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Individuation and Identification of Physical Objects: Evidence From Human Infants

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INDIVIDUATION AND IDENTIFICATION OF PHYSICAL OBJECTS: EVIDENCE FROM HUMAN INFANTS

by

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ABSTRACT OF THE THESIS

Individuation and Identification of Physical Objects:

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The research presented here investigates how infants use perceptual features, specifically shape and color, to individuate and identify physical objects. Individuation is the process whereby objects come to be represented as distinct individuals. This process enables infants to establish the notions *single object* and *more than one object*. Object identification is the process whereby a unique identity is associated with an object, giving rise to the notion *the same one*. Experiment **1** reveals that 12-month-olds will individuate physical objects based upon color differences, but will not identify objects by color. This seemingly paradoxical result is explained in terms of a new theory of the infant's object concept, inspired by theories of object-based mechanisms of selective attention. Experiment **2** demonstrates that 9-month-old infants who have individuated objects based upon spatiotemporal properties do not always identify these objects by their shapes. There may be a developmental progression in the use of features to individuate and identify physical objects. Future work (some already in progress) will explore this possibility.

Acknowledgement

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Introduction

It was once thought that human infants were incapable of representing physical objects as concrete, three-dimensional volumes existing independently of sensory contact (Piaget, 1955). However, recent experimental work capitalizing upon infants' propensity to look longer at unfamiliar events has undermined this view. Empirical studies have used visual habituation, preferential looking, violation of expectation, and other looking-time-based paradigms to show that infants less than six months old appreciate that objects are substantial, relatively permanent, and occupy space (Baillargeon, Spelke, & Wasserman, 1985), and to demonstrate that infants represent several abstract properties of physical objects. For example, we now know that young infants expect physical objects to follow continuous, non-intersecting paths in space and time (Spelke, 1988, 1994), and that they are sensitive to the numerosity of small sets of occluded objects (Wynn, 1992; Baillargeon, Miller, & Constantino, 1994; Uller, Carey, Huntley-Fenner, & Klatt, 1994). In addition, infants can attend to spatial and mechanical relationships among objects; they seem to understand that one object can launch another after a collision (Leslie & Keeble, 1987), that objects do not pass through one another (Baillargeon, 1987; Spelke, Breinlinger, Macomber & Jacobson, 1992), and that only a subset of physical objects exhibits certain special properties, such as self-initiated movement (Leslie, 1984a).

Despite growing evidence that infants possess a relatively sophisticated notion of physical objects, empirical work has also suggested that infants do not always use object properties the way adults do. For example, an adult who watches a sequence in which a distinctive object, such as a bright yellow rubber duck, is taken out from and placed back behind an occluding screen, and then a differently-featured item, such as a white foam ball, is taken out from and replaced behind the same screen, will typically conclude that there are two distinct objects behind the screen, and furthermore, that one of the objects is a white foam ball and the other object is a yellow toy duck. Under the same circumstances, however, 10-month-old infants do not appear to set up representations of numerically distinct individuals. (Xu & Carey, 1996).

In short, adults, but not 10-month-olds, will use featural differences both to individuate and to identify physical objects. Individuation is the process whereby objects come to be represented as distinct individuals. This process enables infants to establish the notions *single object* and *more than one object.* Object individuation is also inherently intertwined with object identification, the process which gives rise to the notion *same one*. In fact, object individuation and object identification presuppose one an other. However, for the purposes of this discussion they will be distinguished as follows: **Individuation** will be used to refer to the establishment of distinct object representations, and **Identification** will be used to describe the process of determining whether a new perceptual episode involves the reappearance of a previously seen object.

Individuation and identification can both take place either by *location* or by *feature*. That is, since there are constraints upon the manner in which an object's location and features can change over time, both differences in location and differences in features can be used to infer distinct individuals. In particular, an object can not instantaneously change location – it must follow a smooth path over space and time, and a single object can not be simultaneously centered at two distinct positions in space. Furthermore, gross featural changes do not typically occur in short time intervals, so gross featural differences should (typically) be interpreted as signifying different individuals. Thus, establishing representations of physical objects may involve any of the following four processes: individuation by location, individuation by feature, identification by location, and identification by feature.

