hidden and later the same or a different object is retrieved. If a different object than what was hidden is retrieved and if infants are able to individuate the objects, they will continue to search for a second object. Infants participated in one of three conditions. In one condition, an experimenter hid the object (experimenter hides condition) and in a second condition, the infant hid the object (baby hides condition). Our expectation was that the infants in the experimenter hides condition would fail at the object individuation task due to the processing demands of the task. However, given that acting on objects can strengthen the nature of representations, we expected infants in the baby hides condition to succeed at the task.

One potential reason that acting on objects enhances object representations is that acting on objects may increase attention to object features. If enhancing object representations is the reason acting on objects allows infants to successfully individuate then increasing one object feature should also result in successful individuation.

We also added a third condition in which an experimenter hid the object, but the object had a flashing light (flashing-object condition). Our expectation was that the saliency of the feature would draw infants' attention to that feature. Encoding one feature into a representation may reduce the overall cognitive load of the manual search task. Drawing focus to one aspect of an object can cause a more robust representation of that feature. Because infants' representations only need to contain enough information to know that this object is different than or the same as the previous object, creating one feature that is more salient may increase the likelihood of successful individuation.

CHAPTER TWO. METHODS SECTION

Participants

Thirty (male = 16), healthy, full term 18-month-old infants completed the experiment. Participants were pseudo-randomly assigned to one of three conditions (experimenter hides, baby hides and flashing-object). Infants were Caucasian (85%), Caucasian, American Indian (7%), Hispanic or Latino (4%), or Asian (4%). Most infants had a least one parent who was a college graduate (75%). Others had parents whose highest education level included some college experience (21%), and the rest had at most a high school diploma (4%). In addition to the thirty infants in the study, twenty infants were excluded due to fussiness or refusing to participate (n = 13) and research assistant error (n = 7).

Stimuli and Experimental Set Up

The familiarization object was a red wood block 8 cm x 2 cm x 2 cm. Objects in the experimenter hides and baby hides condition consisted of two stuffed lions measuring 11 cm x 6 cm and one 8 cm x 6 cm fabric doll shoe (Figure 2). In the saliency condition, the lions had a light inserted into them. The light flashed within the torso of the lion. It was activated when tapped and continued to flash for roughly 20 seconds. Objects were hidden in bucket 18 cm x 10 cm in diameter with a red screw-on lip creating an opening at the top 13 cm in diameter (Figure 3). A spandex piece of fabric with a slit 8 cm long was stretched across the opening and held on by the screw-on cap. There was a trapdoor 12.5 cm x 7.5 cm in the back lower part of the bucket. The inside of the bucket was painted black. The bucket was rested on one of two tables between the experimenter and the infant, a tall table 72 cm or a short table 49.5 cm tall. The tall table has a pull-out shelf that is 5 cm below the table top that is occluded on all sides that do not face the experimenter. The experimenter sat across from the infant who was seated on her parent's lap. The experimenter was wearing a blue shirt and a white visor.

Figure 2. Photographs of objects used in the experiment

Figure 3. Photographs of methods and procedures.

Events and Procedures

The trial began with the experimenter holding the bucket within arm's reach of the participant approximately 90 cm from the ground during the hiding of objects by the experimenter or infant. Each infant participated in one familiarization trial and four test trials. All infants experienced both different- and same-object test trails. The starting trial was either different-object or same-object, counterbalanced across infants. Remaining trials alternated respectively. The experimenter kept one hand on the bucket at all times throughout the experiment to prevent the infant from moving the bucket. Parents were instructed to refrain from interacting with their child. Two observers live-coded within an adjacent room, viewing through a two-way mirror. All infants completed three familiarization trials. Each infant then had a minimum of two same-object test trials and two different-object test trials.

Familiarization Trials

Familiarization 1. The experiment began with familiarization one trial. The experimenter began by showing the infant the red block. Next, the experimenter inserted the familiarization block into the opening of the bucket. The experimenter put her hand into the bucket to retrieve the block and handed it to the infant. While tilting the bucket toward the infant, she asked the infant to insert the block into the opening of the bucket. Once the object was hidden, the experimenter moved the bucket to the lower table and asked the infant to retrieve the block. Once the infant retrieved the block, the experimenter moved on to the Familiarization 2 trials.

