THE PHYSICAL DISCRIMINATION AND POSSIBLE CONCEPT OF OBJECT WEIGHT THAT EXISTS IN INFANTS AND TODDLERS

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THE PHYSICAL DISCRIMINATION AND POSSIBLE CONCEPT OF OBJECT WEIGHT THAT EXISTS IN INFANTS AND TODDLERS

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Young children's attention to a variety of object features has been studied. However, very few studies have examined young children's understanding of object weight. In order to investigate developmental changes in perception and categorization of weight, three tasks were given to 59 18-month-old to 3-year-old children. Three age groups (20; 27 and 34 months old) were analyzed for the final results. The first two tasks used a familiarization and novelty preference paradigm in which attention was assessed by measuring each child's looking time.

The first task's goal was to evaluate young children's ability to discriminate objects on the basis of weight. Children were familiarized with an object of one weight and then tested with an identical looking object that had a novel weight. Half of the subjects were familiarized to a heavy weight and half to a light weight object. Results showed a decrease in looking time over the familiarization trials ($p = .0001$) and an increase in attention to the novel weight ($p = .0001$). Thus, all children in the first task were able to discriminate object weight. Additional analyses for the first task assessed physical discrimination of object weight by examining the amount of arm movement each child exhibited within 250 milliseconds after taking an object. A significant difference in arm movement was found between the last familiarization and novel weight trials of the heavy ($p = .0097$) and light ($p = .0001$) conditions.

The second task's goal was to evaluate children's ability to attend to object weight when appearance varies. Children were familiarized to four objects that had the same weight but differed in appearance. Half of the subjects were familiarized to heavy objects and half to light objects. After familiarization, the children were tested with one object that had the same weight but a different appearance and another object that had the same appearance but a different weight. Results revealed that the children's looking time decreased over the familiarization trials ($p = .0001$). Analyses of test trials revealed that only the two older age groups had significant novelty preference scores for both the new weight and new appearance trials.

The third task used a balance scale to measure understanding of weight by observing a child's ability to pick a heavy object to make a balance scale tip. Children were given a light and heavy object with the same appearance and asked to choose which one would tip the balance scale. Results showed that only 34 month olds had significantly more correct trials ($p < 0.05$). In conclusion, the study's results indicated that all young children are capable of discriminating object weight when familiarized to one object but that only the two older age groups were significantly capable of doing this when familiarized to more than one object. Results also indicated that only 34 month olds were capable of using weight differences in a more functional way, namely to tip a balance scale.

The Physical Discrimination and Possible

Concept of Object Weight that Exists in Infants and Toddlers

Many aspects of sensorimotor development have been studied in infants and toddlers with the hope of discovering how human beings first learned to detect object features. The ultimate goal of such research has been to discover how a detection of object features allowed people to interact successfully with objects in their environment and developed more complex behaviors (e.g., abstract learning and symbolic thought). Among the different types of object features that have been extensively studied, including shape, color and functionality, object weight and how it has been detected by infants and toddlers has been understudied in the developmental psychology field. However, the study of how children discriminate weight differences can provide insight into the sensory cues to which they most respond to when a non-obvious object property has been detected.

For instance, have young children been mostly using visual perception when interacting with objects that have non-obvious object properties, or have they used a combination of sensory cues? Furthermore, has this sensory information been helping them form a cognitive concept of these objects? If young children mostly use visual perception with objects then they may not really have a concept of object weight. On the other hand, if they attend to a variety of sensory cues then they may have a concept of object weight at an early age. Thus, it is important to determine what type of sensorimotor information that young children use to form a concept of object weight.

By definition, sensorimotor cues have been any type of information physically perceived by children that gave them an indication that one object was different from (or was similar to) another object. Will children who show a detection of weight difference through sensorimotor cues (i.e., arm movement) also exhibit a concept of object weight? Or are these two abilities generally present in young children but do not co-exist in one age group? These questions were addressed by the present study. Thus, this paper has focused on the possibility that infants and toddlers have detected object weight through sensorimotor cues and that they may or may not use this information to develop a concept of what they can do with an object because of its weight.

One of the earliest researchers who studied weight discrimination in children was Jean Piaget. Piaget explained the cognitive concepts of weight that children displayed in his studies. Piaget described four stages of development that children experience in order to understand the various physical properties that objects possess (Kohn, 1993). The first stage occurred in children four to six years of age and marked a time when they have a global identity of object concepts. At this stage of development, they often thought that object properties such as volume, weight and quantity co-vary with each other. It was in stage two that five- to seven-year-old children begin to disassociate these properties and viewed an object's weight as being independent of its size or volume. At this stage, they also related an object's matter (composition) to its weight, making statements such as "a pebble is heavier than a boat because it is made of stone" (Kohn, 1993, p. 1638).

Children continued to refer to object composition to describe weight in stage three (Kohn, 1993). Eight to eleven year olds were in stage three and this stage marked a time when children were unable to generalize how an object of specific weight functions in water. For instance, Piaget found that stage three children who saw an object sink in a bucket of water said that the same object would float in a larger body of water. Children in this stage also based their idea of an object's weight on the substance of which it was made (e.g., they thought one object was heavier because it was made of stone). Piaget did not clarify why he described a third stage since children did not display cognitive developments at that time. Finally, children reached the fourth stage at twelve years of age and, in the later portion of this stage, viewed objects as having properties that are unchangeable. In other words, a child believed that the weight of an object was a static property and also thought of density in terms of weight per unit volume (Kohn, 1993). It was also in stage four that children no longer held the belief they had in stage one that object properties were correlated. Thus, Piaget thought that children were able to differentiate cognitively object properties over time.

Despite the contributions that Piaget's work made toward the developmental psychology field, his work had not addressed the concept of object weight that may exist in children younger than four years old. Smith, Carey and Wiser (1985) tried to expand on Piaget's work by testing the concepts that children, including younger children, have about size, weight and density. Smith et al. also studied how these concepts develop over time. Furthermore, they hoped to obtain a better understanding of how children have conceived of object properties by testing them with both verbal and non-verbal tasks. The inclusion of non-verbal tasks in Smith et al. also expanded on Piaget's work since he only tested children's verbal understanding of object properties.

Smith et al. (1985) examined the understanding that children, ranging in age from three to nine years old, have about object properties such as volume, density and weight. Smith et al. wanted to see how the concept of object properties developed in children over time. They wanted to know if these concepts followed the same progression as historically seen in science. For instance, Smith et al. stated that scientific analysis created new hypotheses from those that have already been established. Smith et al. wanted to discover whether the same type of progression occurred with children learning about object properties.

In other words, have children's early concepts of object properties provided them with the foundation upon which more mature concepts are built? If this hypothesis turned out to be correct, then the developmental progression seen in children's concepts of object properties would be similar to how these concepts were developed in the field of science. On a final note, Smith et al. wanted to expand on Piaget's earlier work with object properties because they felt that the tasks he used to test children were too difficult, particularly the conservation task in which children were told to gauge whether a clay ball weighed the same amount as its former sausage state. Smith et al. believed that most children see an object's size as an indicator of its weight and that these concepts were not differentiated by Piaget's conservation task.

Smith et al. (1985) hoped to combat the flaws that they saw in Piaget's previous work by giving children multiple tasks in which their understanding of the interrelations among size, weight and density were tested in various ways. Two nonverbal tasks were used in the study and they tested whether or not a child could make an object work based on one of its object properties. For instance, children fitted objects in a box for the size task and made a foam rubber bridge collapse for the weight task. The other two tasks were verbally oriented and examined whether a child had a clear understanding of the words 'heavier' and 'larger'. In the verbal tasks, children were asked whether there was a difference in size or weight between common items (e.g., a grape and orange) and then were presented with two cylinders that they had to say were either different or equal in size or weight. In all four tasks, Smith et al. used items that correlated volume, density and weight (i.e., as one property increased the other two did as well) and those that did not. Smith et al. did not clarify whether or not object properties were perfectly correlated. Smith et al. used cubes composed of different materials (e.g., aluminum, brass or wood) in the nonverbal tasks and cylinders in the verbal tasks. The cylinders were also composed of aluminum, brass or wood. Both the cubes and cylinders differed in size and weight and either correlated these properties or did not.

Smith et al. (1985) hypothesized that if their participants always correlated size with weight then on every task they should make more errors with items that have not correlated size and weight than with those that have. Smith et al. titled this hypothesis ‘an undifferentiated concept of size and weight’ and they believed that it was faulty. On the other hand, if children have not always correlated these properties then there may be more errors with items that correlated size and weight. Smith et al. believed that children do differentiate between size and weight and they wanted to see whether their study would provide evidence for this notion.

Results of Smith et al. (1985) showed that mistakes with either the items that correlated size and weight or those that did not were not prevalent on the size tasks. Thus, most three to five year old children—participants that Piaget would have labeled as either before stage one, in stage two or in stage three—were able to completely distinguish size from weight. More errors were made on weight tasks but, intriguingly, more errors were made with items that correlated size and weight than with those that did not. Furthermore, these errors occurred mainly with the nonverbal tasks and somewhat with the verbal weight tasks. For instance, in the verbal weight tasks, a size intrusion occurred whenever they judged the bigger item to be heavier but most participants did not make this error and, instead, incorrectly judged both items to have the same weight. In these instances, the items included one small and one large cylinder with the small cylinder weighing more than the large cylinder. Thus, Smith et al. deduced that the errors participants made were not due to an inability to differentiate size from weight.

In contrast, more participants made mistakes with the nonverbal weight tasks and these errors occurred both with items that correlated size and weight and those that did not. The errors that occurred in the nonverbal weight task were probably because the children found the task to be too difficult. For example, there were four items that correlated object properties and four that did not and a child had to differentiate between these two groups in order to determine which cube would make the foam bridge collapse, crushing the toy alligator. Therefore, the participant had to make a judgment of not only which cube was the heaviest to collapse the bridge, but they also had to compare the object's weight against three other items within the same group. This probably confused the participants and influenced them to choose an item by comparing its heaviness against the other items.

Smith et al.'s (1985) results revealed that participants, who chose from items that did not correlate properties, did not choose the lightest of the four other heavier cubes (e.g., a small heavy brass cube). Instead, a small aluminum cube, which was the heaviest of the four light cubes, was chosen as being heavy enough to collapse the bridge. The results also showed that there were only two children who based object weight on its size in these tasks. Thus, it can be determined from these results that children as young as three years old can distinguish weight differences between objects and, thus, do not have a size/weight undifferentiation.

Other weight studies conducted on this age group have tried to study more abstract concepts such as distance and balance, eliminating the complicated outcomes that sometimes occurred when both size and weight were present in objects. Siegler (1976) carried out such a study with the intention of testing formal operation capabilities in four age groups that included five to six, nine to ten, 13 to 14, and 16 to 17 year olds. Siegler used different problems in order to see whether children could predict which way a balance scale would tip when there were different amounts of weight on the scale or when the pegs were placed in different positions on the scale. The problems presented included balance, weight, and distance. The *balance* problems consisted of equal numbers of weight that were placed equally far from the center or fulcrum of the balance scale. Siegler defined *weight* problems as when unequal amounts of weight were placed equidistance from the fulcrum. *Distance* problems were when equal amounts of weight were located different distances from the fulcrum.

Siegler's (1976) results showed that there was a developmental trend in children's ability to solve formal operational problems. Siegler showed that there was no developmental trend for balance or weight problems for the participants tested in his study. The greatest developmental trend occurred for distance problems with the error rate progressively declining as it was tested in increasingly older children. Therefore, Siegler's results showed that children as young as five years old have no difficulty solving balance or weight problems, but they may have profound difficulty with distance problems. Children as young as five years old can solve balance and weight problems whether they were seeing the task modeled or they were solving it on their own. On the other hand, five year olds were not able to solve distance problems even if they had seen the task modeled.

Siegler's (1976) study addressed a point made by Smith et al. (1985): young children can solve formal operation problems only if the task was not too difficult and they understood the relationship among object properties (i.e., weight and size). Siegler eliminated the confusion children may experience from correlating size with weight by using pegs of the same size, but of a different weight. Thus, Siegler's set-up allowed children to focus just on weight difference and not size difference. However, focus on weight in this study was greatly impaired for five year olds if they received a task that required an additional focus on peg distance from the fulcrum (i.e., a harder task for them to solve). Thus, it could be determined from Siegler's study that children as young as five did have great difficulty solving problems that use environmental properties (e.g., distance from balance fulcrum) that they may not be familiar with.

These findings may lead one to suspect that one of the first object properties that children become familiar with is weight. Furthermore, they were able to attend to this object property in a functional manner, such as using weight to get a balance scale to work. This does not imply that size was not discriminated by children early on, but, unlike object weight, size was an obvious object property (i.e., it is detected visually) while weight was a non-obvious object property. Still why would weight be one of the first non-obvious object properties to be comprehended by children?

A review of Eleanor Gibson's (1988) perspective on the exploratory behavior of children and how this behavior relates to perceptual development gave some insight into why children focus on an object's weight early in development. In her review paper, Gibson declared that exploratory behavior in infants was controlled by some anticipation of an outcome and that this behavior was used to develop adaptive actions. Accordingly, discussion of her work will begin with an emphasis on when she said object exploration began and how it developed through the first year of life. Thus, this will create a foundation upon which discussion of infant weight perception and cognition will follow.

Gibson (1988) stated that infants have begun object exploration at five to seven months of age. At eight or nine months of age, they have acquired locomotion and discovered the affordances of their environment. Affordances were the advantages that objects in the environment provided you and the functions that the objects possessed. For example, Gibson stated that a swing can be manipulated in many ways and provided various kinds of playing opportunities. Gibson believed that earlier theories stating that perception precedes action in infants and that perception and action were separate entities were incorrect. Instead, she believed that perception and action provided input to each other and created a cycle in which each produced an opportunity for the other. Gibson stated that this was why even newborns engaged in exploratory activities and used these activities in functional ways, despite their lack of ability to take executive action. A further point made by Gibson was that the spontaneous exploratory activity that newborns engaged in created cognition.

Gibson (1988) further revealed that exploratory activity in the first year of life was used to build an infant's knowledge about the world. This knowledge included an understanding of what is permanent in objects and the world, how to predict relationships between events and how the infant can act upon objects and events in order to manipulate them for his or her own purpose. However, how does this very general purpose lead to a specific identification of weight by infants and an understanding of how to use the affordances that an object's weight provides in their daily lives? In addition, can such an accomplishment occur in an infant's first year of life, a time in which object exploration and how to use object affordances is actively explored (according to Gibson)?

Mounoud and Bower (1974) tested infants ranging in age from six to 16 months old to see whether they identified weight differences in objects through sensorimotor cues. They conducted a habituation procedure in which they presented the same brass rod for three trials to the participants. Then they presented a rod that was visually identical yet had a different weight than the rod to which the participants were habituated. This second part of the procedure was known as a discrimination test and it was used to see whether the children could differentiate between objects based on a weight difference.

The results of Mounoud and Bower's (1974) study seemed to confirm that infants were able to identify object weight by their first year. For example, their study showed that 9.5-month-old infants had a sensorimotor adaptation to weight differences. Additionally, it was at this age that infants began to associate variation in their arm movement(s) with variation in the weight of objects. In other words, 9.5-month-old infants adjusted their arm movements to accommodate the weight of an object presented to them. Hence, it could be, with these arm adjustments, that they are starting to learn how to control their bodies physically in order to manipulate how an object is used and, possibly, understand what affordances an object provides because of its weight. Weight could give an early indication of how an object can be used for a functional purpose.

However, were these infants basing their arm adjustments on the visual size of the objects or on sensorimotor cues?

Mounoud and Bower (1974) demonstrated that infants used visually perceived object size to determine its weight with mixed results. Mounoud and Bower (1974) examined infants' ability to understand conservation of object weight. In order to do this, the researchers first had to determine whether adaptation to an object's weight was based on visually perceived size of the object. Mounoud and Bower hypothesized that if a child habituated to an object of a certain size and weight then that child would have an expectation that another object twice as large and heavy would weigh more and, therefore, have a reduced arm drop when taking this larger/heavier object. Thus, they concluded that a child that demonstrated this type of behavior was showing an understanding of conservation (e.g., an object twice as large as the last will be twice as heavy).

Mounoud and Bower (1974) found that only at 9.5 months of age did infants use visual size of an object to determine their response to it. For instance, their results showed that 9.5 month-old infants presented initially with an object of one size and weight would show significant arm drop when subsequently presented with a larger/heavier object. Still, this capability did not lead to an understanding of weight conservation because this ability was only present in 18-month-old infants. Furthermore, visually based assessment of size could not be fully determined because the participants did not always elicit fewer or smaller arm drops (or elevations) on subsequent trials. In other words, Mounoud and Bower stated that if participants had always based weight on visual size then they should maintain an anticipation of weight through the seriation set and have less pronounced arm movements as the trials progressed. In fact, this was only seen in 15-month-old participants and even then the finding was not consistent: 15-month-olds did not start to show reduction in their arm movements until they received the third object in the seriation task (Mounoud and Bower, 1974).