The distinctions among these four processes are motivated by *object indexing* theory, a new theoretical framework which may be used to explain infants' (and adults') individuation and identification of physical objects. This framework is inspired by some current theories of adult attention, and has been very heavily influenced by two of them. The central concepts of these two theories, FINSTS and object files, will be briefly described below, followed by a quick overview of some the major ideas of the object indexing framework.

Pylyshyn (1989, 1994) argues that, in order to detect simple geometrical relations among the elements of a visual scene (e.g. being inside, or being collinear), the visual system must be able to simultaneously reference multiple objects. His model of such indexing is based on the notion of a "*FINST*" (*F*inger of *Inst*antiation). FINSTs are spatial indexes, assigned to items in the visual field. They can be assigned regardless of spatial contiguity, and serve as a means through which higher-level processes, such as focal attention, are able to access the items in the visual field to which the FINSTs are assigned. Like pointers in a computer data structure, they provide access to an information-rich location without representing that information themselves. Unlike pointers, however, FINSTs are limited in number; there are only about four of them. Finally, FINSTs are *sticky*: if an indexed item in the visual field moves, the FINST moves with it. Experiments using a multiple-object tracking paradigm offer support for the FINST-based theory of visual attention. Subjects in these experiments are able to track about four randomly moving targets among numerous identical moving distractors. Subjects are therefore attending to and tracking items and not regions of space (Pylyshyn et al., 1994).

Kahneman & Treisman (1984; Kahneman, Treisman & Gibbs, 1992; Treisman, 1988) propose a model of attention whereby an *object file* is opened whenever a object or an event is first detected. According to this model, a newly created object file contains only spatiotemporal information; only a location and a time are recorded initially. Like a FINST, an object file can function as an index to an object's location. However, unlike FINSTs which do not themselves contain any featural information, object files do generally contain featural information; this information is gradually added as it becomes available. The featural information contained in an object file can be added and changed without affecting its indexing function. Since making modifications to the contents of object files (spatiotemporal or featural information) is assumed to require attention, there is a limit upon the number of object files which can simultaneously be "open" for modification.

The Object Indexing Framework

A key postulate of object indexing is that attention can span a small number of physical objects by assigning to each a mental token, called an object index, that points at their actual or probable locations. Indexes are assigned primarily by location; however, they are not assigned to the locations themselves but to "bounded physical objects" (Spelke, 1988) in these locations. In addition, indexes can be assigned by feature if location information is ambiguous. Since, like FINSTs, object indexes are limited in number, they must be re-used; but assigned indexes must be de-assigned before they can be used again. There are three basic rules of index assignment:

1) a distinct object is assigned a single index;

2) once an index is assigned, it sticks to the object as the object moves through different locations in space;

3) if objects occupy distinct locations in space, different indexes may be assigned to each of them.

Leslie, Xu, Tremoulet & Scholl (in preparation) describe object indexing in full detail.

Object indexes cannot simply be identified with either FINSTs or object files. As originally defined, FINSTs are inherently tied to vision, whereas object indexes must operate cross-modally, e.g., to track objects in tactile or motor space. Furthermore, object indexes must track objects that are partially or completely occluded. In such cases the indexed item will not appear on the retina, and the locational access the index provides may be only approximate. While it is possible that FINSTs may operate under occlusion, FINSTs and object indexes may operate under different time scales. (After occlusion, it is likely that FINSTs will decay rapidly, but object indexes must endure for relatively long periods of time.) Object files also would be expected to behave differently under non-brief periods of occlusion than object indexes, since the former individuate perceptual *episodes* while the latter individuate physical objects. The re-appearance of a physical object from behind a screen could be considered a new perceptual episode but it is certainly not a new physical object. When an indexed object is temporarily occluded an then re-appears, it pulls the index with it. Meanwhile, the reappearance of a physical object should generate a new object file. As featural information becomes available, the new object file will be associated with, or collapsed into, the first.[1]

[1]It is unclear what happens in situations where the occlusion is very brief. Since opening a new object file requires attention, in cases of short occlusion it is likely that an existing object file would be updated instead of creating a new one, unless there is reason to open an additional object file anyway (e.g. the detection of a new object).