Familiarization 2, different-object trial. The familiarization two trials took place to allow the infant to further gain experience with the experimenter and the bucket. Each familiarization two trial began with lion placed at the top of the bucket for three seconds. The experimenter drew the attention of the infant to the lion by saying "Look at this," before pushing it through the slit into the bucket. Immediately afterward, the experimenter switched the lion with the shoe through the trapdoor in the back of the bucket out of view of the infant. The bucket was then placed on the small table and the infant had the opportunity to retrieve the object. Once retrieved, the experimenter placed her hand over the opening of the bucket and asked for the toy. Once the object was placed in the experimenter's hand, she returned it to the pull-out shelf signaling the initiation of the search portion of the trial. Next, the experimenter tilted her head down shielding her eyes, to allow the infant to focus on the bucket. The search portion of the trial lasted ten seconds.

Familiarization 3, same-object trial. The same-object familiarization trial was identical to the different-object familiarization trial with one exception. The lion was swapped with the second lion instead of with the shoe.

Experimenter Hides Condition Test Trials

Experimenter hides, different-object test trials. The different-object test trials were identical to the Familiarization 2, different-object trial.

Experimenter hides same-object test trials. The same-object trials were identical to the Familiarization 3, same-object trial.

Baby Hides Condition Test Trials

Each trial began with a lion placed at the top of the bucket for three seconds. During the three seconds, the experimenter drew the attention of the infant to the lion by saying, "Look at this." She then handed the lion to the infant and asked, "Can you hide it?" while tilting the bucket toward the infant. The infant then inserted the lion through the opening at the top of the bucket. The remainder of the trial proceeded exactly as the different- and same-object test trials of the Experimenter Hides condition.

Flashing-Object Condition Test Trials

The flashing-object condition different- and same-object test trials were the same as the different- and same-object test trials of the experimenter hides condition with one exception. The lions used had a flashing light in their torso that appeared when the lion was tapped. The flashing occurred for about 20 seconds.

Coding Procedures

Search time was operationally defined as the time during which an infant reached into the bucket and their whole hand (wrist to finger-tips) was occluded by the spandex during the search portion of the test trial. This portion was coded live during the experiment by two trained coders. Each coder held a computer controller attached to Hewlett-Packard All-in-One - 22-b315z computer. When the infant exhibited the target behavior, the coder pressed the button for the duration of the behavior. A custom software application recorded the duration the button was pressed to a tenth of a second and automatically calculated observer reliability.

CHAPTER THREE. RESULTS

Data Analysis Plan

Mean search times across different- and same-object test trails were calculated for each infant. The data was checked for normal distribution and no assumptions of Analysis of Variance (ANOVA) were violated. A 3 condition (experimenter hides, baby hides, flashing-object) x 2 trial type (same, different) mixed-model ANOVA was conducted. All analyses were conducted using SPSS 25.0. The main effect of condition was not significant, $F(1, 27) = 3.22$, $p = .05$, $\eta_p^2 = .19$, however there was a main effect of trial type, $F(1, 27) = 7.89$, $p = .009$, $\eta_p^2 = .22$ (different trials, *M* = 3.49, *SD* = 2.85; same trials, *M* = 2.16, *SD* = 2.36) . The interaction was not significant, $F(1, 27) = 3.17$, $p = .05$, $\eta_p^2 = .19$.

Planned comparisons, using a Bonferroni adjustment, revealed that in the experimenter hides condition, infants searched about equally in the same- (*M* = 2.00, *SD* = 1.69) and different-object (*M* = 2.16, *SD* = 2.16) test trials, $F(1, 9) = 0.16$, $p = .69$, $\eta_p^2 = .01$. Results for the flashing-object condition were also not significant, with infants search approximately as long in the same- (*M* = 3.75, *SD* = 3.05) and different-object (*M* = 4.61, *SD* = 2.34) test trials, $F(1, 9) = 0.73$, $p = .41$, $\eta_p^2 = .07$. However, in the baby hides condition there was a significant difference in search times in the same- (*M* = 0.73, *SD* = 0.83) and different-object (*M* = 3.70, *SD* = 3.56) test trials, $F(1, 9) = 10.37$, $p = .01$, $\eta_p^2 = .53$. Taken together, these results suggest that only infants in the baby hides condition recognized that a second object was retrieved in the different-object trials, and that the originally hidden object may still be inside the bucket.