According to Mounoud and Bower (1974), these results showed that 15 month-olds were only meeting a minimum requirement of basing weight on visual size. Their error in grasping the second object was greater than their error in grasping the first object due to too much or too little force exerted on the second object. Mounoud and Bower believed that there should be no error in grasping the second object if visual size was the basis for detecting object weight. Thus, Mounoud and Bower's results indicated that infants were using some perception other than vision to detect object weight differences. In fact, it was possible that they were using sensorimotor cues to detect the weight differences.

Mounoud and Bower's (1974) findings also lend credence to Gibson's discussion of what an infant has learned when he or she explored his or her environment. Gibson (1988) stated that learning should not be defined just by what is reinforced by others. After all, learning to discriminate weight is not a concept often demonstrated by a child's teacher or parents when they are trying to teach the child academic topics such as math or science. Instead, Gibson argued that spontaneous self-initiated learning has important consequences for the knowledge acquired by an infant. It was during such lessons that a child comprehended the affordances of objects and its environment.

By understanding the affordances offered by an object's weight, a child can know how to physically interact with an object and what function an object provides because of its weight. For instance, if a child has achieved a sensorimotor adaptation to an object's weight then she or he can avoid being injured when they manipulate the object with her or his hands. Also, if children understood how to use an object's weight in order to make a toy work--either by using weight to create action (e.g., a heavier person makes a seesaw tip) or build something (e.g., lighter blocks go on top of the structure)--then they have gained an ability to function more independently in tasks involving object manipulation. Thus, a child may have only needed to focus on the elementary concept of weight and, later on, have developed an understanding of how other object functionalities build on this concept. An example of this would be a child having understood a more complex concept like weight conservation after he or she has understood that an object's weight does not always correspond to its size or shape.

Mounoud and Bower (1974) tested weight conservation in children ranging in age from nine to 18 months. In this task, a rod of a light or heavy weight was presented for three trials and then its shape transformed by the experimenter as the participants watched. Thus, on the fourth trial, the object was re-presented and the researchers measured the pressure participants applied to it. The researchers determined that weight conservation was being displayed if the participant had not changed the pressure they applied to the transformed object. Indeed, Mounoud and Bower (1974) found that weight conservation did not appear in their infant participants until several months after they had developed a sensorimotor adaptation to weight changes. However, was the inability to solve weight conservation problems due to a lack of experience (with weight conservation) or was it the result of what Smith et al. (1985) termed an 'undifferentiated concept of size and weight'? Was it possible that an inability to solve weight conservation problems was the result of both concepts?

As will be discussed in more detail below, I have deduced from Mounoud and Bower's (1974) study that children less than a year old had an undifferentiated concept of size and weight probably due to their inexperience with many different types of objects. As seen in the results from Smith et al.'s (1985) study, this undifferentiated concept seems to have disappeared when children reach the age of three years old. Thus, the concept of undifferentiated size and weight may become less prominent as a child developed both physical and mental capacities. This ideology did not argue against Piaget (Kohn 1993) who stated that children gradually learned to differentiate an object's size from its weight, but it did show that this process might occur earlier than Piaget's study revealed: Piaget stated that children differentiated size from weight at five years old while Smith et al.'s results implied that the concept of size-weight differentiation occurred in three year olds.

One conclusion that can be made from Mounoud and Bower (1974) was that infants at 9.5 months cannot cognitively distinguish weight differences if they were presented with two objects that had an equal size but a different weight. This was the case even when infants displayed a significant arm elevation to the lighter object. Instead, the participants appeared to anticipate that an object would weigh the same as a previously presented object because it was the same size. Yet, the significant increase in arm elevation showed that this anticipation was corrected for when the subject had physically adjusted to the lighter weight. The researchers indicated how they thought this anticipation of object weight was corrected for in the following statement: "inspection of their behavior indicated that these babies tended over trials to lock their arm against their body…weight of their body acted as a counterweight to the object placed in their hand" (Mounoud & Bower, 1974, p. 33). Thus, Mounoud and Bower's study revealed that infants physically adapted to weight change. However, the possible functional understanding of object weight that might be present in infants cannot be determined by their study's parameters. Still, it was implied that a possible size/weight undifferentiation occurred with children as young as 9.5 months.

The description of the 9.5-month-old infants' behavior seemed to suggest that they were physically adapting to different weights because their body braced for the possibility of a weight that was different from the previously presented weight. Nevertheless, had this physical adaptation transferred into a cognitive conception of weight differences? Although this type of hypothetical question has not been addressed with infant research participants, it has been studied in adults. Flanagan and Beltzner (2000) studied the perceptual and sensorimotor predictions of participants when they were introduced with objects that projected the size-weight illusion. They described the size-weight illusion as a phenomenon that occurs when participants tested with two equally weighted but not equally sized objects perceived the smaller object as being heavier after successive trials. When a participant first saw these objects, he or she probably thought that the larger object was heavier than the smaller one. However, as they repeatedly lifted the two objects, they judged the smaller object to be the heavier one. This occurred even though they have increased their grip and lift forces and vertical acceleration for the larger box. Thus, the participants were physically adapting to the respective weights of the boxes, but this physical adaptation was not changing their cognitive perception that one of the boxes was heavier than the other.

Flanagan and Beltzner (2000) hypothesized that the sensorimotor adaptation that occurred in response to varying object weights did not affect the cognitive perception of weight because the cognitive and sensorimotor systems were separate. Therefore, since the participants thought that one of the objects was heavier and their physical experience did not change this concept (or clue them in that the objects weighed the same) then they started to equate the conceived heaviness with density and believe that the small object was heavier. Furthermore, Flanagan and Beltzner discovered that their participants' force predictions were influenced by cognitive conceptual cues during initial lifting trials, but that sensorimotor cues guided the force they used on successive trials. Consequently, the adult participants in Flanagan and Beltzner's study were making conceptual predictions of weight in a different way than infants were in Mounoud and Bower's (1974) study: adults based weight on object size differences even if the objects were equally weighted and the infants based weight differences on sensorimotor cues even if the objects were different in size. Therefore, these results suggested that infants paid more attention to sensorimotor than conceptual (e.g., size equals weight) cues. Both studies used variations in object size but only Mounoud and Bower used variation in object weight and, thus, Mounoud and Bower were not testing the size-weight illusion.

Since I did not find a study that addressed the size-weight illusion in young children, I wondered whether the phenomenon existed in that age group. Although the phenomenon was not tested in my study, it still was an interesting subject to ponder because, if it occurred in infants and toddlers, it would have been a good indication that they based an object's weight on its size. Based on the results obtained from Smith et al. (1985), participants that were three years old or older did not associate (or base) weight with (on) size, or had an undifferentiated concept of size and weight. It seemed that children in this study chose objects based on their weight even if the objects differed in size. For instance if participants received a set of four light objects all different in size (e.g., Styrofoam and balsa wood were large in size while aluminum and Plexiglas were small), then they would have chose the aluminum cube to collapse the bridge since it was the heaviest of the four light cubes in the set. They only chose the small brass cube (i.e., lightest of the four heavy cubes and the item that would have collapsed the bridge) if they were instructed to choose an item that would not collapse the bridge.

The inability to judge weight difference in the two cubes (and pick the correct cube) might have been due to the difficulty of a task in which children were asked to separate items into light and heavy categories based on small differences in felt weight. For instance, in Smith et al.'s (1985) pre-test, adult participants stated that the "felt weight" differences between objects were much smaller than the actual weight differences between the objects (e.g., there was a 180 gram difference between the brass and aluminum, but the adults said that there was only a 37 gram difference). Smith et al.'s results did not dispute the fact that children can physically discriminate object weight differences since Mounoud and Bower (1974) demonstrated that much younger children did display this ability.

Based on the results in Mounoud and Bower (1974), I have ascertained that the participants in their study were using more sensorimotor cues than cognitive conceptions of weight to discriminate between the weights of different objects. Their use of sensorimotor cues was seen in the fact that they displayed a sensorimotor adaptation to the weight changes in objects. This contrasted with the results obtained with adults tested in Flanagan and Beltzner (2000). Hence, it could be construed that children at three years of age did not have a cognitive concept of weight in the sense that they based weight on object size (e.g., as seen in adults).

However, it has yet to be tested whether or not cognition of weight might occur in children when they *do not* have to base an object's weight on its size. Instead, was it possible that children based weight on its functionality as seen in Siegler's (1974) balance results and referred to in Gibson's (1988) discussion of affordances? If they were basing weight on the function that it provides an object, then it might be possible that a way to measure cognition of weight in children would be to give them objects that create a change in their environment due to the objects' weight. An example of a task that would measure weight concept in this way would be to present two identical looking objects to children in which the heavy one would make a balance scale tip downwards but the light one would not. Before I delve into how this hypothesis would be tested, I will review one final study that indirectly tested whether or not cognitive concept of weight exists in young children.

Molina and Jouen (2003) studied haptic weight perception in 12-month-old infants and measured the amount of time they held an object and the amount of manual pressure exerted on an object. Molina and Jouen used these methods as a way to expand the measurements used in Mounoud and Bower (1974). Thus, like Mounoud and Bower, Molina and Jouen wanted to obtain a measurement of the sensorimotor perception of object weight that infants used. In Molina and Jouen's study, they used objects that were visually identical and varied only in weight. They conducted an infant controlled habituation procedure in which an infant was given the same object until they experienced a 50% decline in holding time on three successive trials as compared to the holding time they displayed in the first three trials.

Molina and Jouen (2003) used a between groups design in which infants either received a heavy or light habituation object. After three habituation trials, half of the infants received a new object weight and half received the same object weight that they had been presented with in the habituation procedure (i.e., familiar weight). By presenting the familiar object weight after habituation, Molina and Jouen were able to utilize a control trial in which they could compare a child's response to an object weight that he or she received during the habituation session. If the child had the same reaction to the object as they did on the last habituation trial (or they have less of a reaction) then Molina and Jouen could conclude that the child was truly habituated to that object weight.

Molina and Jouen's (2003) study showed that a significant difference in holding time for the novel object (as compared to the habituation object) was observed for infants in both habituation groups. Furthermore, infants in both habituation conditions showed a significantly higher grip force for the novel object. Still, the increase in grip force did not vary whether the participant received a light or heavy novel object. Therefore, Molina and Jouen concluded that grip force was increasing due to the novelty of the object and not because of the novel object's actual weight. If grip force corresponded to object weight then one might expect more grip force to have occurred when participants were given a heavy novel object. The researchers decided that these findings showed that 12-

month-old infants were not thinking about the weight of an object, but manually reacted to a change in an object's physical property when they were given a novel object.

The between subjects design employed by Molina and Jouen (2003) produced a low statistical power in terms of detecting differences in performance between different habituation groups. Therefore, Molina and Jouen's design was not the most efficient way to run a procedure. Indeed, it would have been more statistically powerful to have all of the infant participants receive a novel weight object and then a completely novel object (i.e., differing both in appearance and weight from any object presented before) to observe how they increased attention to both objects. Thus, a within subjects design was employed in my study.

Molina and Jouen's (2003) study showed that whether a 12-month-old was discriminating between a light habituation object and a heavy novel one (or a heavy habituation object and a light novel one), the weight of the novel object did not change how he or she physically interacted with it. Would it change if the design of Molina and Jouen's study was modified? A better assessment of the difference in physical manipulation that might have occurred when handling two different novel weights may be obtained with a within subjects design that did not present a familiar weight object during test trials. Like Molina and Jouen's study, this study's design familiarized one-half of the participants to a heavy weight object and the other half to a light weight object. However, this design differed from Molina and Jouen by presenting all participants with a novel weight and then a completely novel object during the test trials (instead of a familiar weight object). Thus, this study's design would have given a better assessment of the how children reacted to the novel weight within habituation groups.

Consequently, this method might also have provided more statistical power than Molina and Jouen's method did in finding significant differences in the physical manipulation of the two different novel weights.

The current study examined the physical or sensorimotor adaptation to weight change and the possible cognitive concept of weight that might exist in children 1.5 to 3.0 years old. We tested children at three different ages from 18 to 36 months old. These particular age groups were studied because Molina and Jouen (2003) showed that physical adaptation to weight change occurred at one year old and object weight discrimination has not yet been studied in toddlers. Consequently, I expected that all the age groups tested would be able to discriminate object weight differences by sensorimotor perception because Molina and Jouen revealed that children were capable of doing this at one year of age.

The ultimate goal of this study was to see whether a cognitive concept of weight difference existed in children before they can adequately verbalize. Since I could not find any previous research that addressed infants and toddlers' ability to perform on a balance scale task, my hypotheses did not address the possible developmental differences that may be observed with the balance task. Instead, I hypothesized how this task may be tested in children before they can adequately verbalize or have obtained the ability to solve formal operation problems. The hypothesis stated that a cognitive concept of weight could be tested in children older than one year old if they were tested with a task that measured their knowledge of how weight is used (i.e., to get a balance scale to work) instead of what weight is (i.e., this weight is heavier than the other).

A portion of my design included a balance scale because Siegler (1976) and Smith et al. (1985) showed that cognitive concept of weight can be studied in children when they were given a task in which an object's weight produced a visual outcome. This was possibly due to the fact that young children often have been engaged in and understood tasks that did not require much verbal instruction. Furthermore, a balance scale was used because it can be an easy and engaging apparatus for a child to operate especially if it is modified so that a child needs to focus only on the action of one of the scale's buckets. One goal in using this task was to discover whether a developmental progression of the weight concept existed in children 18 to 36 months old. In other words, was the idea of weight more accurate in 36 month olds than in 18 month olds?

I hypothesized that the ability to use sensorimotor perception to detect weight differences (e.g., arm movement) would not affect cognitive concept of weight. In other words, a child who has detected object weight differences using sensorimotor perception (i.e., by showing a novelty preference) may not have performed well on the balance scale task. Such a result would be expected because previous research has shown that there is a disassociation between sensorimotor perception and cognition of object weight (e.g., Flanagan and Beltzner, 2000). In addition, even though Piaget (Kohn, 1993) found that four to six-year-old children had some concept of object weight (i.e., they used the term 'heavy' in his weight-density study), his participants did not display an understanding that an object's weight affected how an object would operate in the environment until they were about eight to eleven years old. For instance, Piaget found that four to six year olds thought that a boat floated in the water because it was "clever" or "big" and not because its weight was lighter than the water. Thus, the younger children's sensorimotor perception of an object's weight did not affect their concept of how an object would function in its environment because of its weight.

Methods

Participants

A total of 59 healthy participants between the ages of 18 and 36 months old were tested with the three tasks. The young age group (twenty month olds) ranged in age from 18.08 to 24.06 months old (M = 19.71 months) and included 17 participants. The middle group (twenty-seven month olds) ranged in age from 24.19 to 30.34 months old (M = 27.48 months) and included 20 participants. Finally, the older group (thirty-four month olds) had an age range of 30.37 to 37.34 months (M = 34.57 months) and contained 18 participants.

No child had a known history of vision or hearing problems. Out of 59 participants, ten participants failed to complete the discrimination task and could not be included in the final analysis for the following reasons: did not take test objects (n = 4), would not take the first object given so testing could not start (n = 4), experimental error with session recording (n = 1) or experimental error with timing of the trials (n = 1). Twenty-five males and 24 females completed the discrimination task.

The same participants were also tested with the categorization task. Six participants failed to complete the categorization task or could not be included in final analysis for the following reasons: did not take test objects (n = 3), would not take the first object given so testing could not start (n = 2), or experimental error with timing of the trials (n = 1). Twenty-seven males and 26 females completed the categorization task.

Of the original 59 participants, 57 were tested with the balance scale task. Ten participants in the balance scale task did not complete all five trials. These participants were in the 20 month (n = 6) and 27 month (n = 4) age groups and were included in the final analysis. One participant at twenty months old could not be included in the final analysis because experimental error occurred with recording this participant during the balance scale task (n = 1). This was the only participant tested who could not be included in the analysis. Therefore, the final sample of the three age groups in the balance scale task contained 53 participants. Twenty-seven males and 30 females completed the balance scale task.

Participants were randomly chosen from birth announcements stored in our infant database. All participants were from the local area of Bowling Green, Kentucky. When a child was approaching their birth date, parents were contacted by letter and a follow-up phone call to schedule an appointment. Children participated within two weeks of their target birth date. The children received a t-shirt for their participation. All children were treated in accordance with the guidelines provided by the Human Subjects Review Board.