Finally, both the opening of an object file and the assignment of a new FINST can never be driven purely by featural information. In contrast, the object indexing framework allows for the possibility that, in situations where locational information is ambiguous, featural information is sufficient to drive the assignment of indexes. Despite these differences, object indexing framework inherits a very important property of FINST-based and object file-based theories: it contains a level of representation in which objects can be individuated independently of being identified. Object indexing theory assumes that *object individuation* is driven by an attentional mechanism which assigns indexes to distinct physical objects. It assumes that *object identification* is governed by whether an object has already been indexed or requires the initial assignment of an index. According to object indexing theory, featural information is attached to object indexes by a non-default process of feature binding.

The primacy of location information for assigning indexes under the object indexing framework suggests the following hypothesis: early in development, object indexation, and thus individuation, may be driven entirely by spatiotemporal information. For young infants, features may be bound to objects but only *after* the assignment of an index by location. Later in development, differences in features may be sufficient to motivate the assignment of a new object index. This hypothesis may be investigated empirically.

In short, although object indexing theory proposes a framework which may be used to account for infants' individuation and identification of perceptual objects, it leaves many questions open for empirical investigation: Is there a developmental progression from individuation by location to individuation by feature as hypothesized above? What is the role of *feature* in the case where objects are individuated by *location*? Are features bound to object representations when the individuals have been set up by location? These questions will be addressed by the experiments presented here. Before these experiments are introduced, however, some recent findings relevant to object individuation and object identification will be briefly reviewed.

Background & Methodology

Recent work bearing upon Object Individuation and Object Identification

There is a great deal of empirical evidence suggesting that even young infants individuate and identify by location, using spatiotemporal properties of physical objects. For example, Spelke, Kestenbaum, Simons, & Wein (1995) familiarized 4-month-old infants to a display in which an object moved behind an occluder, crossed a gap, and then moved behind a second occluder. They found that these infants then looked longer at a test display of two objects than at a test display of a single object, implying that the infants inferred that only one object was present during the habituation trials. Spelke et al. familiarized a second group of infants to a similar display in which an object moved behind one occluder and then a second identical object appeared from behind the far side of a second occluder without crossing the gap. This group of infants looked longer at the test display showing a single object than at the display showing two objects, implying that the infants inferred that there were two objects present during the habituation trials. These results indicate that infants use continuity of trajectory to determine object individuation.

Xu & Carey (1996) expanded upon Spelke et al.'s work. In the Xu & Carey paradigm, objects were removed from behind a single screen, placed in view of the infant, and then replaced behind the screen.[2] Initially, there were two objects behind the screen which belonged to different kinds and thus differed in many features. These objects were pulled out from behind the screen and displayed, either one at a time (properties condition) or both at the same time (spatiotemporal condition). Following familiarization, the screen

[2]The scenario described earlier with a duck and a ball emerging from behind a screen is an example of the Xu & Carey paradigm.

was removed to reveal either one of the previously shown objects, or both objects. Unfortunately, Xu & Carey's test displays suffered from a *baseline* problem: infants are predisposed to look longer at displays of two objects (especially two differently-featured objects) than at displays of a single object. To get around this problem, Xu & Carey measured their subjects' preference for two-object-displays in a series of pre-test "baseline trials." In the baseline trials, infants were presented with single-object- and two-object-displays, similar to the outcome displays of test trials, and their looking times were measured.

Xu & Carey found that the infants in their spatiotemporal condition looked the same amount of time at single-object-outcomes and as they did at two-object-outcomes; however, this pattern was significantly different from the pattern of looking times during the baseline trials. Thus, Xu & Carey interpreted their results as evidence that infants in their spatiotemporal condition expected there to be two objects behind the screen and were surprised to see outcomes with a single object. In contrast, in their properties condition (where the two different objects were never shown simultaneously), only older infants (around 12 months) looked as long at the unexpected single-object-outcomes as at the expected two-object-outcomes; younger babies (around 10 months) looked significantly longer at two-object-outcomes than at single-object-outcomes. (That is, the younger babies in the properties condition did not look differently in the test trials than they did in the baseline trials.)