CHAPTER FOUR. DISCUSSION

The primary finding of the present study is that when infants were given the opportunity to act on and have control over the object, they are more likely to succeed in individuating objects relative to infants who were observing. This conclusion is supported by a significant difference in search times of the different-object test trials compared to the same-object test trials for the baby-hides condition. We now know that allowing infants to hide the object aids in object individuation.

These findings bring about additional questions to consider. One of the primary questions is what aspects of the experience of hiding the object aided in object individuation? One possible explanation for why infants in the baby hides condition successfully individuated the objects is that the act of hiding the object, as a self-directed, multisensory movement enhanced the object representation. Not only were infants in the baby hides condition given the opportunity to hide the object, they also had the opportunity to explore the object before it was hidden as well as after it, or a different object, was retrieved. The additional information about object features from closer examinations may have aided in object individuation (Johnson & Woods, 2016; Wilcox, Woods, Chapa, & McCurry, 2007; Woods & Wilcox, 2013).

Another explanation could be that infants in the baby hides condition successfully individuated the object simply because they may have had the opportunity to interact with the objects longer than infants in the other conditions. It is possible that before the object was hidden by the infant there may have been time to interact with the object for a longer duration because the object was not taken away by the experimenter as it was in the other conditions. Even when asked to hide the object, infants would have been in control of when they hid the object and what they did with the object before it was hidden. Infants who did not have the opportunity to hide the object were subjected to the rigid time constraints imposed by the experimental protocols of the other conditions.

A third explanation regards infants' knowledge of the object's hiding location. The act of hiding the object gives different information than the act of finding the object. When the infant hid the object in the baby hides condition, he or she was learning information about the objects' hiding location. Tracking an object may be easier when the infant is in control of the object's location (Schaub, Bertin, & Cacchione, 2013).

An additional explanation for why infants searched more in the baby hides condition could be due to attention. Sustained attention involves focusing on relevant stimuli and features and disregarding distracting stimuli (Johnson & Proctor, 2004). It is possible that the act of hiding the object encouraged sustained attention to the important features that could aid individuation. Sustaining attention to an object may enhance object individuation by increasing attention to those important features. In order to test the idea that focused attention might facilitate object individuation, we added a salient feature to the lion in the flashing lion condition. If infants searched more in the baby hides condition because of their sustained attention to the object, then we would expect a pattern of results in the flashing lion condition similar to the pattern seen in the baby hides condition. However, this was not the case. Infants in the flashing lion condition searched similarly across same- and different-object test trials, suggesting that sustained attention is not sufficient to aid in object individuation under these conditions.

However, there are some alternative explanations for infants' failure to individuate in the flashing lion condition. One possibility is that the flashing light was simply not salient enough. In an infant's daily experience numerous toys having flashing lights. If the infants regarded the flashing light as just another object feature and not a more salient feature relative to other features, it could result in unsuccessful individuation. That is, if the flashing light did not draw infants' attention to that feature, then it would not serve to enhance the ability to individuate. Another possibility is that unlike the other features of the objects, the light was not present consistently; it flashed on and off. It could be that the light was not consistent enough for the infants to encode it as an object feature. If the flashing light flashed off when the infant was looking at it and flashed on after they had looked away, it is possible that it was not included in the object representation as an object feature. Alternatively, the flashing lion may have been too salient. If the flashing light was the only thing infants could focus on it may have distracted from the task.