Materials

All of the objects were of sizes and shapes that appear to be easily handled by children at the ages specified. The stimuli used in the discrimination task were two 3 x 3 inch compressible cubes with beaded handles. The heavy object weighed 323 grams (11.39 ounces) and the light object weighed 51 grams (1.79 ounces). The compressible cubes were similar to the objects used in Molina and Jouen (2003) in that the light and heavy objects were the same visually and tactually. The completely novel object was a foam rubber ball approximately the same size as the cubes connected to a plastic chain. This object had a different weight than the cubes, weighing 18 grams (0.64 ounces)

Five pairs of additional objects were used in the categorization and balance scale task. The two objects in each pair were nearly identical in appearance, but differed in weight. All light objects weighed between 44 and 51 grams, and all the heavy objects weighed between 319 and 324 grams. This range of weight differences is within the limits of what has been used to test object weight discrimination in children of the age groups tested in this study (e.g., Mounoud & Bower, 1974; Molina & Jouen, 2003). The completely novel object for the categorization task alone was a tri-colored geometric Styrofoam figure weighing nine grams (0.32 ounces). Pictures of all the stimuli as well as the apparatus (i.e., balance scale) and set-up used in the current study are displayed in the appendix.

A balance scale with a small bear attached to one bucket was used in the balance scale task. The balance scale was weighted on one side. These weights were intermediate to the light and heavy objects and were placed on one side of the scale so that the scale would not tip when a light object was placed on the other side of the scale, but it would tip when a heavy object was. The bear was located above the bucket in which the children were to place the objects so they would focus their attention on this bucket and not the one with the weights. Timing of the trials was counted by a wall clock that has a seconds hand and a digital video camera (Canon model # NTSC 2R90) was used to record the children's interactions with the objects.

Design and Procedure

Discrimination Task. A participant was seated in an infant booster seat. The experimenter sat across from the participant and the participant's parent sat behind the participant. A digital video camera was on the left side of the participant, facing the opposing wall, which was covered in a checkerboard pattern. This set up ensured that the participants' arm movements could be distinctly measured by the checkerboard pattern and that any other activity that they engaged in (e.g., looking) was recorded. Each black or white square on the pattern measured one-half of an inch in length. On each trial, the experimenter presented an object by holding it sideways with the handle pointed toward a participant, allowing the participant to grab the object with his or her arm extended. The experimenter asked each participant to take an object by saying “can you grab it by the beads?” If a participant hesitated to take an object then a hand puppet (i.e., a purple hippopotamus or a green dragon) was used to engage the children in taking the objects.

The experimenter made a “thumbs up” sign when a participant took an object to signal to the coders that a trial had begun. Once an object was taken the participant was allowed to handle it physically for ten seconds. Inter-trial intervals were standardized as much as possible. Inter-trial intervals were standardized by the experimenter performing the same routine after every trial ended: the experimenter took the object, placed it behind the wall on a box and then retrieved it, re-presenting it to the participants. Objects were presented from a far enough distance so that a child had to extend her or his arm to grasp an object. This ensured that the amount of arm movement that a child exhibited was clearly detected and measured by the checkerboard pattern.

The discrimination task was comprised of three phases: the pre-test, the familiarization trials and the test trials. All participants were randomly assigned to either a light or heavy familiarization condition. The familiarization phase consisted of eight ten-second trials with an object of one weight. The procedure used during the familiarization phase of the discrimination task was loosely based on the familiarization procedure used in experiment 1 of Oakes, Madole, and Cohen (1991).

The test phase consisted of two trials. The goal of the first test trial, the novel weight trial, was to see whether participants discriminated between objects that only had a weight difference. Participants were presented with an object that was identical in appearance to the familiarization object but had another weight. The goal of the second test trial, the completely novel trial, was to test whether or not participants were still attending to stimuli. Participants were presented with the completely novel object that differed in appearance, weight and texture from the compressible cubes. These trials also lasted ten seconds each.

A pre-test was conducted before the familiarization phase by using the same object weight that was presented in the novel weight trial. This pre-test was used to show whether there was a difference in the dependent measures (i.e., looking time, arm movement) for how a child first interacts with a particular weight. It was also used to show how a participant interacts with a certain object weight before undergoing familiarization to another weight. The pre-test was the same duration as all of the other trials in the discrimination task (i.e., 10 seconds). Therefore, there were eleven trials in the discrimination task, including one pre-test, eight familiarization and two test trials.

Categorization Task. The categorization task was always conducted after the discrimination task. The goal of this task was to determine whether children of this age group generalize the concept of object weight across different types of objects. It was also used to see whether children paid more attention to the weight of an object or its appearance. The procedure was similar to the discrimination task, and included a familiarization and test phase. All trials were 15 seconds in length.

During familiarization, four objects with different appearances but the same weight were presented. The familiarization trials consisted of two blocks of four trials each. Each object was presented once in each block; the order of presentation of the objects was different in each block. The familiarization phase used in the categorization task was loosely based on the familiarization phase of experiment 2 in Oakes, Madole, and Cohen (1991).

After the familiarization phase, four test trials were given: 1) a completely familiar trial with an object that had been presented during familiarization, 2) a trial with an object that had a novel appearance but a familiar weight, 3) a trial with an object that had a familiar appearance but a novel weight, 4) and a completely novel trial. The completely familiar trial was always presented first while the completely novel trial was always presented last. The novel appearance and novel weight trials were presented in a counterbalanced order so that changes in attention could not be attributed to an order effect. Half of the participants were randomly assigned to each presentation order.

There were five different combinations in which the objects in both the familiarization blocks and the test trials were presented as well as what objects were presented. Therefore, any single combination of objects did not have the same presentation order as another combination nor did it include all of the same objects that were found in another combination.

Balance Scale Task. While the discrimination task tested whether young children can discriminate between objects based on their weight, the balance scale task was used to see whether participants can use weight functionally. This was the final task conducted with all the participants used in the study. The participants were seated across from the experimenter at a table. All participants were given the same objects for this task, but the order in which they were presented was randomized. The participants were presented with all the stimuli used in the categorization task except for the completely novel object.

The design of the balance scale task was comprised of two phases: modeling and testing, respectively.

Phase One (modeling)

The researcher presented the light and heavy compressible cubes used in the discrimination task to the child. The experimenter told the participant that "this one (light object) does not make the bear drop or go down [the experimenter proceeds to put the light cube in the bucket] but this one does [the experimenter places the heavy cube in the bucket]". The participant was then given the compressible cubes to hold and could perform the task herself after she saw how it is modeled. The experimenter encouraged these responses by saying "can you make the bear drop (go down)" or "can you make the bear fall?" If the child seemed to understand the modeling task, then the experimenter moved on to phase two.

Phase Two (testing)

On each of five trials, the participant was presented with one pair of objects. These were the same objects presented in the categorization task. All participants were randomly assigned to an object presentation order. The heavy object of a pair was presented to the right hand in some trials and to the left hand in other trials. Each trial began when a pair of objects was presented and a participant was asked to pick one that would make the bear drop or 'fall down'. Participants were encouraged to pick up both objects.

Coding

Discrimination Task. Testing sessions were recorded on digital videotape and coded for two dependent variables. Looking time was one of the dependent variables and it was defined as the amount of time that a participant looked at an object during each 10-second trial. All looking time was coded using Habit 7.8 (Cohen, Atkinson, & Chaput, 2000). The second dependent variable, arm movement, was the amount of drop or elevation that a child's arm displayed when she or he first took an object. This measurement was determined by analyzing the first 250 milliseconds after a child took an object. The number of units that a participant's arm rose or dropped within this time frame was determined by the checkerboard pattern located next to the child. This measurement was calculated for each trial in the discrimination task, including the pre-test trial. The measurement for each trial was also tallied so that an overall view of participants' performance could be measured across age groups and familiarization conditions.

Inter-coder reliability was calculated for looking time in the discrimination task. The calculation was an average of the Pearson correlations of all the coder's looking time data except for the data of one coder who conducted all the experiments and coded only nine participants. Twenty-six of the 49 participants (i.e., 53%) were coded by two or more coders in order to calculate inter-coder reliability. A majority of this sample (22 of the 26 participants) was coded by at least three coders. It was found that the average inter-coder reliability for looking time in the discrimination task was 0.82.

Fourteen of the 49 participants (i.e., 29 %) were coded by two coders in order to measure inter-coder reliability for the arm movement measure. The inter-coder reliability for the arm movement measure was remarkably high, averaging around 0.97. Like the looking time reliability, the reliability of the arm movement measure was calculated using an average of the Pearson correlations between coders for all of the arm movement data.

Categorization Task. Looking time was the only dependent variable coded for the categorization task. Other than this difference, the same coding procedures and measurements that were used with the discrimination task were also used with the categorization task. Inter-coder reliability was calculated for looking time. The calculation was an average of the Pearson correlations of all the coder's looking time data except for the data of one coder who conducted all the experiments and coded only nine participants. Thirty-two of the 53 participants (i.e., 60%) were coded by two or more coders in order to calculate inter-coder reliability (i.e., 26 of the 32 participants were coded by at least three coders). It was found that the average inter-coder reliability for looking time in the categorization task was 0.80.

Balance Scale Task. All modeling and testing observations received a binary coding after the videotapes were reviewed with a zero to code incorrect responses and a one to code correct responses.

Results

Discrimination Task

Looking time.

Session Looking Time

Did children maintain attention throughout the entire task?[1]

The first analysis tested for overall changes in looking time in order to determine whether participants maintained their attention throughout the session. If children maintained attention throughout the session then they should increase their looking time in the completely novel trial. A 2 (familiarization condition) x 3 (age group) x 3 (trials) ANOVA was conducted on looking time data for the first and last familiarization trials as well as the completely novel trial. There was a significant main effect of trials, $F(2, 86) = 31.69$, $p < .01$, revealing that there were significant differences in looking time among the three trials. Single df post-hoc analyses on this trials effect revealed that participants showed a significant decrease in looking from the first familiarization trial ($M = 5.53$, $SD = 2.69$) to the last familiarization trial ($M = 2.92$, $SD = 2.55$), $F(1, 86) = 32.80$, $p < .01$. In contrast, a marginally significant increase in looking time occurred between the first familiarization and completely novel trials ($M = 6.38$, $SD = 2.06$), $F(1, 86) = 3.71$, $p =$

[1] The results section was organized by questions to increase readability.

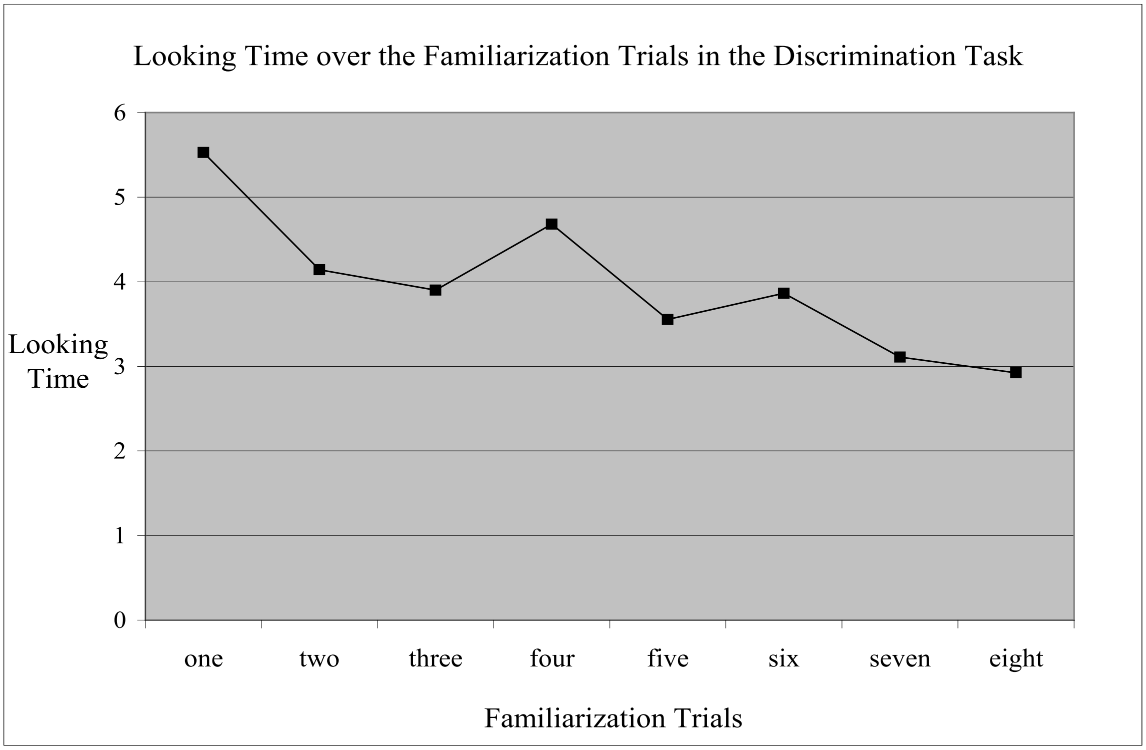
.06. Since participants did not decrease their attention to the completely novel object, it can be determined that they maintained attention throughout the session. Thus, it appears that the participants decreased attention during familiarization but maintained general attention across the session.

Familiarization Trials

Did children decrease attention during familiarization?

To further explore the decrease in attention during familiarization, a 2 (familiarization condition) x 3 (age group) x 8 (familiarization trials) ANOVA was conducted on looking time data for the familiarization trials. If children showed a decrease in looking time over the familiarization trials, then it could be concluded that they were sufficiently familiarized to the object. A significant main effect of familiarization trials was found, $F(7, 301) = 7.06$, $p < .01$. A linear trend analysis also showed that there was a significant decline in looking time over the familiarization trials, $F(1, 301) = 35.56$, $p < .01$. The significant decline in looking time over the familiarization trials of the discrimination task is seen in figure 1. Thus, an analysis of the familiarization trials confirmed the result found in the session analysis: a significant decline in looking time occurred during familiarization for all the age groups tested.

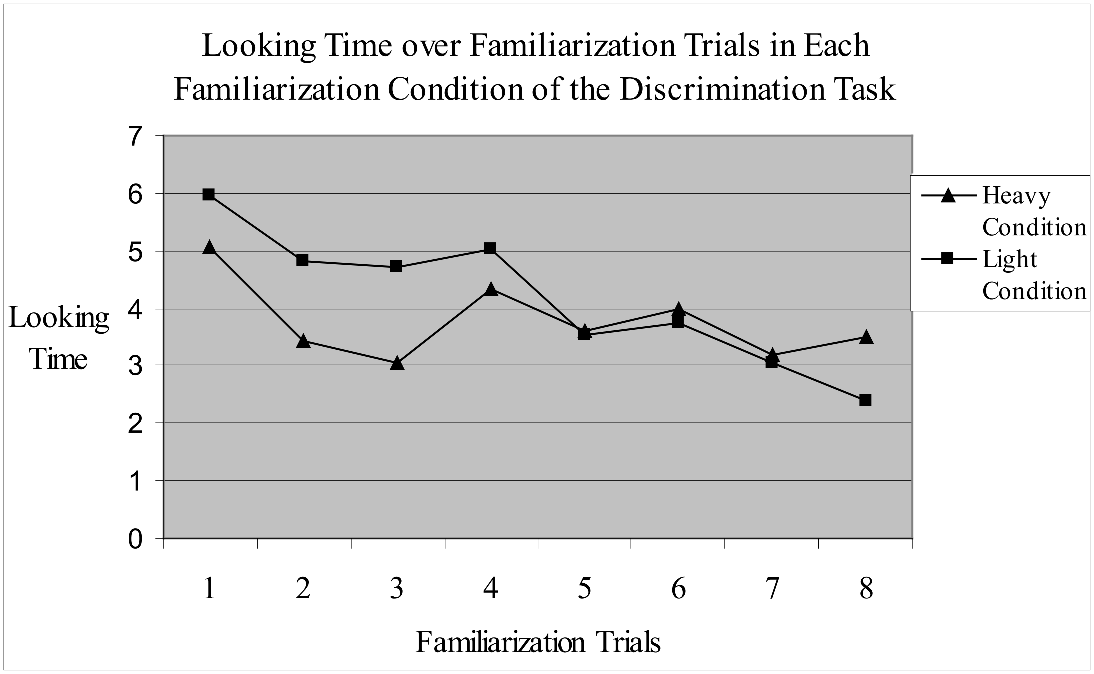
Figure 1



Did the decline in looking time differ between the familiarization conditions?