Xu & Carey argue that younger infants do not know that, e.g., a cup and a ball, shown sequentially, must be two distinct objects; they suggest that the younger infants may expect only one object, or may be agnostic about the number of objects which must be behind the screen. However, it is possible that infants younger than 12 months old can use features to individuate objects; it may simply be harder for younger infants to overcome their baseline preference for two-object-displays than for older infants. It is also possible that the infants in Xu & Carey's properties/kind condition looked longer at the two-object-displays than the infants in their spatiotemporal condition did because those in the former condition were never exposed to a two-object-display (since, by design, they never saw two objects simultaneously) during the test trials, in contrast to those in the latter condition. This is also true of the infants who participated in habituation-based replications of their experiment.

Xu & Carey argue that their findings support Bower's (1974) theory of infants' earliest representations of object identity. Bower proposes that object identity is initially determined by spatiotemporal information alone. He claims that 3- to 4-month-old infants do not take features into account when establishing object identities, asserting that these young infants define the identity of moving objects in terms of their movements, and define the identity of stationary objects solely in terms of location. (Bower, 1974).

Although Xu & Carey's results are consistent with the hypothesis that young infants use spatiotemporal information before they use features to *individuate* objects, unfortunately, their technique can not address how infants *identify* objects, since it confounds identification with individuation. Xu & Carey tested whether infants expected two objects, but not on whether they expected the objects to have *particular* properties.

The only research described in print which bears upon infants' ability to *identify* objects is the work of Simon, Hespos & Rochat (1995). However, this issue was not the main focus of their work; they were investigating infants' understanding of arithmetic. Simon et al. first familiarized 5-month-old infants to two types of dolls (an "Ernie" and an "Elmo"). Then Simon et al. presented the infants with an addition event, run as follows: First, a doll was placed upon a stage and a small screen was positioned such that it occluded the doll. Next, a second doll was introduced onto the side of the stage and then placed behind the occluding screen. Finally, the screen was removed to reveal one of several outcomes. In the expected outcome, there were two dolls behind the screen corresponding (in identity) to the two dolls placed behind the screen in the addition event. In another two-object outcome, (impossible-identity correct-arithmetic), one of the two dolls had been surreptitiously replaced by a different doll (e.g. an Ernie was substituted for an Elmo). Much to their surprise, Simon et al. found that infants did not look longer at the "impossible-identity correct-arithmetic" outcome than they did at the expected outcome. In short, 5-month-olds seemed to understand that one object plus another object should yield two objects, but they did not appear to expect *specific* objects. Thus, the subjects in Simon et al.'s study did not use perceptual features to *identify* the dolls.

Unfortunately, the Simon et al.'s work suffers some methodological difficulties. For example, the two "different" object types used in their experiments were actually quite similar to one another; both were plastic dolls roughly the same size and shape. Moreover, these dolls were relatively complex objects. Simon et al. showed that, in principle, 5-month-old infants could discriminate these two objects, since a separate group of infants recovered interest to one doll after being habituated to the other. However, the similarity between the objects and the age of the subjects leaves open the possibility that with simpler, more contrastive objects and/or older subjects, identification by feature might occur.

In another study, focusing directly upon infants' identification of objects by feature Hall & Leslie (1995) improved upon the methods used by Xu & Carey and by Simon, Hespos & Rochat. Following Xu & Carey, Hall & Leslie familiarized 12-month-old infants with two different objects that were pulled out from behind and replaced back behind a screen, one at a time. However, the objects used by Hall & Leslie were very simple and differed only in a single feature, either shape or color. In addition, Hall & Leslie always tested infants with displays of two objects, thus avoiding Xu & Carey's baseline problem.