Interestingly, infants in the flashing lion condition searched longer in all test trials compared to the other two conditions. There are numerous reasons for why infants in the flashing lion condition may have searched longer in all trials compared to the other conditions, but equally across same- and different- object test trials. The timing of the flashing lion was periodic rather than sustained; infants could be searching equally because they believe that the flashing lion they saw being hidden is different from the lion they retrieved. This could be because they did not see that the lion being hidden was flashing but saw that the lion they retrieved was flashing or vice versa.

An alternative explanation for why infants searched longer overall in the flashing lion condition is due to the projection of the light. When the flashing lion is hidden inside the bucket, they may have been able to see the flashing light through the top of the bucket. If this was the case, they may have thought that there was a new and different object flashing inside the bucket. If the infants believed there was a new flashing object in the bucket rather than the one that was hidden, they may have been searching for the new hidden object, not necessarily individuating the first object.

Limitations and Future Directions

There are several limitations to this study. The first limitation is the homogeneity of the demographics of the sample. Our overall sample consisted of mostly Caucasian infants whose parents were highly educated. Because of the overall sample demographics, generalizations to other populations should be made with caution. However, the vast majority of the studies on this topic have samples with similar demographics, indicating that the study fits well within the findings from the rest of the literature.

A second limitation is that the small sample size leads to reductions in generalizability and power. However, statistically significant planned comparisons suggest that power was sufficient. Third, as previously mentioned, a limitation of the flashing lion condition is that it is possible the lion could have been not flashing when the infant retrieved it. The increased searching time across different- and same-object test trials could be that because the lion wasn't flashing, they were individuating across all trials. Fourth, the non-natural environment of the experiment compared to real-world settings could also create issues with generalizability. The overall experiment is very structured, because of this we cannot be certain what they are learning in the real world and how that compares to our results.

In order to further explain the results of the baby hides condition, future directions should include additional separations of the behaviors. For example, if infants in the baby hides condition succeed due to the action of hiding the objects, allowing infants to hide the toys with a tool may yield similar results. Using a tool instead of their hands would separate the action from the experience with the hiding location of the object. If infants successfully individuate because they have more knowledge of the location of the objects, then allowing infants to experience the location while not hiding the object, should result in success. If the amount of time that the infants interact with the object enhances object individuation, then allowing the infants more time overall with the object should result in successful individuation.

Final Conclusions

Infants as young as 3 months are capable of individuating objects if assessed using an assessment method that is easier for infants. The current study used an assessment method that places a greater demand on the infant, a manual search task, which is more appropriate for 18-month-old infants than a looking time task. Older infants are capable of object individuation, but they rely on the same information that aids younger infants in individuation, such as object manipulation (Libertus & Needham, 2010).

The effect acting on objects has on infants' ability to individuate has been of interest in the field of infant development. However, most of the research on the influence of action on cognition involves prior object manipulation or exploration. The current study demonstrates the influence that action and control over an object and its location have on infants' ability to individuate objects. The findings are consistent with previous research that shows that having an opportunity to actively engage with objects enhances object processing.

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APPENDIX. PARTICIPANT INFORMATION SHEET

Baby's sex: F M I

Baby's birthdate: ______________________ **Birth weight:** __________________

Baby's Race/Ethnicity: Please check all that apply

______American Indian/Native Alaskan ______ Native Hawaiian/Pacific Islander

______Hispanic/Latino/Spanish Origin ______ Black/African American

______Asian ______ Asian Indian

______White/Caucasian ______Other: ________________________________

Baby was born at how many weeks?

At Term

32 33 34 35 36 37 38 39 **40** 41 42 43

Has baby suffered any **serious illness or injury**? ______________________

Does your baby have any known **cognitive delays?** ______________________

Does your baby have any known **visual impairments?** ______________________

Family History of Colorblindness:

Is there anyone in your infant's immediate or extended family who is **colorblind**?

___ Yes How is this person related to your infant? ______________________________

___ No On Baby's: Mother's Side Father's Side

Parent's Education: (circle for one or both parents)

Some High School High School Some College College Grad

Referrals

I would like to refer a friend. Please give me ___#___ brochures to share.

For Baby Lab Use:

Video Approval ◻ Video ◻ No presentations ◻ No video