The familiarization trials analysis also revealed a significant Familiarization trials X Familiarization condition interaction, $F(7, 301) = 2.58$, $p = .01$. A linear trend analysis on the heavy condition showed that the decline in looking time over the familiarization trials was small and marginally significant, $F(1, 161) = 3.04$, $p = .08$. On the other hand, a linear trend analysis on the light condition found a strong significant decline in looking time, $F(1, 168) = 52.64$, $p < .01$. Looking time significantly differed between familiarization trials one and eight of the light condition, $F(1, 168) = 38.60$, $p < .01$, and of the heavy condition, $F(1, 161) = 6.07$, $p = 0.02$. Therefore, looking time significantly declined in both conditions even though the decline was less pronounced in the heavy condition. Figure 2 shows the difference in looking time decline between the two familiarization conditions.

Figure 2



A significant Age group X Familiarization condition interaction was also found, $F(2, 43) = 4.56$, $p < .05$, revealing that overall looking time was significantly different between the two familiarization conditions for the age groups tested. No significant effect of familiarization condition was found for either the twenty or twenty-seven month olds ($p = 0.17$ and $p = 0.94$). However, a significant difference in looking time was found between the conditions for the thirty-four month olds with overall looking time being higher in the light condition ($M = 5.41$, $SD = 2.50$) than in the heavy condition ($M = 3.06$, $SD = 2.68$), $F(1, 14) = 8.07$, $p = .01$. Thus, the thirty-four month olds were the only age group that looked longer at the light familiarization object than the heavy one. No other significant main effects or interactions were found in the familiarization trials analysis of the discrimination task: all other results had a p value above 0.30.

Test Trials

Did children increase their looking time to the novel weight object after familiarization?

A novelty preference analysis was conducted to see whether children discriminated the novel weight from the weight to which they were familiarized. If children discriminated the novel weight object from the familiarization object, then they should increase their looking time toward the novel weight object during test. In order to test discrimination of object weight, novelty preference scores were calculated.

Novelty preference scores were calculated for each participant by dividing the novel weight trial's looking time by the summation of the looking time in the novel weight and last familiarization trials [looking time$^{\text{novel weight trial}}$/(looking time$^{\text{novel weight trial}}$ + looking time$^{\text{last familiarization trial}}$)]. They served as the dependent variable in the discrimination test trial analysis.

A 2 (familiarization condition) x 3 (age group) ANOVA was conducted on the novelty preference scores. None of the results were significant (i.e., all *p* values were above 0.12). Hence, neither the participants' age nor the familiarization condition had an effect on their response to the novel weight trial. However, because the purpose of this study was to discover whether all of the age groups increased their attention to the novel weight over chance levels, one sample t-tests were conducted on the novelty preference score of each age group.

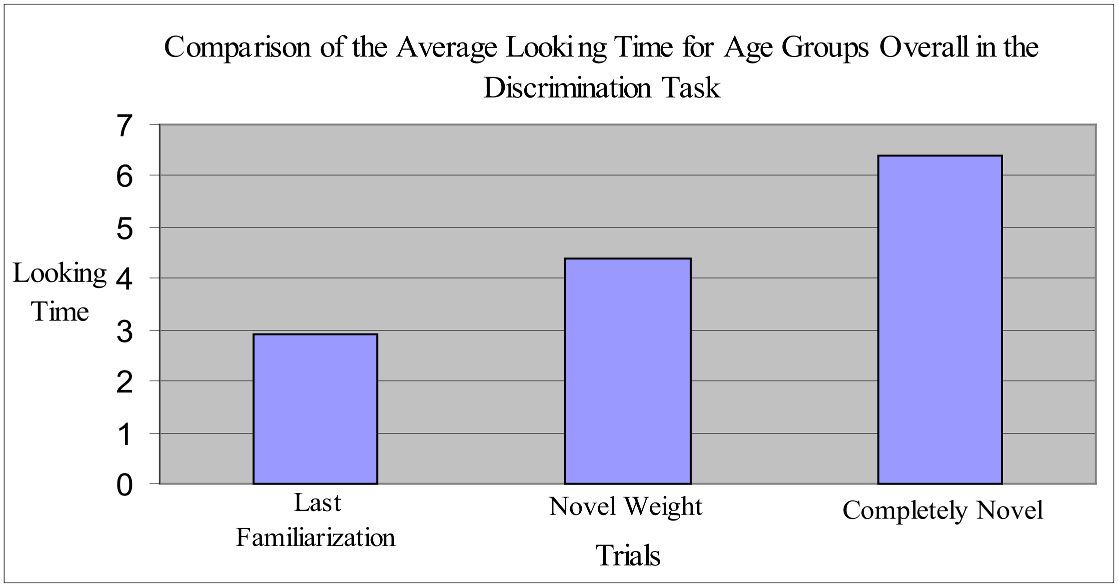
Results revealed that the overall novelty preference score (M = 0.603, SD = 0.024) was significantly greater than chance, $t(48) = 29.94$, $p < .01$. The novelty preference scores for twenty (M = 0.621, SD = 0.269), $t(15) = 11.10$, $p < .01$, twenty-seven (M = 0.585, SD = 0.239), $t(16) = 8.25$, $p < .01$, and thirty-four month olds (M = 0.604, SD = 0.294), $t(15) = 9.63$, $p < .01$, were also significantly greater than chance.

Thus, all of the age groups tested showed a significant increase in attention to the novel weight object.

Even though no significant main effect of familiarization condition was found for the novelty preference scores, one sample t-tests were conducted on the score of each condition to be certain that they were significantly greater than chance. The novelty preference scores of the light familiarization condition ($M = 0.653$, $SD = 0.220$), $t(24) = 10.48$, $p < .01$, and the heavy condition ($M = 0.552$, $SD = 0.297$), $t(23) = 3.42$, $p < .01$, were both significantly greater than chance. Thus, participants in both conditions showed an increase in attention to the novel weight object.

In order to provide a more complete picture of the increase in attention that occurred between the familiarization and test phases, figure 3 shows the average amount of looking time that the age groups overall had in the last familiarization, novel weight and completely novel trials. The raw data presented in this figure was not analyzed or discussed in the discussion and, therefore, is only provided only for comparative purposes.

Figure 3



Arm movement measure.

Familiarization Trials (familiarization blocks)

Did an adaptation to object weight occur during familiarization?

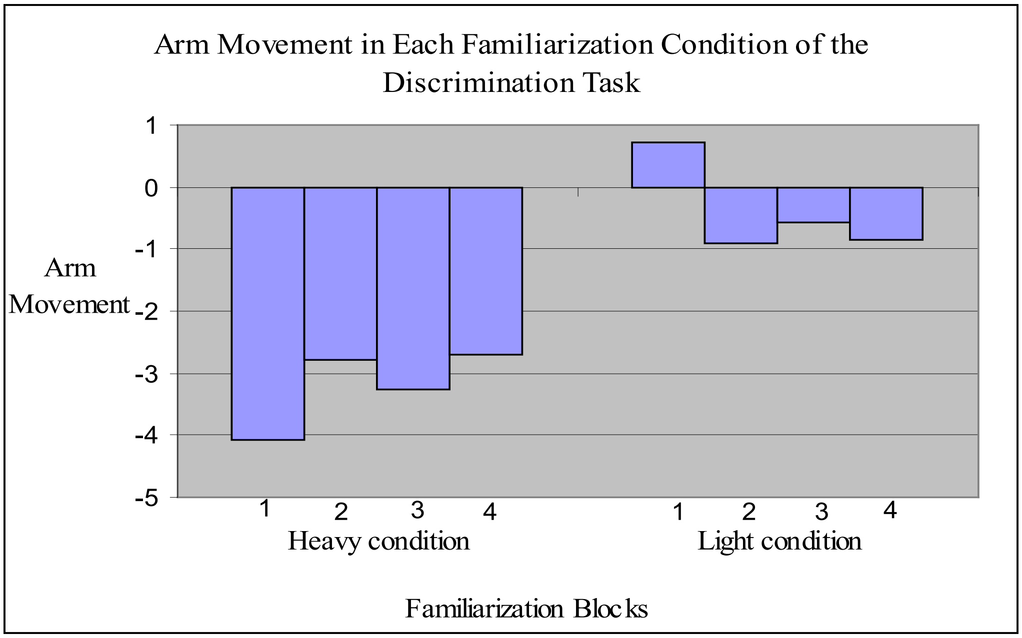
A 3 (age group) x 2 (familiarization condition) x 4 (familiarization block) ANOVA analyzed the average arm movement that occurred across the familiarization trials. In order to decrease variability, the familiarization trials were divided into four blocks with each block consisting of two familiarization trials. Negative numbers indicated a drop in the children's arm movement while positive numbers indicated a rise in arm movement. A significant difference in overall arm movement between the familiarization blocks was not expected because positive and negative arm movements should cancel each other out. The main effect of familiarization blocks was not significant, showing that there were not significant differences in arm movement between the blocks (or trials) (p value at 0.92).

Was arm movement significantly different between the two conditions?

It was expected that arm movement would differ between the conditions as a function of the different object weights. Results revealed that the overall arm movement in the heavy familiarization condition (*M* = -3.20, *SD* = 2.46) was significantly larger than the arm movement in the light condition (*M* = -0.401, *SD* = 1.99), $F(1, 42) = 30.56$, $p < .01$.

This analysis also found a significant Familiarization blocks X Familiarization condition interaction, $F(3, 126) = 8.10$, $p < .01$. Arm movement not only significantly differed between the conditions but also differed across specific blocks of both conditions. The arm movement that occurred across the familiarization blocks of each condition is seen in figure 4. Post-hoc analyses were conducted to see whether each condition had significant differences in arm movement across blocks. A 3 (age group) x 4 (familiarization block) ANOVA on each condition showed that a significant effect of familiarization blocks was found for the heavy, $F(3, 63) = 3.13$, $p < .05$, and light conditions, $F(3, 63) = 5.51$, $p < .01$. Therefore, there were significant differences in arm movement across the familiarization blocks (trials) of both conditions (refer to figure 4).

Figure 4



Single df contrasts were carried out on each familiarization condition to determine specifically where the significant differences in arm movement occurred. The means of each condition are displayed in figure 4. A significant difference was found between the first (M = -4.06, SD = 1.63) and second blocks (M = -2.80, SD = 2.82) of the heavy condition, $F(1, 63) = 6.46$, $p = .01$. However, no significant differences in arm movement were found between the second and third or third and fourth blocks (p values for both comparisons were above 0.27). Thus, in the heavy condition, participants adapted to the object weight within the first four familiarization trials.

Similar results were found in the single df contrasts conducted on the light familiarization condition. A significant difference in arm movement was only found between the first (M = 0.71, SD = 1.76) and second (M = -0.91, SD = 1.48) familiarization blocks of the light condition, $F(1, 63) = 12.82$, $p < .01$. Comparisons between the second and third as well as the third and fourth blocks were not significant (i.e., *p* values for both were above 0.48). Thus, as seen in the heavy condition, adaptation occurred halfway through the familiarization phase of the light condition.

Was arm movement significantly different between the age groups?

If the age groups displayed significantly different arm movements during familiarization then some age groups did not familiarize to the object weight as well as others did. Such a difference implied that some of the age groups were not able to adapt physically to one of the weights because it was too heavy. No significant main effect of age was found in the familiarization block analysis (*p* value at 0.69). Therefore, all of the age groups adapted to the object weights presented in each condition. On a final note, no other significant main effects or interactions occurred in the analysis on the familiarization blocks (i.e., their *p* values were above 0.55).

<u>Test Trials</u>

Did age or familiarization condition have an effect on arm movement during the test trials?

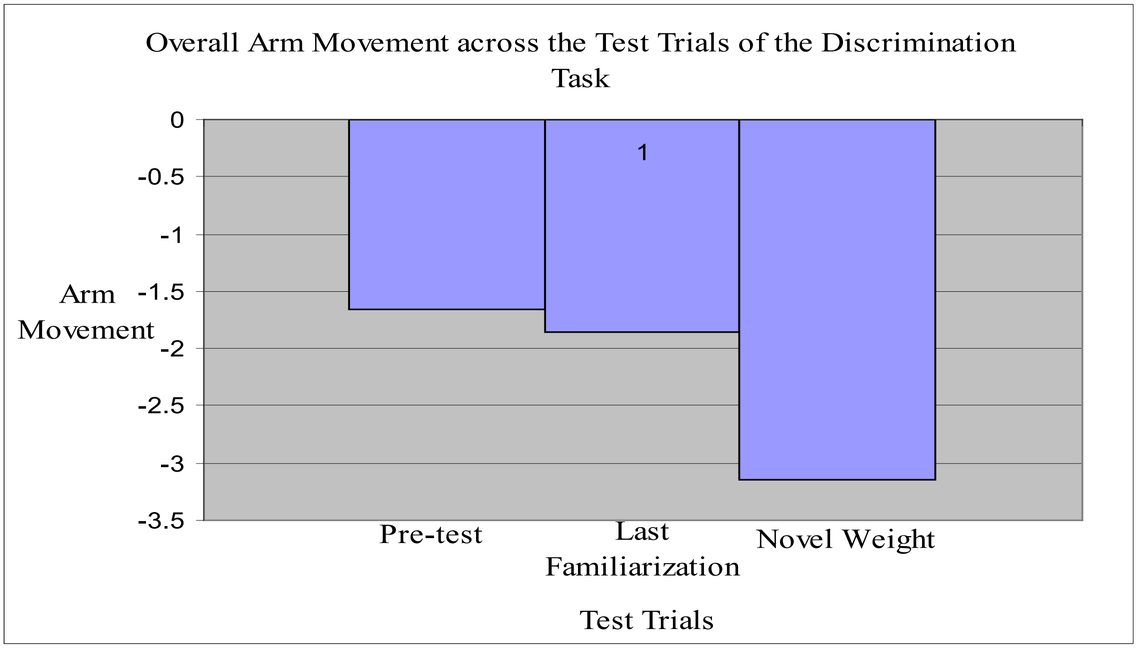
Arm movements during the pre-test, last familiarization and novel weight trials were analyzed by using a 3 (age group) x 2 (familiarization condition) x 3 (test trials) ANOVA. This analysis was conducted to see whether age or familiarization condition had an effect on the arm movement displayed during the test trials. If significant differences in arm movement were found among the age groups then it could be determined that some of the age groups reacted differently to the novel weight than did other age groups. It was not expected that age would affect arm movement during the test trials. On the other hand, familiarization condition may affect arm movement during the test trials because different weights were used in each condition.

No main effect of age was found (i.e., *p* value at 0.35), revealing that the different age groups did not display significantly different arm movements during the test trials. However, the main effect of familiarization condition was significant, revealing that the overall test trial arm movement for the light condition (M = -4.20, SD = 3.54) was significantly larger than the arm movement for the heavy condition (M = -0.159, SD = 4.07), $F(1, 39) = 37.24$, $p < .01$. These results can be attributed to the fact that participants received the heavy weight object during the pre-test and novel weight trials of the light condition and the light weight object during the same trials of the heavy condition.

Did children show a discrimination of object weight through a difference in arm movement?

If children physically discriminated the novel weight from the familiarization weight, then they should show a significant difference in arm movement between the last familiarization and novel weight trials. A significant main effect of test trials was found, $F(2, 78) = 4.84$, $p = .01$. Thus, significant differences in arm movement were found among the last familiarization, pre-test and novel weight trials of both conditions. Figure 5 shows that overall arm movement gradually increased over the course of the test trials.

Figure 5



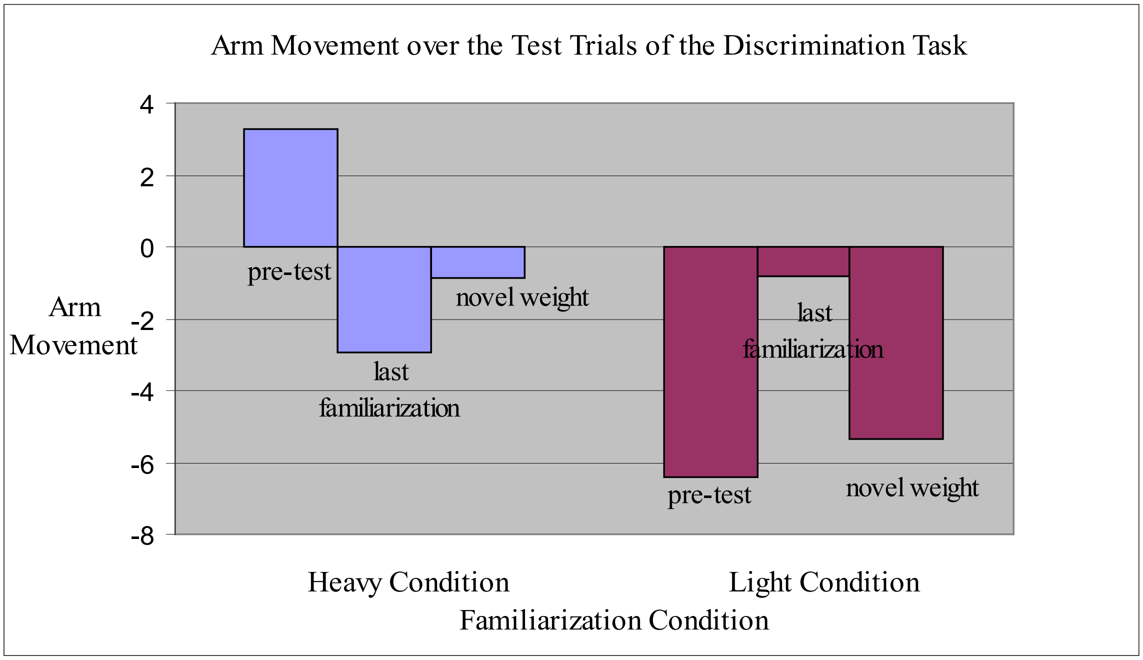
The arm movement that took place during the test trials was further analyzed by familiarization condition to see whether arm movement in the novel weight trial significantly differed from arm movement in the last familiarization trial. Single df contrasts on the last familiarization and novel weight trials of each condition showed that a significant difference in arm movement was found between these trials in the heavy, $F(1, 38) = 7.42$, $p < .01$, and light conditions, $F(1, 40) = 41.76$, $p < .01$. Thus, participants in both conditions showed a significant physical discrimination of the novel weight object after being familiarized to the other object weight. No other significant results were found in the 3 x 2 x 3 ANOVA (i.e., their *p* values were above 0.34).