Hall & Leslie's test trials began like their familiarization trials, with two different objects pulled out from and then replaced behind the screen. Next, however, the screen was removed to reveal two objects. Half the infants saw the familiarized pair of objects (Expected Shape and Expected Color conditions). The rest of the infants were shown two objects which were identical to one of the familiarized objects (Drop Shape and Drop Color conditions). Hall and Leslie found that infants in their Drop Shape condition looked longer than infants in the Expected Shape condition. These infants apparently expected the screen to reveal two differently shaped objects, and looked longer when both objects had the same shape. In contrast, they found that infants in the Drop Color condition did not look reliably longer than infants in the Expected Color condition.

The methodology pioneered by Hall & Leslie (1995) will be adopted here to explore the mechanisms which may underlie object individuation and object identification. A first experiment builds upon the work described above which demonstrates that 12-month-olds can individuate and identify objects by feature, in particular by shape (Xu & Carey, 1996; Hall & Leslie, 1995). It explores the possibility that 12-month-old infants individuate objects by color without identifying objects by color. The second experiment examines Xu & Carey's finding that 10-month-olds do not individuate by feature but only individuate by location (Xu & Carey, 1996). Having individuated two objects by location, will 9-month-old infants then identify these objects by feature?

Experiment 1

Experiment 1 investigates whether 12-month-old infants use differences in color to individuate and identify physical objects. This experiment attempts to replicate Hall & Leslie's (1995) two color conditions (*Expected Color* and *Drop Color*), and extends their work by including two novel conditions. As noted above, Hall & Leslie found that infants who were shown two differently colored circles successively withdrawn from and replaced behind a screen looked about the same amount of time at an outcome where two identical circles were revealed as they did at the expected outcome, where two differently colored circles were revealed. This result is consistent with two possibilities; 12-month-olds may fail to individuate and to identify based upon color differences, or they may individuate based upon color, but not identify objects based upon color. Two new conditions are introduced: *Add Color & Object* and *Add Object Only*. These conditions are designed to distinguish between individuation by color and identification by color. In both these conditions, two identical objects are shown (one at a time) during familiarization trials, so that infants can not individuate based upon featural differences; hence, both spatiotemporal and featural information are consistent with there being only one object behind the screen. (Although logically there could be any number of objects behind the screen, it is plausible that infants, like adults, will conservatively assume the minimum number that they have evidence for.) If infants look longer at the same two-object displays under these conditions than they do in the first two conditions, then infants must expect two objects in the Expected Color and Drop Color conditions.

The second possibility described above, that infants can individuate based upon color differences but not identify based upon color, requires some comment; in order to individuate based upon color, one must attend to the colors of objects, and also remember the colors of objects which are not currently in view. However, the fact that infants might use features to set up distinct object representations does not entail that the representations which are created will record what those features are. For example, I could attend to a group of eight objects just long enough to count them, and disregard their features after determining that there were eight. Later, I would definitely expect there to be eight objects, but I might make mistakes about what sorts of features they possess. Similarly, the infant could attend to an object long enough to set up a representation for it, then notice that a second object differs somehow from the first, and set up a second object representation, but later be uncertain about precisely how the two objects differ. The object indexing theory introduced previously can account for this possibility: infants may assign object indexes based upon featural differences but fail to bind the featural information to these indexes.

Method

Subjects

Forty-eight full-term infants participated in the study (26 female and 22 male), age range from 11;16 to 13;1 (mean age 12;7). Equal numbers of infants were tested in each of the four conditions (mean ages 12;8, 12;10, 12;4, and 12;4). 16 additional infants were tested and excluded from the sample due to fussiness (10), experimenter error (2), observer error (2), or parental interference - pointing to stage or talking (2). All infants were recruited by obtaining copies of birth announcements from local newspapers and contacting their parents by mail.

Materials

Two pairs of identical wooden circles, the first pair painted bright red, and the second pair painted bright green were used in all trials. The circles were 10.5 cm in diameter, and .9 cm thick. A small wooden cube (2 cm^3) was glued to the back (the non-painted side) of each circle for stability, so the circles could stand on their "edges". In addition, a white posterboard screen 34 cm x 33 cm, with the front face covered by orange construction paper, was used as an occluder in all trials.