Was the difference in arm movement between the last familiarization and novel weight trials a true test of discrimination?

The arm movement that occurred during the pre-test and novel weight trials was analyzed for each condition to see whether participants showed a significant difference in arm movement with the same weight after familiarization. The difference in arm movement between the last familiarization and the novel weight trials may only be a true test of discrimination if there is a significant difference between the novel weight and pre-test trials of the same condition. A significant difference between the pre-test and novel weight trials would show that children reacted to the same weight differently after being familiarized to another weight. A post-hoc single df contrast on the heavy condition revealed that a significant difference in arm movement occurred between the pre-test ($M = 3.30$, $SD = 2.87$) and novel weight ($M = -0.85$, $SD = 3.30$) trials, $F(1, 38) = 26.95$, $p < .01$. These results showed that participants' arms rose when they took the light weight object in the pre-test but dropped when they took it in the novel weight trial. Thus, in the heavy condition, participants reacted differently to the same object weight after being familiarized to another weight.

In contrast, no significant difference in arm movement occurred between the pre-test and novel weight trials of the light condition (i.e., p value at 0.19). Therefore, participants showed a true discrimination of object weight in the heavy familiarization condition but not in the light condition. Figure 6 reveals that there was a greater difference in arm movement between the pre-test and novel weight trials of the heavy condition than of the light one. This figure also shows the difference in arm movement between the last familiarization and novel weight trials of each condition.

Figure 6



Categorization Task

Looking time.

Did children maintain attention throughout the entire task?

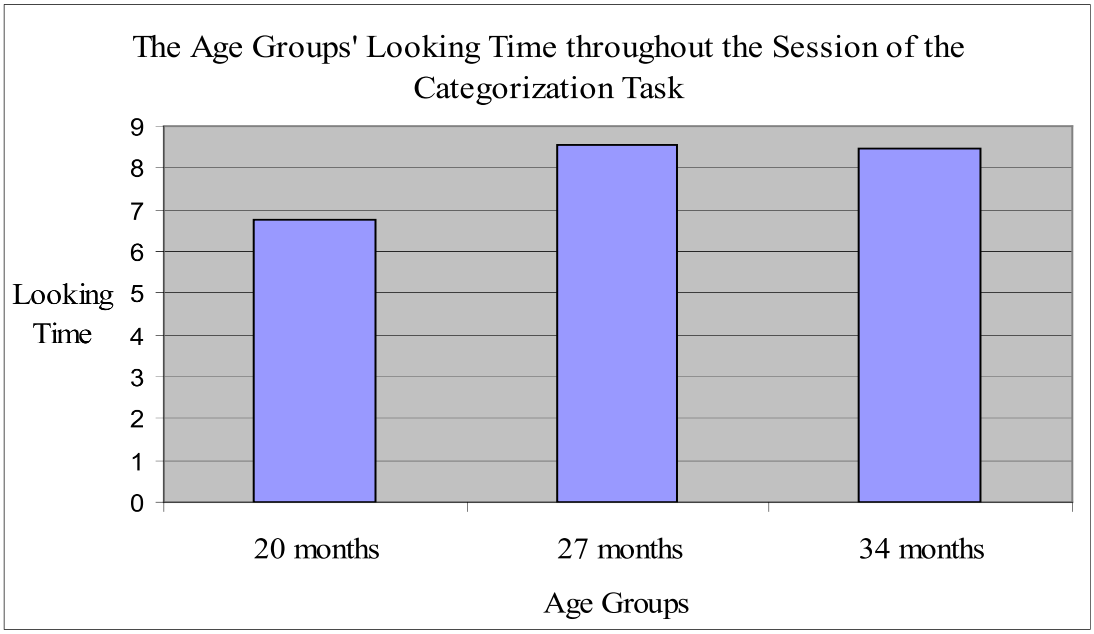
A 3 (age group) x 2 (familiarization condition) x 3 (trials) ANOVA analyzed the first familiarization, last familiarization and completely novel trials to see whether looking time declined over the familiarization trials and then increased with the completely novel trial. This analysis was conducted to show whether children were still attending to objects at the end of the session. There was a significant main effect of the trials, $F(2, 94) = 24.77$, $p < .01$. Single df contrasts compared the mean looking times of the three trials to determine which trials significantly differed from each other. Results revealed that the mean looking time of the first familiarization trial ($M = 7.72$, $SD = 3.08$) was significantly higher than the looking time of the last familiarization trial ($M = 6.02$, $SD = 4.12$), $F(1, 94) = 10.17$, $p < .01$. However, the looking time of the first familiarization trial was significantly lower than the looking time of the completely novel trial (*M* = 10.06, *SD* = 3.37), $F(1, 94) = 14.74$, $p < .01$. Thus, the participants' looking time significantly decreased during the familiarization phase. Furthermore, their looking time did not significantly decrease when they received the completely novel object. Participants in the categorization task maintained attention throughout the session.

Did the age groups show significantly different looking times throughout the session of the categorization task?

If looking time during the session significantly differed between the age groups then it could be inferred that at least one of the age groups did not maintain attention during the session as long as the other age groups did. If one of the age groups maintained less attention during the session than the other age groups then this age group may not have attended to objects during the session long enough to discriminate a change in object property during test.

A main effect of age was found, $F(2, 47) = 3.29$, $p = .05$, revealing that the age groups showed significant differences in looking time during the session. Single df contrasts compared the looking times of each age group to see which age groups significantly differed. The looking time of the twenty month olds (*M* = 6.74, *SD* = 4.07) was significantly lower than the looking time of the twenty-seven month olds (*M* = 8.53, *SD* = 3.77), $F(1, 47) = 3.56$, $p = .07$. In addition, the mean looking time of the twenty month olds was also significantly lower than the looking time of the thirty-four month olds (*M* = 8.46, *SD* = 3.66), $F(1, 47) = 5.97$, $p < .05$. No significant difference was found between the looking times of the twenty-seven and thirty-four month olds ($p = 0.54$). Therefore, the twenty month olds did not maintain attention during the session as well as did the other two age groups. Figure 7 compares the looking time of the three age groups.

Figure 7



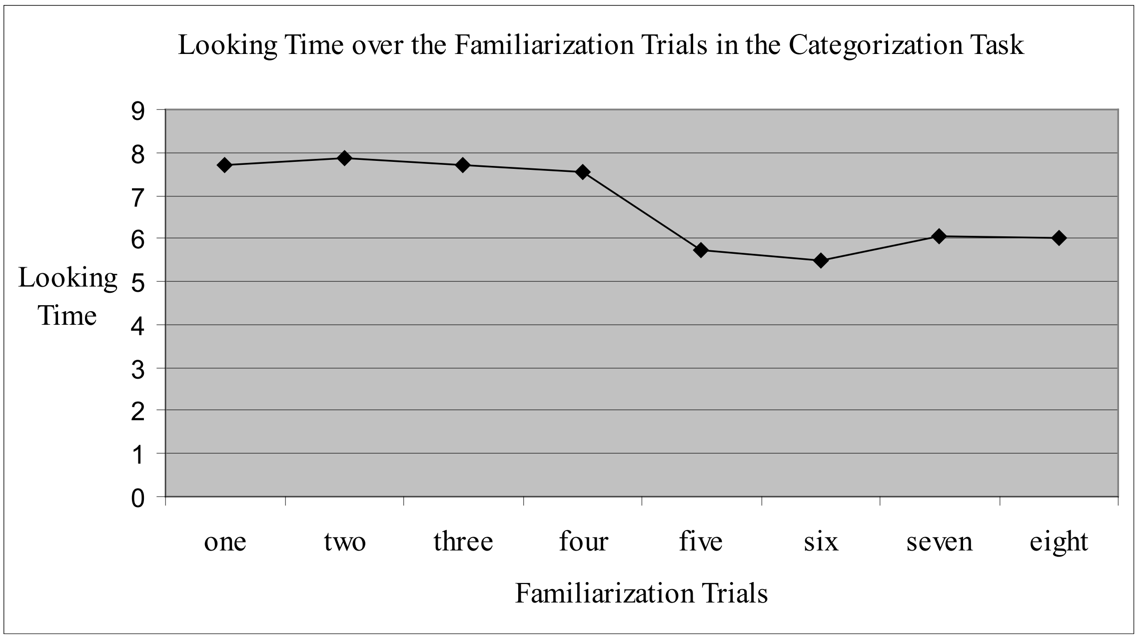
<u>Familiarization Trials</u>

Did children decrease attention during familiarization?

A 3 (age group) x 2 (familiarization condition) x 8 (familiarization trials) ANOVA was used to see whether looking time declined over the eight familiarization trials. This analysis answered whether or not the participants familiarized to the objects presented during familiarization despite their appearance changes. A significant decline in looking time over the familiarization trials would show that the participants did familiarize to the objects. A significant main effect of familiarization trials was found, $F(7, 329) = 7.92$, $p < .01$, revealing that significant differences in looking time occurred across the familiarization trials. Furthermore, a linear trend analysis showed that there was a significant decline in looking time over the familiarization trials, $F(1, 329) = 40.65$,

$p < .01$, revealing that participants familiarized to the objects despite their appearance changes. Figure 8 depicts the decline in overall looking time that occurred over the familiarization trials of the categorization task. No other significant main effects or interactions were found in this analysis (i.e., all had *p* values above 0.09).

Figure 8



Test Trials

Did children pay attention to both novel weight and novel appearance or do they just pay attention to appearance?

If children increased their looking time to the novel weight or novel appearance object (or both) after receiving the completely familiar object then it is determined that they are discriminating these objects from the familiarization objects. Furthermore, this analysis would show whether children can discriminate these object properties (i.e., weight and appearance) when presented with more than one familiarization object. Novelty preference scores were calculated for the novel weight and novel appearance trials. These scores were calculated to see whether the children increased their attention to a weight or appearance change after familiarization. If the participants significantly increased their looking time (i.e., attention) toward the novel weight or novel appearance object, then their novelty preference score should be greater than chance (or greater than a population mean of 0.5).

The novelty preference score for the novel weight trial was calculated the same way as the novelty preference score in the discrimination task except, in this task, the novel weight looking time was compared to the looking time in the completely familiar trial. Thus, the novelty preference formula for the novel weight trial was looking $\text{time}^{\text{novel weight trial}}/(\text{looking time}^{\text{novel weight trial}} + \text{looking time}^{\text{completely familiar trial}})$. For the novelty preference score of the novel appearance trial, the formula compared the novel appearance looking time to looking time in the completely familiar trial $[\text{looking time}^{\text{novel appearance trial}}/(\text{looking time}^{\text{novel appearance trial}} + \text{looking time}^{\text{completely familiar trial}})]$.

The novelty preference scores for novel weight and novel appearance trials were analyzed by two separate ANOVAs. A 3 (age group) X 2 (familiarization condition) ANOVA analyzed each novelty preference score. The 3 x 2 ANOVA conducted on the novel weight trial found no significant main effects or interactions (i.e., all results had *p* values above 0.19). Thus, there were no significant differences in looking time between the age groups or the familiarization conditions for the novel weight trial. There was also no significant Age Group x Familiarization condition interaction. Hence, neither the participants' age nor the weight they were familiarized with affected how they responded to the novel weight object in the categorization task.

One sample t-tests were conducted on the novelty preference scores of the novel weight trial to see whether the scores were significantly greater than chance (0.5). Results showed that overall the novelty preference score ($M = 0.607$, $SD = 0.050$) was significantly greater than chance, $t(52) = 15.51$, $p < .01$. Furthermore, the results revealed that only the twenty-seven ($M = 0.663$, $SD = 0.192$), $t(18) = 8.32$, $p < .01$, and thirty-four month olds ($M = 0.614$, $SD = 0.177$), $t(16)$ 5.18, $p < .01$, had novel weight preference scores which were significantly greater than chance. In contrast, the twenty month olds' had a novel weight preference score ($M = 0.544$, $SD = 0.215$) that was only marginally greater than chance, $t(16) = 2.00$, $p = .06$. Thus, only the two older age groups significantly increased their looking time toward the novel weight object after familiarization. However, the youngest age group (twenty month olds) also showed some capability of discriminating the novel weight object after undergoing familiarization.

One sample t-tests were also conducted on the novel weight scores of the two familiarization conditions to see whether they were significantly greater than chance. Participants in both the heavy ($M = 0.594$, $SD = 0.209$) and light conditions ($M = 0.624$, $SD = 0.188$) had novel weight preference scores which were significantly greater than chance, $t(26) = 18.43$, $p < .01$ and $t(25) = 22.55$, $p < .01$, respectively. Participants in both conditions significantly increased their attention toward the novel weight object.

Unlike the first test trial analysis, the 3 x 2 ANOVA conducted on the novelty preference score of the novel appearance trial found a significant main effect of age, $F(2, 47) = 3.74$, $p < .05$. Consequently, the age groups had significantly different looking times during the novel appearance test trial. This result was the only significant one found in the analysis; the familiarization condition main effect and the Age group x Familiarization condition interaction both had *p* values above 0.30.

The age groups' novel appearance scores were further analyzed with single df contrasts to see which scores were significantly different from each other. The twenty-seven month olds (M = 0.725, SD = 0.171) and the thirty-four month olds (M = 0.689, SD = 0.179) both had novel appearance looking times that were significantly higher than the looking time for the twenty month olds (M = 0.537, SD = 0.246), $F(1, 47) = 6.84$, $p = .01$ and $F(1, 47) = 3.96$, $p = .05$, respectively. No significant difference was found between the novel appearance scores of the twenty-seven and thirty-four month olds (*p* value at 0.59).

One sample t-tests were conducted on each novelty preference score of the novel appearance trial to see whether each score was significantly greater than chance. Results revealed that overall the novelty preference score (M = 0.650, SD = 0.076) was significantly greater than chance, $t(52) = 14.42$, $p < .01$. Thus, overall the age groups significantly increased their attention to the novel appearance object. However, the twenty month olds did not significantly increase their attention to the novel appearance object ($p = 0.28$). Thus, the twenty month olds did not discriminate the novel appearance object after undergoing familiarization.

Significant novel appearance scores were found for the two older age groups. The twenty-seven, $t(18) = 7.63$, $p < .01$, and thirty-four month olds, $t(16) = 5.71$, $p < .01$, increased their attention to the novel appearance object significantly more than chance. Consequently, the analyses for the categorization test trials revealed that only participants older than twenty months could significantly discriminate the novel weight and novel appearance objects after undergoing familiarization to more than one familiarization object. However, the twenty month olds showed some capability of discriminating the novel weight object after undergoing familiarization to various familiarization objects.

To provide a more complete picture of the differences in looking time that each age group displayed between the familiarization and test objects, figures 9 through 11 show the average amount of looking time that each age group had in the completely familiar, novel weight, novel appearance and completely novel trials. The raw data presented in these figures were not analyzed or further discussed and, therefore, were only provided only for comparative purposes. The data in each of these figures shows the average looking time each age group displayed in each trial since there was a main effect of age for the novel appearance trial. Figure 9 shows the average looking time of the twenty month olds between the familiarization and test phases of the categorization task.

Figure 9

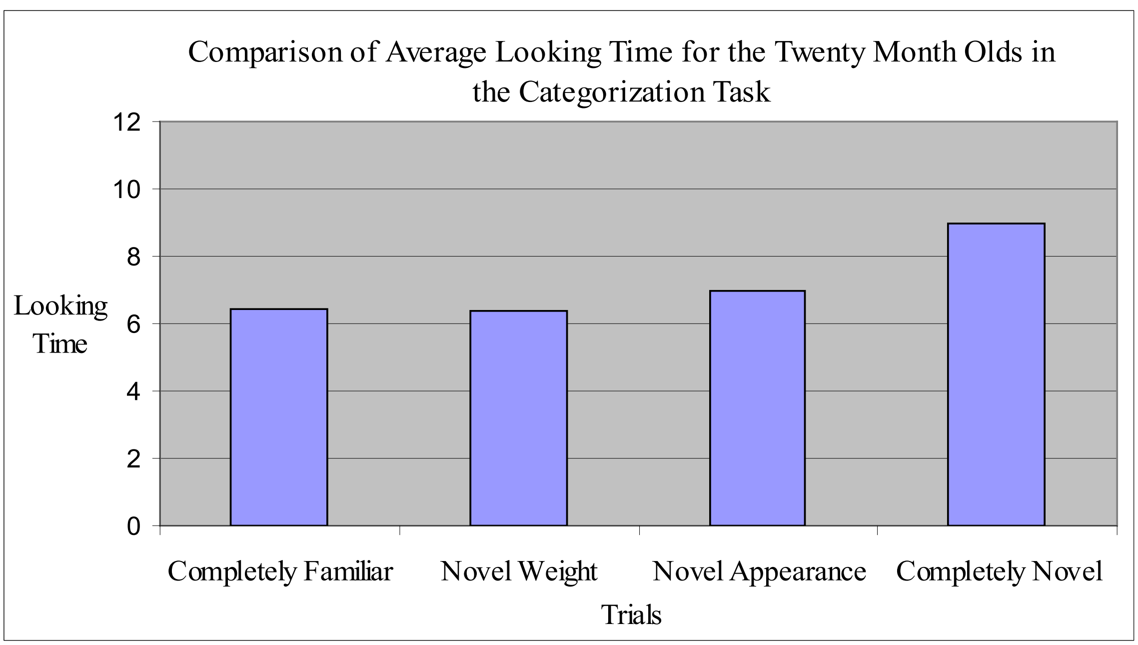


Figure 10 shows the average looking times for the twenty-seven month olds between the familiarization and test phases for the categorization task.

Figure 10

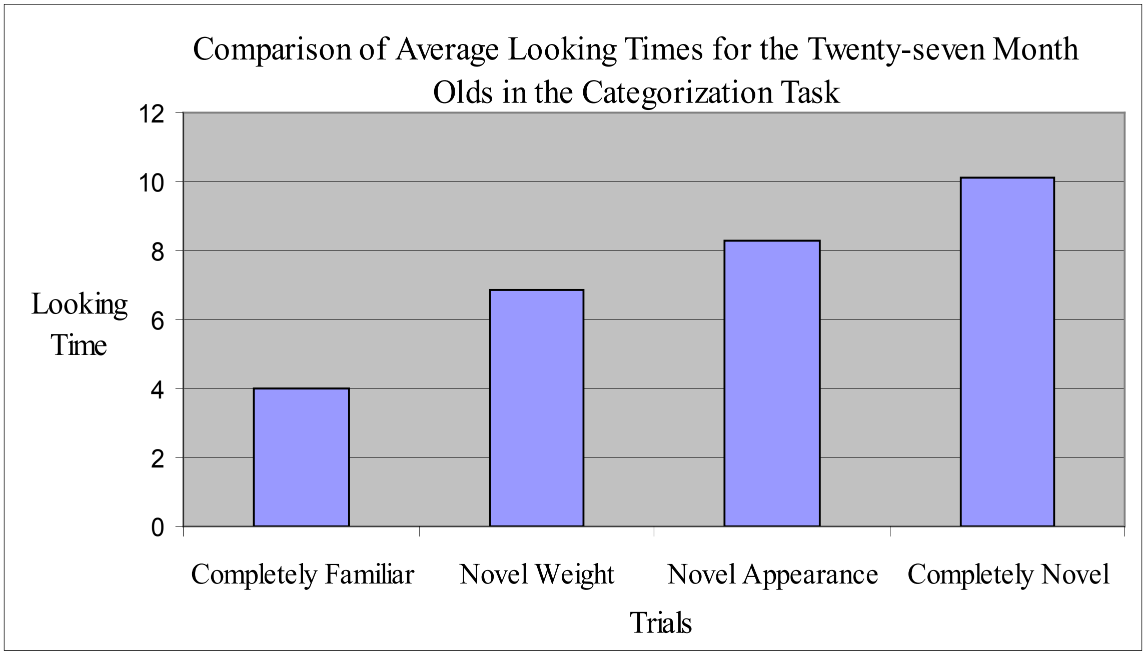
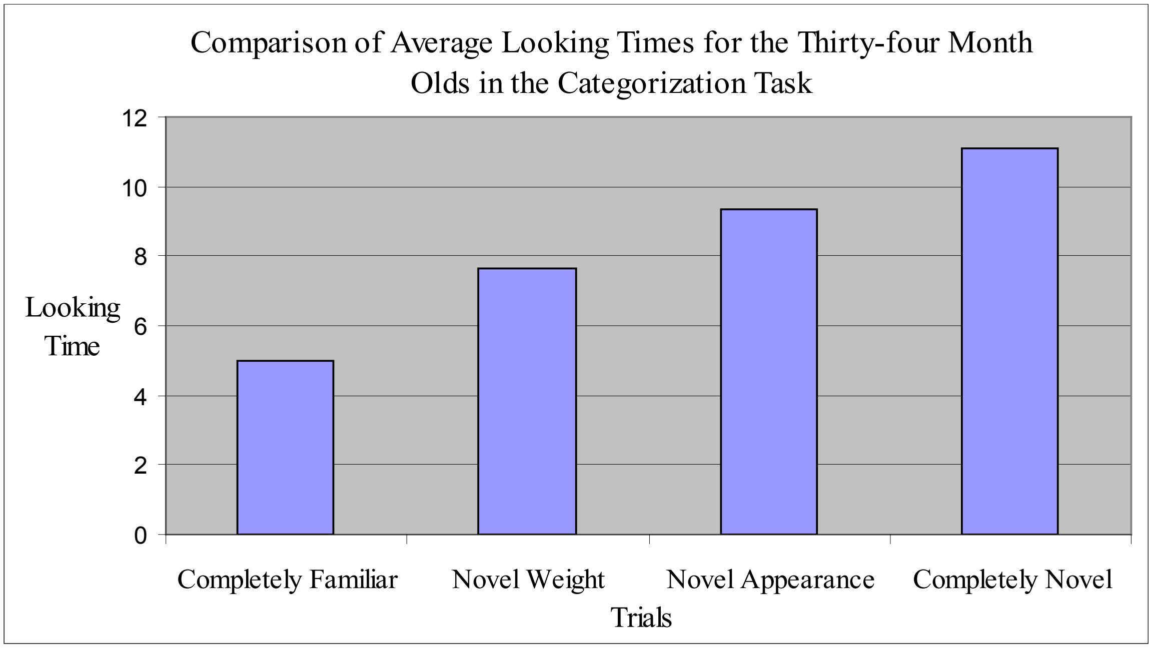


Figure 11 shows the average looking times that the thirty-four month olds displayed between the familiarization and test phases.

Figure 11



Balance Scale Task

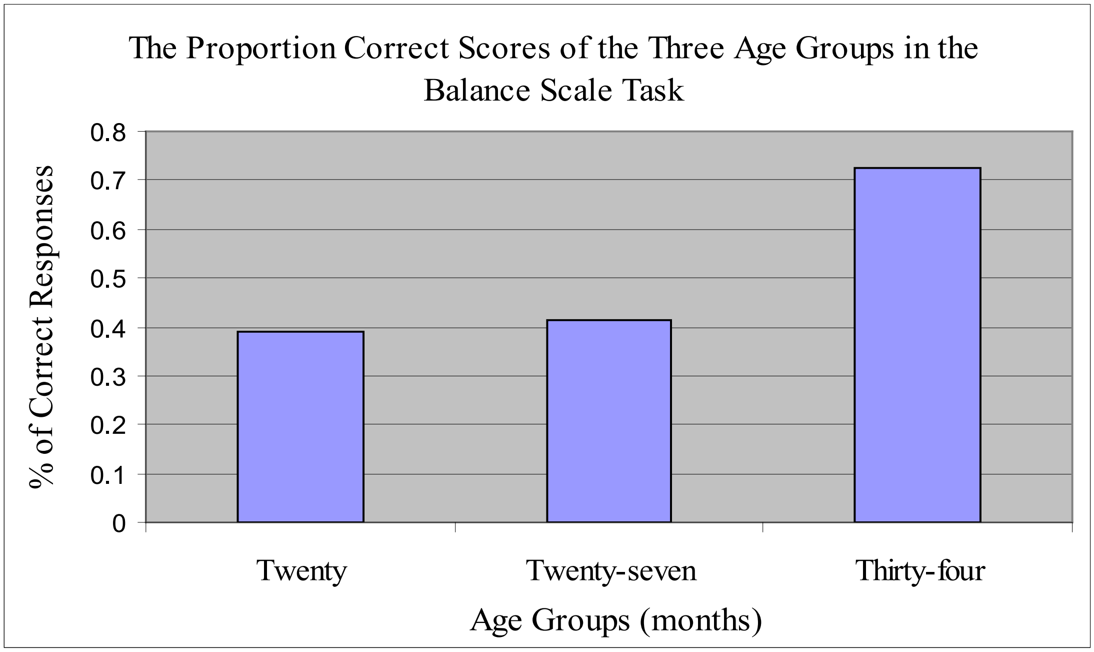
Overall proportion correct.

Were there developmental differences on the balance scale task?

Main effects and interactions. Previous research on the balance scale task did not reveal whether there was a developmental difference in performance of children younger than five years old. If my study found such a developmental difference then it would reveal when the ability to solve this task emerges in young children. Performance on the balance scale task was determined by the proportion correct each age group received. The proportion correct was defined as the number of correct trials out of the total number of trials that were completed. Analysis on the overall proportion correct would show whether the 34 month olds' overall performance surpassed the overall performance of the other age groups.

A 3 (age group) x 2 (heavy side) ANOVA was conducted on the proportion correct data. A significant main effect of age was found, $F(2, 50) = 7.39$, $p < .01$. Therefore, the three age groups had significantly different proportion correct scores. These scores are displayed in figure 12.

Figure 12



A Student-Newman-Keuls post-hoc test was conducted on the proportion correct scores of the three age groups to see which ones significantly differed. All of the age groups had proportion correct scores that significantly differed from the score of the oldest group ($M = 0.724$, $SD = 0.406$). Thus, significant differences were found between the proportion correct scores of the twenty ($M = 0.392$, $SD = 0.380$) and thirty-four month olds ($p < .05$) and the twenty-seven ($M = 0.412$, $SD = 0.408$) and thirty-four month olds ($p < .05$). A significant difference was not found between the proportion correct scores of the twenty and twenty-seven month olds ($p > .05$).

One sample t-tests showed that the average proportion correct scores for the twenty and twenty-seven month olds were not significantly different from chance, p = 0.13 and p = 0.19, respectively. In contrast, the average proportion correct score for the thirty-four month olds was significantly different from chance, $t(37) = 3.39$, $p < .01$. Hence, the oldest age group was the only one to receive more correct test trials than would be expected by chance alone.

Correlations were conducted on age and proportion correct to determine whether performance on the balance scale task increased as age in an age group increased. A moderate negative correlation (r = -0.44) was found between age and proportion correct for the 20 month olds. As age increased in this age group, performance decreased. A weak positive correlation (r = 0.23) was found between age and proportion correct for the 27 month olds, showing that as age increased performance also increased but the relationship was weak. Finally, a strong positive correlation (r = 0.87) was found for the 34 months olds. Thus, the only age group that had a significant proportion correct score was also the only one to show a strong positive association between age and performance on the balance scale task.

Cross-task Comparisons

Did a sensorimotor perception of weight difference lead to a cognitive concept of weight?

It was hypothesized in the introduction that children who can physically detect an object weight difference would not show a cognitive concept of it. This outcome was expected because previous research has shown that there is a disassociation between sensorimotor perception and cognition of object weight (e.g., Flanagan and Beltzner, 2000). The relationships among the three tasks were analyzed on the basis that they reflect a developmental progression in the understanding of object weight. In other words, if the discrimination task tested the basic sensorimotor discrimination of object weight, the categorization task tested a generalization of the weight concept across different looking objects and the balance task tests understanding of object weight function, then certain patterns of performance across the tasks should be more likely.

The more likely patterns of performance were labeled 'developmentally plausible' and included the following scenarios. For example, children who failed to dishabituate to a change in object weight in the discrimination task should not subsequently attend to a change in object weight in the categorization task. Furthermore, children who failed to dishabituate to a change in object weight in the categorization task should not correctly respond in the balance scale task. Any scenario in which a child failed the discrimination task but passed the categorization and/or balance scale tasks would be considered 'developmentally implausible'. Refer to table 1 for more details on developmentally plausible and implausible scenarios.

Performance across the three tasks was compared by establishing a criterion for pass or fail in each task. In order to pass the discrimination and categorization tasks, a participant had to receive a novelty preference score of 0.58 or above on the novel weight trial. For the balance scale task, a participant had to receive a proportion correct score of 0.60 or above in order to pass the task. Table 1 shows all possible patterns of performance and the number of participants that showed each pattern. Chi-square analyses revealed that the developmentally plausible patterns of performance occurred significantly more often than what would be expected by chance, $X^2(1, N = 29) = 3.84$, $p < .05$.

Table 1

Developmentally Plausible and Implausible Patterns of Performance across Tasks

Discrimination	Categorization	Balance Scale	N
	Developmentally plausible		
Fail	Fail	Fail	7
Pass	Fail	Fail	7
Pass	Pass	Fail	10
Pass	Pass	Pass	5

Discrimination	Categorization	Balance Scale	N
	Developmentally implausible		
Fail	Pass	Pass	7
Fail	Fail	Pass	3
Fail	Pass	Fail	2
Pass	Fail	Pass	3

Discussion

The results of the present study support the hypothesis that all of the age groups tested would show a discrimination of weight difference. All of the age groups scored a novelty preference score that is significantly greater than chance in the discrimination task. Thus, participants at all of the ages tested show a significant difference in looking time when presented with the novel weight object. Furthermore, novelty preference scores in both conditions were significantly greater than chance so familiarization condition did not affect participants' ability to discriminate the novel weight.

Another finding was that all of the age groups showed a significant decline in looking time during familiarization. However, this decline was only marginally significant in the heavy condition. Therefore, participants in the heavy condition did not learn (or remember) that they were receiving the heavy weight object repeatedly during familiarization as well as they did with the light weight object in the light condition.

Overall looking time during familiarization was also lower for the heavy condition, particularly for the thirty-four month olds who were the only age group to show a significantly lower amount of overall looking time in the heavy condition. The other two age groups did not have a significant difference in overall looking time between the familiarization conditions. Therefore, it is possible that the thirty-four month olds in the heavy condition are paying less attention toward the familiarization object but this attention is given more consistently than it is (did not decline as much as it did) in the light condition. Therefore, it did not affect their ability to discriminate the novel weight object in the heavy condition during test.

Physical adaptation during familiarization in the discrimination task was also not as pronounced in the heavy condition as it was in the light condition. For the first four familiarization trials of both conditions, arm movement rose then dropped in the light condition while arm drop only lessened in the heavy condition. Still, significant differences in arm movement during the familiarization phase were only found for these trials in both conditions. Thus, participants in both conditions are adapting to the familiarization weight at the same rate. Consequently, participants pay more consistent attention when handling the heavy familiarization weight due to its heaviness. It may have also caused the participants' arms to be continuously pulled down but results showed that they are able to counteract this movement and adapt to the weight as quickly as they did the light familiarization object.

Results also show that participants in both familiarization conditions are able to discriminate between the two weights with sensorimotor perception. For instance, participants in the heavy condition showed a significant decrease in arm drop between the last familiarization (i.e., heavy object) and novel weight (i.e., light object) trials. Furthermore, participants in the light condition showed a significant increase in arm drop between the same trials. Thus, participants show a physical difference in arm movement between the familiarization and novel weight objects depending on the weight of the novel object. For example, participants showed less arm drop when handling the light novel weight and more arm drop with the heavy novel weight. These results reveal that infants and toddlers can show a discrimination of object weight through sensorimotor perception.

However, a closer inspection of the arm movement results reveal that only participants in the light condition did *not* show a significant difference in arm movement between the pre-test and novel weight trials. All of the other results of the test trial comparisons in the two familiarization conditions showed a significant difference in arm movement. This result raises the question of why the participants' arms dropped a similar amount when the heavy weight object was presented in the pre-test and novel weight trials of the light condition. For instance, is the arm movement they are displaying with the heavy novel weight in the light condition due to an expectation they formed of receiving the light familiarization object again or is it because the heavy object is too heavy? The inclusion of the pre-test in the discrimination task indicates the answer.