Apparatus

The occlusion events were presented on a three-sided white posterboard mini-stage, 55 cm (tall) by 90 cm (wide) by 45 cm (deep), with a light blue floor. The side walls of the stage were plain white, and the back wall was textured white, decorated with 3 cm wide strips of white poster-card arranged in a lattice pattern. This decoration disguised a 25 cm by 25 cm door centered in the back wall of the stage, through which objects were put in or taken out as necessary.

Caregivers were seated, with infants in their laps, in a generic plastic chair, whose back was 160 cm from the front of the stage. Two black curtains extended from either side of the stage back behind this chair, concealing the rest of the room from the subjects (and caregivers) when they were seated before the stage. A surveillance camera was mounted just above the top of the stage, hidden behind a black window shade, which had a small hole cut out of it to allow the camera lens to focus upon the subjects. A second surveillance camera was mounted upon one of the curtain holders, capturing the events shown to the subjects on stage.

The outputs from the two cameras, plus that from a small backstage microphone, were piped into a video mixer, and then sent to a VCR and to a black and white television monitor. An observer sat facing the monitor, and recorded when the babies were looking at the stage, using two push-buttons which were connected to a 486 computer. The top half of the monitor's image, which showed the events occurring on the stage, was blocked from the observers view with an opaque white cloth taped to the top of the monitor. Thus, the observer was always blind to the condition the subjects were in.

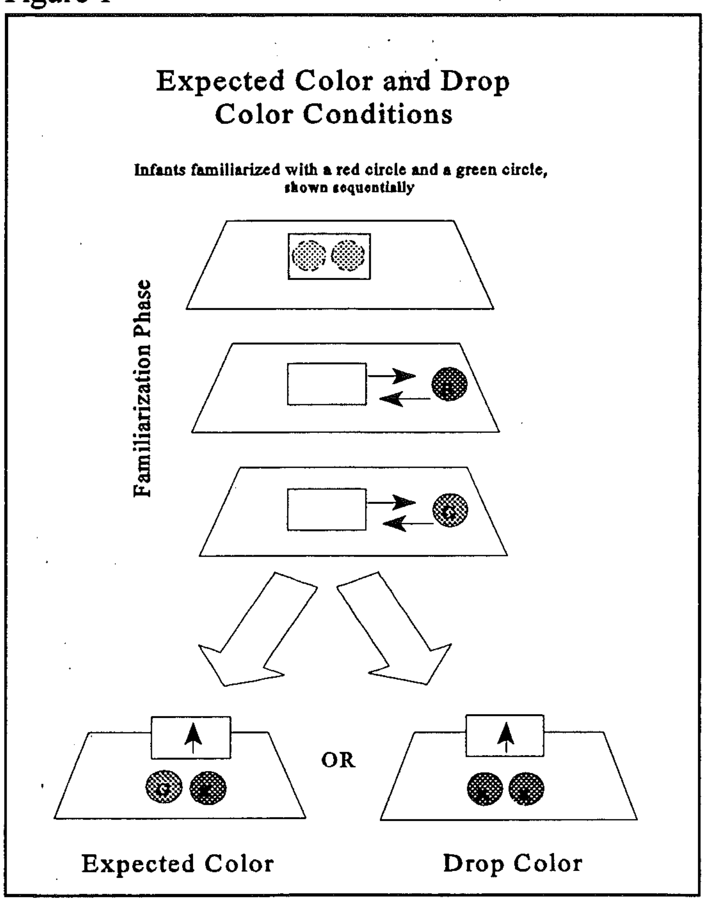
The stage was lit from above and from one side of the baby; otherwise the room was dark. The caregivers were asked to sit quietly during the experiment, and not to attempt to draw the baby's attention either towards or away from the stage. They were forewarned that they would be prompted to close their eyes before the test trials began, and were instructed to keep their eyes closed until the experimenter had completed the session, so they would not influence the baby's response.

Design and Procedure

Fourty-eight infants were randomly assigned to each of the four conditions (twelve per condition): Drop Color, Color Control, Add Color & Object and Add Object Only. (See Fig. 1 for schematic representations of Drop Color and Color Control, and Fig. 2 for schematic representations of Add Color & Object and Add Object Only.)