The pre-test shows the participants' initial physical reaction to a certain weight before familiarization while the novel weight trial shows their reaction to the same weight after familiarization. Analyzing the difference in arm movement between these two trials shows whether participants reacted differently to the same weight before and after familiarization to another weight. A significant difference in arm movement shows that participants truly discriminated the novel weight after familiarization. Arm movement significantly differed between the pre-test and novel weight trials for the heavy condition but not the light condition. Thus, participants showed a significant difference in arm movement when handling the light weight before and after familiarization but not with the heavy weight.

Further review of the pre-test and novel weight trials of the light condition show that arm drop lessened when participants received the heavy weight in the novel weight trial. It is possible that participants in the light condition somewhat adjusted their arms to rise upward in response to receiving the light weight object during familiarization. A review of Mounoud and Bower's (1974) results showed that participants in their study elevated their arms in response to receiving the lighter weight. Thus, my study's participants may have an expectation of receiving the light weight again during the novel weight trial and, consequently, display a smaller amount of arm drop when receiving the heavy weight object in the novel weight trial as compared to when they receive it in the pre-test trial.

Participants in the heavy familiarization condition also show an arm adjustment in the novel weight trial. Their arms rise when they take the light object in the pre-test trial and slightly drop when they take it in the novel weight trial. These results show that participants in the heavy condition are reacting to the novel weight in a similar way to how participants react to it in the light condition: they had adjusted their arm movement to the weight of the familiarization object. While participants in the light condition move their arms upward to accommodate the light weight object in the familiarization phase, those in the heavy condition move their arms downward to accommodate the heavy familiarization weight. Therefore, when they receive the novel weight they continue to move their arms in the direction they moved them when handling the familiarization weight. These results reveal that participants in both conditions formed an expectation of receiving the same object weight in the novel weight trial that they received during familiarization.

The difference between the two conditions is that, in the heavy condition, arm movement with the novel weight was significantly different from that in the pre-test trial.

This result is possibly because participants could adjust their arm movement to the light weight easier than the heavy weight, which just pulled their arms down in the pre-test and novel weight trials of the light condition. For instance, when participants in the heavy condition took the light weight in the pre-test their arms rise upward, possibly revealing that they anticipated applying force against a weight heavier than the one they received. In the novel weight trial of the heavy condition, their arms drop slightly downward, possibly in anticipation of receiving another heavy weight.

Participants in the light condition also show anticipation of receiving a certain object weight. Their arms are greatly pulled down by the heavy weight in the pre-test possibly because they were anticipating receiving a certain object weight but they could not apply enough force to counteract the downward movement of the weight they actually received. As previously discussed, participants move their arms slightly upward in the novel weight trial in anticipation of receiving another light weight. Thus, participants in both conditions show anticipation of receiving a certain object weight in the pre-test and novel weight trials but only the object weight presented in the heavy condition could be easily handled by participants.

Since the ultimate goal of this study is to discover whether a cognitive concept of object weight could exist in children before they can solve formal operation problems, the categorization task served as an alternative to the balance task in testing the presence of this concept in younger children (i.e., 20 month olds). The categorization task shows whether children generalized the weight concept across different types of objects. A significant decrease in looking time over the familiarization trials would imply that the weight concept exists in younger children. Consequently, such a result shows that children decreased attention to different looking objects because they had the same weight. The age groups overall did show a significant decrease in looking time over the familiarization trials. Furthermore, since there is no significant main effect of age or familiarization condition, it can be determined that these factors did not affect looking time. Thus, all of the participants (including the 20 month olds) did decrease attention to the objects because they recognized that the weight of the objects remained the same while their appearance changed.

However, this result does not confirm whether any age group attended to weight and appearance changes in the categorization task. One sample t-tests on the novelty preference scores for the novel weight and novel appearance trials revealed that only the twenty-seven and thirty-four month olds significantly discriminated changes in weight and appearance. However, the twenty month olds did obtain a marginally significant novelty preference score for the novel weight. Thus, twenty month olds somewhat attend to a change in weight but not in appearance. Why are the twenty month olds unable to attend significantly to changes in object property (particularly novel appearance) in the categorization task? One possibility is that they did not attend to the task's familiarization objects as well as the other two age groups did. The results of looking time during the session of the categorization task revealed this likelihood.

Results of the session looking time during the categorization task revealed that participants overall decreased attention during familiarization and increased it when they received the completely novel object. Thus, they maintained attention throughout the session. Results also showed that the age groups displayed significantly different looking times during the session. The average looking time for the twenty month olds was significantly lower than the looking times for the two older age groups. The average looking times of the twenty-seven and thirty-four month olds did not significantly differ. Thus, the two older age groups look at the objects for roughly the same amount of time during the session. Consequently, only the twenty month olds did not attend to objects during the session for a substantial amount of time. Their average looking time during the session did not even parallel the average amount of time that the participants paid attention to the first familiarization object ($M = 7.72$). Therefore, the twenty month olds did not pay enough attention to the objects to notice when there was a change in object property, particularly in appearance. So why did they somewhat notice a change in weight?

One possibility is that they were somewhat familiar with noticing a change in weight since they had received the discrimination task before the categorization task. In the discrimination task, participants can only focus on a change in weight since they are receiving objects with the same appearance until they get the completely novel object. Another possibility is that they are unable to notice an appearance change in the categorization task because their memory is overloaded with appearance changes from the familiarization objects. This may be why they could not discriminate an appearance change in the categorization task. However, they could somewhat attend to a weight change because their memory was not overloaded with changes in this object property during familiarization. It could be inferred that children at 27 months of age or older are able to retain a memory of five or more items since there are five familiarization objects in the categorization task. In order to determine whether this statement is verifiable, a memory span test should be conducted in future studies.

Another way to determine children's ability to discriminate changes in object property in the categorization task is to measure arm movement. The use of looking time has mostly been used to test young children's ability to discriminate visual stimuli, so it is hard to know whether it can measure their ability to discriminate tactile stimuli. If some of this study's participants mostly pay attention to an object's superficial features, then it would help explain why they did not show a stronger novelty preference. A case in point is the twenty month olds' marginally significant novelty preference with the novel weight object in the categorization task.

It is possible that the twenty month olds did not increase their attention as much as the other age groups because they were more focused on the fact that they received this same object before (i.e., same appearance but with a different weight). However, the twenty month olds may have shown a stronger discrimination of the novel weight object in the categorization task through arm movement. It would also be interesting to know whether they showed a significant discrimination of the novel appearance object through arm movement. An inclusion of this type of analysis on the categorization task would show whether the discrimination of tactile stimuli (i.e., weight) is better evaluated with a sensorimotor measurement. It would also show whether participants handle objects differently when they only have an appearance change. Finally, if future studies analyzed arm movement in the categorization task then they could compare these results to the ones already obtained from the discrimination task, showing whether there was a difference in weight discrimination between the two tasks.

A more precise measurement of what participants are paying attention to during the session of the discrimination and categorization tasks should be conducted in future studies. Although this study analyzed the amount of attention they give to an object, it is often difficult to tell which features of an object to which they are paying attention. A better comprehension of participants' focal point would allow an experimenter to determine children's awareness of certain object properties more fully. Possible devices that could be used to clarify participants' focal point would be an eye tracker and an additional digital camera set up in front of the participants.

One of the hypotheses discussed in the introduction was that participants who displayed a sensorimotor perception of weight difference would not automatically show a cognitive concept of weight. This hypothesis was predicted because Flanagan and Beltzner (2000) showed that a disassociation exists between sensorimotor perception and cognition of object weight. The current study analyzed patterns of performance across the three tasks to see whether they are developmentally plausible or implausible: a plausible pattern of performance would include participants passing all three tasks or passing just the discrimination or categorization tasks but not the balance scale task. The most common developmentally plausible pattern is participants passing the discrimination and categorization tasks but failing the balance scale task. Thus, participants in this study must be able to discriminate an object weight difference *and* respond to weight as a property that can exist in many objects before they can conceptualize that weight has functional purposes.

These abilities are present in the age groups tested. Results from the discrimination and categorization tasks show that infants and toddlers can discriminate object weight in one or both tasks. Results from the balance scale task also show that one of the age groups tested could respond to the object weight in a functional way. As predicted, this shows that a cognitive concept of weight can be tested in children younger than school age if the task measures knowledge of how weight is used and not what it is (i.e., is this object heavier?).

Any developmental differences in performance that may occur with the balance scale task could not be hypothesized in advance due to a lack of previous research. However, results revealed that a developmental difference in performance did exist for the balance scale task in this study. The 34 month olds were the only age group who had a proportion correct score that was significantly greater than chance. They were also the only one to have a proportion correct score that was significantly higher than the other two age groups. It is a safe conclusion that performing well on the balance scale task does not emerge in young children until the age of 34 months.

So what is the reason that children are not capable of performing well on the balance scale task until the age of 34 months? One answer to this question may be the fact that young children seem to be incapable of forming a dual representation of an object in that they can treat it as both a physical entity and a symbolic representation. DeLoache (2000) studied dual representation in 2.5 year olds by testing their ability to use a scale model as a symbolic representation for a room that they could physically enter. DeLoache described dual representation as a person's ability to not only form a mental representation of an object itself but a mental representation of the relationship between the object and what it symbolizes. She stated that young children often have difficulty attaining dual representation because they have problems with overall cognition and limited experience with symbolic artifacts in general. Thus, DeLoache believed that it is hard for young children to keep two mental representations (i.e., its concrete and symbolic nature) of an object active in their mind mostly because they have not encountered many symbolic artifacts and, consequently, are not used to thinking that a new object may have symbolic importance.

Furthermore, DeLoache (2000) believed that young children would have a particularly hard time seeing the dual representation of a scale model due to the attractiveness and intrigue it generates for them. Interestingly, this is the same type of problem that is present in my study: the younger participants were often so engaged in playing with the balance scale like they would a toy that it was hard for them to concentrate on the required task. These participants would concentrate more on moving the balance scale up and down or playing with the toy bear attached to it than they would on choosing an object to make the balance scale go down. The balance task's results revealed that ten participants did not complete all five test trials. All of these participants were in the 20 ($n = 6$) and 27 ($n = 4$) month age groups, showing that children at these ages had a hard time understanding the abstract purpose of this task and probably thought 'what's the point of continuing to do it?'.

The oldest age group (i.e., 34 month olds) displayed an adept understanding of the abstract purpose of the balance scale task. Did an increase in performance occur with the older children within an age group? This study conducted correlations between age and proportion correct on each age group to find out whether older age correlated with a higher proportion correct score. The strongest positive correlation between age and proportion correct occurred with the 34 month olds. Therefore, an increase in age in this group correlates with an increase in performance. The 27 month olds were the only other age group that showed a positive correlation between age and proportion correct but the relationship was weak between these two variables. The reason that older children perform better than younger children is easier to understand with the 34 month olds since the ability to perform well on the balance scale task seems to emerge at 34 months old. Therefore, it is only logical that more of the oldest children in this age group would have higher proportion correct scores than the youngest. However, it is harder to understand why older age would make a difference in performance in the 27 month olds but not in the 20 month olds.

DeLoache (2000) stated that dual representation is challenging for young children because they must keep in mind not only the object's identity and purpose but also what it represents. Even though young children do engage in symbolic play (i.e., using a piece of wood as a car) and can understand various symbols (e.g., language and gestures), according to DeLoache, these symbolic uses do not require dual representation because children do not have to remember the real identity of the object that they are using along with its symbolic representation. Instead, DeLoache declared that they could use a block of wood as a car and not think about its identity as a block of wood unless they are inhibiting a real response to it. For example, a young child playing with a piece of wood as a car would not expect the piece of wood to continue to roll after it was pushed because it does not have wheels like a car does. Thus, in situations like this, a child can focus on an object's symbolic representation and not its real identity.

However, a child must use dual representation in order for him or her to understand how to use a scale model. DeLoache (2000) stated that this is why children younger than three years old have problems with the scale model task: it requires them to keep mentally active the use of the model as a real object and as a symbolic representation for something else. However, symbolic play—an activity that helps develop dual representation in young children—starts emerging in children when they are one to two years old (Tamis-Lemonda, Katz, & Bornstein, 2002).

According to Tamis-Lemonda et al. (2002), adults help support children's burgeoning pretence by assigning symbolic meanings to their actions. An example given by Tamis-Lemonda et al. was a scenario in which a mother tells her child that he or she is 'patting the baby' whenever the child touches a doll. Tamis-Lemonda et al. stated that parent-child interactions such as this help young children start using substitutive objects (e.g., using a banana as a telephone) instead of just pretending with literal replicas (i.e., toy telephone). In a study testing 13 to 20 month olds, a positive correlation was found between the amount of time mothers elicit symbolic play with their children and the amount of time their children engage in this type of play (Tamis-Lemonda et al., 2002).

Although this result did not address the impact that early symbolic play has on the symbolic competence of infants, it does show that the use of symbolism by young children can vary depending on the amount of symbolic play that they engage in with an adult. Even though the use of symbolic play in parent-child interactions was not addressed in my study, it is possible that older age made somewhat of a difference in the balance task performance of the 27 month olds because their parents had increased how often they engaged in symbolic play with them from the time the participants were infants. This increased use of symbolic play may not have been present as much in the parent-child interactions of the 20 month olds, resulting in age not having an effect on balance task performance in this age group.

However, there is no way to test this assumption since no data was collected on the amount of symbolic play that the participants engaged in, either with their parents or on their own. A follow-up survey asking the parents of the 27 (and 20) month olds tested about their children's symbolic play during the time they were 13 to 20 months old would be a beneficial way to assess the impact of early symbolic play on later symbolic competence. Then again this type of assessment would give incomplete (and possibly incorrect) data because it would be based on the parents' memories of how they played with their child (or how their child played) during the age in question.

Besides parental support of early symbolic competence, there is a way for children to achieve dual representation at an earlier age than 34 months old. DeLoache (1991) discussed the fact that pictures can assist young children in achieving dual representation because they are not interesting as objects, unlike scale models and balance scales. The picture-superiority effect is the ability of young children to achieve dual representation with a picture and not an object and DeLoache and other researchers have reported this effect in several studies. DeLoache discussed her picture-superiority effect findings in which 30-month-old children were more successful with locating a toy hidden in a room when the toy's location was pointed to in a picture than when the child observed a miniaturized version of it hidden in a model of the room. Children younger than three years old can achieve dual representation when the task has been simplified by using two-dimensional pictures instead of a three-dimensional model.

It can be hypothesized that the balance scale task in my study was not simplified enough for the 27 month olds to achieve dual representation with it since they did not receive a significant proportion correct score. As addressed in the introduction, my study used a balance scale task because it is an engaging apparatus for young children that tests their cognitive concept of object weight. In addition, it only requires participants to comprehend a small amount of verbal instruction in order to perform the task correctly. Thus, it is more possible to test the cognitive concept of object weight that young children have with this task because they are not limited by their inability to understand what the task requires them to do.

However, a review of the younger children's performance of the balance scale task in my study suggests that they are focusing on the scale as a toy and not as a device they can use to discriminate between two different weights. This is particularly the case with the 27 month olds' performance on the balance scale task. As previously discussed, their inability to comprehend this task reveals itself in how they played with the scale. Closer inspection of the balance task performance of the twenty-seven month olds also revealed that 62% performed below criterion (proportion correct criterion equals 0.60). Results also showed that 71% of the 20 month olds performed below criterion while only 32% of the 34 month olds did. These results provide further evidence that the ability to perform well on the balance task does not emerge until 34 months old.

However, would participants younger than 34 months old have performed better on the balance scale task in my study if they could not touch the scale during testing? DeLoache (2000) discovered that the 30-month-old participants in her study were more able to achieve dual representation with the scale model task when the presence of a window prevented them from touching it. In other words, DeLoache stated that the creation of a physical distance between a child and the model allowed the child to develop a psychological distance to the model. Thus, they were more capable of mentally representing the abstract relationship between the model and room. One possible way to achieve a physical distance with the balance scale task used in my study would be to place the scale behind a transparent (i.e., plastic) partition, allowing the children to see the scale but not touch it. Therefore, the children could handle both the light and heavy objects and then give the object that they thought would tip the balance scale to the experimenter. The experimenter would put the chosen object in the balance scale, showing the participants whether it tipped the scale downward.

The inclusion of this type of method in the balance scale task might also give the experimenter a better understanding of each participant's "first choice." The object that a child chooses as a first attempt to get the balance scale to tip is a participant's "first choice." Providing more clarity on a participant's first choice would allow an experimenter to better comprehend whether a child has an understanding of how the balance scale task works and a cognitive concept of object weight difference. This clarification would be particularly useful during times when it was hard to determine which object was a participant's first choice. For example, there were a couple of instances during testing in which participants first attempted to place an object in the balance scale but they did not place it completely into the scale (i.e., they moved their hand with the object in and out of the scale). Instead, these participants opted to put the other object they were holding completely into the scale. Under these circumstances, their "first choice" is marked as the object they put in the scale completely, or the second object they picked up. It is easy to see that results from these particular participants may not have given an accurate depiction of their cognitive concept of object weight.

Nevertheless, why would creating a physical distance between the balance scale and participants younger than 34 months be important in allowing them to achieve psychological distance and, possibly, dual representation of the balance scale? Furthermore, in regards to my study, why are children at 34 months old able to achieve dual representation with the balance scale when there is no physical distance between them and the scale, but children seven months younger cannot? One reason why physical distance from the scale may help younger children obtain dual representation with it is children at these ages have just started to think about their actions. In other words, they are *starting* to have the capability of knowing what the outcome of an action will be before they carry through with it.

Sternberg (2002) stated that children between the ages of 18 and 24 months have the beginnings of thought-mental combinations and, therefore, are capable of thinking through actions before they produce them. Consequently, children at this age have not fully developed their ability to mentally represent an action or inhibit a dominant response. Sternberg based this ideology of young children's cognitive development on Jean Piaget's sixth substage of sensorimotor development, the last stage in sensorimotor development before children enter the preoperational stage of their cognitive development.

According to Sternberg (2002), the thought-mental combinations that occur in the sixth substage lead to the development of 'symbol systems', which allow children to represent thoughts, objects and events in abstract ways. However, complete abstract thought is not even fully developed in the preoperational stage, a period which covers the ages of two to seven years old and, therefore, two of the age groups in my study (i.e., the

27 and 34 month olds). Piaget (1962) claimed that children in the preoperational stage did not fully represent concepts in their mind and still relied on concrete physical situations to understand the world.

In his article titled ‘The Stages of the Intellectual Development of the Child’, Piaget (1962, pp. 4) explained, “The stage of representation of thought (i.e., the preoperational stage) is superimposed on the sensorimotor stage” and not an extension of this previous stage. Piaget clarified this statement by asserting that children in the preoperational stage rely on perceptual information to understand objects and events, just as they did in the last substage of the sensorimotor stage. In addition, he declared that even though children could verbalize in the preoperational stage, it did not mean that they could mentally reconstruct situations and ideas. In summary, Piaget’s observations on children in both the last sensorimotor substage and the preoperational stage revealed that they must rely on their immediate surroundings to comprehend situations and, therefore, cannot mentally represent abstract concepts such as a heavier weight producing a visual outcome with a balance scale.

Piaget’s assessment of children in these two stages provides some interesting insight into why they would need physical distance from the balance scale in order to be able to achieve dual representation with it. Since children at these ages depend on current perceptual information to understand things, they must be separated from an object in order to direct their attention away from its physical salient features. DeLoache (2000) effectively showed that when a plastic window prohibited her 30-month-old participants from touching or playing with the scale model, they showed a 41% improvement in their ability to retrieve the toy hidden in the larger room. In contrast, when DeLoache’s 36–

month-old participants played with the scale model before they are tested, they made 10% less correct retrievals than the 30 month olds and 31% less correct retrievals than a comparison group of 36 month olds that did not play with the scale before testing. DeLoache's results showed that decreasing the physical salience of the scale model by providing distance between the model and participants allowed the children to think about the model's symbolic nature and interact with it using abstract thought.

Once young children divert their attention from the physical salience of an object, they, in turn, may think of the object in more abstract and symbolic terms, enabling them to create a psychological distance with the object. In fact, DeLoache (2000) claimed that children's experiences with symbolism help them attain psychological distance with objects. However, despite the fact that DeLoache's findings seem to suggest that physical distance can enable a young child to experience psychological distance, it is difficult to find research that shows a relationship between the two. Carlson, Davis and Leach (2005) discussed psychological distance in terms of it being a child's ability to separate him or herself cognitively from the surrounding environment. Carlson et al. further stated that the presence of symbols helps children achieve psychological distance and, thus, they are more able to control an immediate response to an object that bears a symbolic nature.

Zelazo and Frye (1998) compared psychological distance to physical distance, but did not necessarily offer an association between the two. Zelazo and Frye stated that psychological distance is a person's ability to distance him or herself from one way of thinking about an object or event so that he or she can conceptualize the object or event in other ways. They explained that this is why even three year olds are unable to sort cards based on an opposing rule in their dimensional-change card sort task (executive function task). Three year olds cannot distance themselves psychologically from one way of conceptualizing a card and, thus, cannot switch between ways of sorting the cards (i.e., by shape or by color) when they are asked to. This take on psychological distance relates to the findings from my study. As discussed previously, 27-month-old participants played with the balance scale more than they performed the task they were asked to do by the experimenter. Hence, they were only able to focus on the balance scale's physical function (i.e., it moves up and down) while the 34 month olds who achieved psychological distance with the scale were able to see that it had an abstract purpose, such as it goes down by itself only when the heavy weight is placed in it.

Zelazo and Frye (1998) likened psychological distance to physical distance in the sense that physical distance allows a person to see a larger perspective of the surrounding environment while psychological distance allows one to visualize the larger context and meaning of an object. Thus, Zelazo and Frye seemed to suggest that children who experience psychological distance with an object do not need to separate themselves physically from it in order to pay attention to its less tangible characteristics. Instead, like Carlson, Davis and Leach (2005), Zelazo and Frye proposed that children obtain psychological distance with objects when they increase their executive functioning abilities. In other words, they are able to use their knowledge of an object (or situation) to control how they behave with that object (or in that situation).

In summary, previous research on psychological distance shows that children before the age of 34 months need to have physical distance or a decrease in physical salience in the object before they can achieve psychological distance and dual representation of it. On the other hand, children at 34 months old (and older) can achieve psychological distance despite a lack of distance from the object or the fact that the object has a lot of physical salience.

DeLoache (2000) discussed the reasons why dual representation develops in young children, including an increased ability to understand deeper structural relations among entities, awareness that an entity can be perceived in more than one way and an ability to inhibit a response to a symbolic object as a real object. The last reason may be one explanation for the 34 month olds' ability to perform well on the balance scale task: they could inhibit responding to the scale as a real object and, instead, used it to perform a symbolic function. DeLoache claimed that the ability to inhibit one's responses improves throughout the first few years of life. Thus, it is possible that a developmental trend exists with performing well on the balance scale task and that 34 month olds can inhibit their responses better than 27 month olds can.

Furthermore, it was discussed in the introduction that young children might have a cognitive concept of object weight not based on the object's size but on its functionality. The results from the balance scale task revealed that the 34 month olds have a concept of the functionality of object weight since they were able to inhibit responding to the scale as a real object and use it for its symbolic purpose. Thus, they were able to perceive that the objects and scale are more than just something with which to play. As discussed in the introduction, this shows that children within the first couple of years of life are able to understand the affordances (i.e., the functions) that the weight of an object can provide. This understanding was present even though the children were in a situation (i.e., laboratory experiment) that was sometimes frightening and unfamiliar to them. Thus, young children's understanding of affordances and dual representation allow them to successfully problem solve in situations in which they do not actively know the outcome of their actions.

Although children's increased understanding of symbolism and executive functioning may lead to their ability to use dual representation, it may also be the result of understanding what the experimenter was requiring them to do in the balance scale task. In other words, the participants had to understand the intention the experimenter had when she told them to use the object that would make the bear on the balance scale 'go down'. DeLoache (2000) explained that the ability to understand other people's thoughts and intentions allows children to achieve dual representation. In conclusion, previous studies show that in order for children to develop a concept of object weight based on its function, they must first achieve general cognitive milestones.

The greater inhibitory control that 34 month olds seem to display with the balance scale task should be further explored in future research with the incorporation of an executive function task. Executive function tasks have been used with children age 2.0 to 3.0 years old in the past to see whether they are able to produce a new behavior based on the rule they are expected to follow. As previously discussed, Zelazo and Frye (1998) found that 3.0 year olds kept repeating an original response when they were presented with a new sorting rule, causing them to switch between pairs of rules in the dimensional-change card-sorting task. However, in tasks in which they switched between single rules, Zelazo and Frye stated that the three year olds were able to produce a different behavior based on the new rule. Thus, three year olds can produce a behavior based on the rule present (i.e., use executive function) when the task is not as complicated.

Zelazo and Frye (1998) also stated that three year olds are able to think about pairs of rules simultaneously while two year olds can only represent single rules. However, three year olds have difficulty choosing which rule to use when presented with conflicting rule pairs. Children younger than three years old are more apt to keep repeating the same response because they can only think of one rule at a time. In general, these statements show that an executive function task like the dimensional-change card-sorting task gives insight into the cognitive developmental differences that are present between older infancy and young toddlerhood. Therefore, the addition of an executive function task with the balance scale task could give more insight into why children at 34 months are able to cease playing with the balance scale as a toy and perform the task they are expected to do (i.e., change behavior) while children at 27 months old often continued to play with the scale or kept responding only with the object that was at a particular hand (i.e., perseveration).

Future research should also address and try to improve upon the limitations that are present in this study. For example, another measurement of object weight discrimination, which might give a better assessment of whether or not children were attending to the object's weight, would be holding time. Molina and Jouen (2003) used this variable to measure habituation to one weight and reaction to a novel weight. Molina and Jouen stated that they monitored the holding time of their participants to see when they showed a 50% decline in holding time over three consecutive trials as compared to the holding time displayed in the first three trials. Once they reached this criterion, Molina and Jouen considered that participants had habituated to the object. After habituation, the participants received three test trials with the new object weight in which holding time was measured to see whether it was significantly different from holding time during habituation. I believe that this measure would work well in a future study because preliminary observations reveal that many of the participants in my study held the familiarization object for an increasingly smaller amount of time the more they received it. Furthermore, holding time is a direct measure of a participant's reaction to an object weight so it would serve as a more efficient assessment of this variable than looking time.

Another limitation in the methodology of my study is the taking of objects by the participants in the discrimination task. Although the participants did have their arm extended when they initially grasped the object, their arm extension had lessened by the time the experimenter had let go of the object. Therefore, the arm movement values found in this study may not have been a complete assessment of how much physical discrimination is taking place. Using an automated system to present the objects to children might provide a more complete assessment of physical discrimination. Unlike a human experimenter, this type of system could provide a more exact presentation of the objects, including not supporting an object when a participant's hand is fully supporting it. An automated system may also provide an exact measurement of how far to present the objects in order to aid participants' arm extension.

A mechanical device was used in Flanagan and Beltzner (2000) in order to obtain a more exact measurement of load force (i.e., the amount of vertical force used to pick up objects). Molina and Jouen (2003) also used air tubing to present objects so that infants would use a palmar grasp and not a finger-thumb grasp. Thus, it is possible that a device could be used to measure when a child has completely grabbed an object and the device is no longer supporting it. This type of device would help provide a more complete picture of the type of arm movement (e.g., arm rising or dropping) that participants display when they initially take an object.

To summarize, the present study's findings show that a cognitive concept of object weight does not exist in children before the age of 34 months. Furthermore, this study reveals that a presence of object weight concept can be tested in young children if the task measures the functionality of object weight and not how to categorize it (e.g., is this weight heavier?). As expected, children at all of the ages tested display an ability to discriminate object weight through sensorimotor perception and looking. The participants also reveal that they generalize the weight concept across objects by showing a decrease in looking time across the familiarization trials of the categorization task. However, only the twenty-seven and thirty-four month olds show that they can discriminate a change in both object appearance and weight when presented with a few different looking objects. Possible reasons that the 34 month olds were able to perform better than the younger children on the balance scale task were discussed, including their greater ability to inhibit responding to the scale as a real object so that psychological distance and, ultimately, dual representation of the scale could take place. Finally, chi-square analyses show that children must significantly attend to a change in object weight in both the discrimination and categorization tasks before they can perform well on the balance scale task.

In conclusion, the present study lays a foundation for the continuing research that should be conducted on young children's ability to discriminate object weight and show a cognitive concept of it. Why should this kind of research be continued? The answer lies in its ability to shed some insight on the cognitive and perceptual abilities of children starting to use language and enter the academic realm (i.e., preschool). Twenty to 34 month olds are not often the subjects of psychological research due to the difficulty of maintaining experimental control during testing. However, they hold the key to understanding early cognitive development, including how intellect expands from sensorimotor perception to abstract thought. By using tasks that research both perception and cognition in infants and toddlers, the connection that exists between sensing the physical world and giving abstract meaning to those sensations is clearer. It is my belief that any research that helps social scientists make a conclusion about that connection is well worth the effort. As the current study shows, the journey in understanding the complex association between perception and cognition may not always be smooth and linear, but it opens up avenues for exploring the development of children's early comprehension of objects.

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Appendix

Pictures of the Stimuli, Apparatus and Set-up used in the Current Study

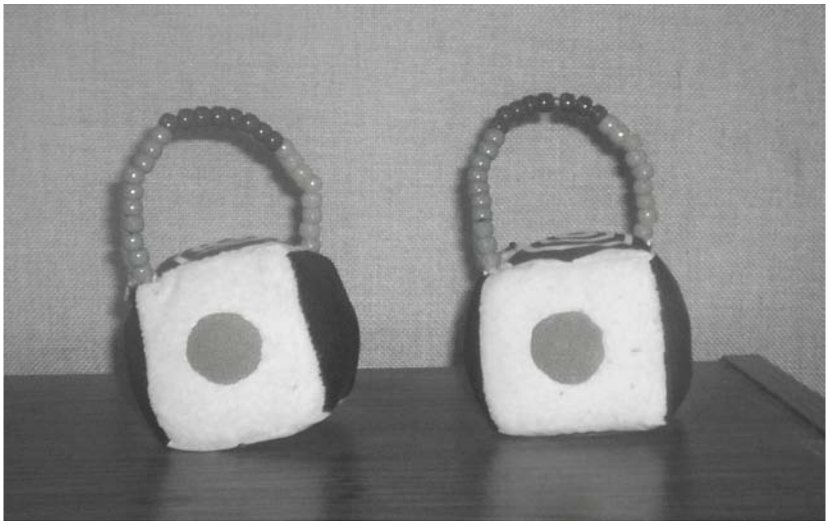

Figure 1. Two compressible cubes used as the familiarization and novel objects in the discrimination task. Also used in the modeling phase of the balance scale task. Light left, heavy right.

Figure 2. Two small Tupperware containers used in the categorization and balance scale tasks. Light left, heavy right.

Figure 3. Two rectangular boxes used in the categorization and balance scale tasks. Light left, heavy right.

Figure 4. Two mini baby bottles used in the categorization and balance scale tasks. Light left, heavy right.

Figure 5. Two pill bottles used in the categorization and balance scale tasks. Light left, heavy right.

Figure 6. Toy treasure chests used in the categorization and balance scale tasks. Light left, heavy right.

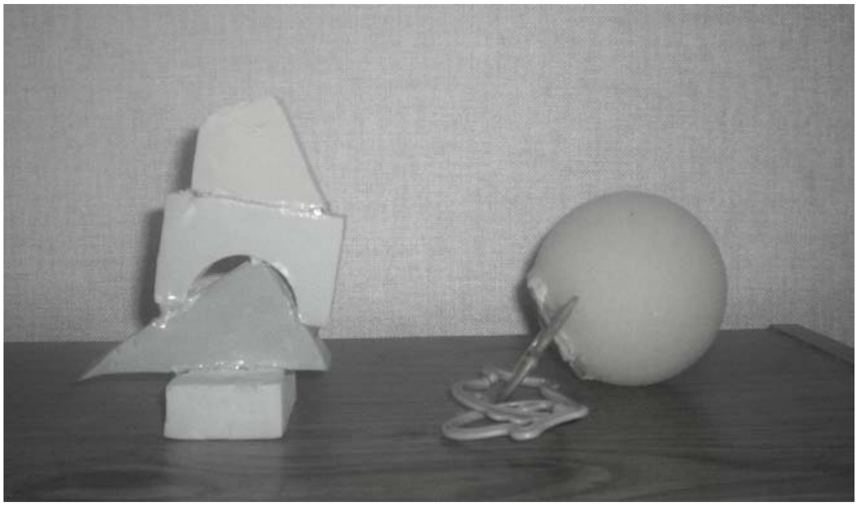

Figure 7. The tri-colored geometric Styrofoam figure on the left was the completely novel object in the categorization task. The yellow foam ball with chain on the right was the completely novel object in the discrimination task.

Figure 8. The balance scale used in the balance scale task.

Figure 9. The set-up. Illustrated in this picture is the infant booster seat that participants were seated in during testing. The checkerboard pattern was used to measure arm movement.