Introductory phase: After seating the baby and the caregiver, and pulling back the curtians to occlude the rest of the room, the experimenter prompted the observer to turn on the stage lights using one of the push-buttons. All experiments began with the screen centered upon the stage, and two objects hidden behind the screen. The experimenter lowered her hand onto the stage from above, to one side of the screen. (Only the experimenter's hand was visible to the infant, and the experimenter was wearing a pair of off-white elbow-length gloves, with small bells attached to the wrist of the right glove.) Then the experimenter tapped lightly on the stage twice, and called out to the baby "Hi (baby name)." Next, she moved her hand across the front of the stage, and tapped twice on the opposite side of the stage, calling "Can you look here for me?" Finally, she raised her hand to the top center area of the stage, just below the camera, and called out "And look here (baby name)," twisting her hand so that the bells would ring. After withdrawing her hand, she said to the infant. "Good job. OK, let's see what I have for you today," and immediately began the familiarization trials. The introductory phase served two purposes; first, it served to familiarize the infant with the experimenter's gloved hand and the ringing bells; second, it provided a quick calibration check for the observers when the baby was prompted to look towards various parts of the stage.

Figure 1



<u>Familiarization trials: Expected Color and Drop Color conditions</u>: The familiarization trials give the baby an opportunity to look at each of the objects (a red circle and a green circle) which would be used during the test trials. Three identical familiarization trials were presented. The

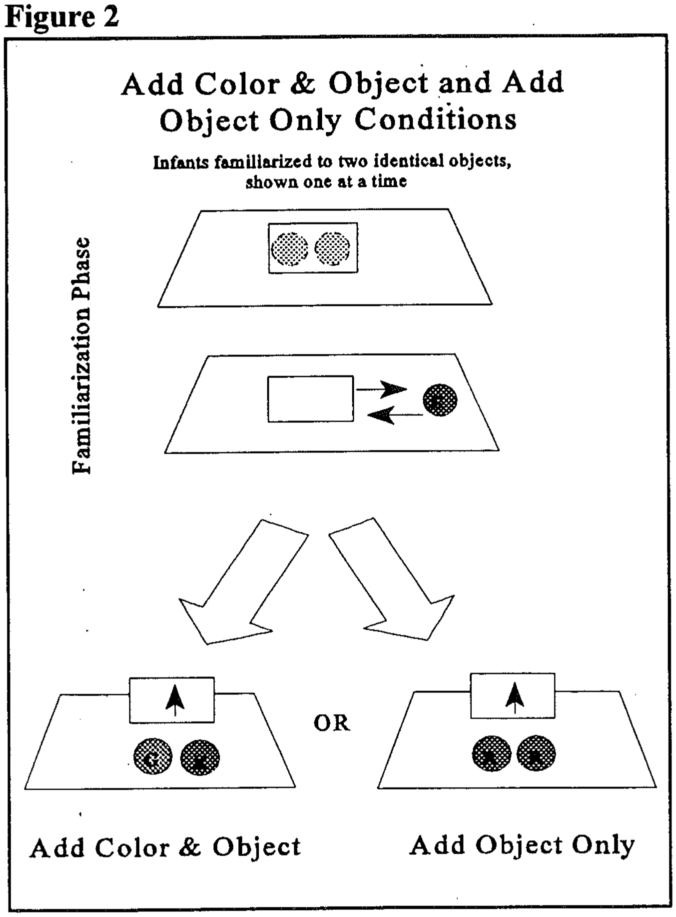
experimenter lowered her hand onto the stage behind the screen, and pulled out an object from behind the screen, placing it on the side of the stage, next to the screen. After approximately one second, the experimenter put the object back behind the screen. (If the infant did not look at the object after it was pulled out from behind the screen, the observer would signal to the experimenter, who would tap her hand, ring the bells on her wrist, or call out the subject's name to make sure the subject saw the object.) After another second, the experimenter pulled the second object out from behind the screen, left it in view for a second, and replaced it behind the screen. Then the entire sequence was repeated. After the fourth in/out sequence, the stage lights were turned off for three seconds, then relit, and the next trial was started. At the end of the third familiarization trial, the experimenter said to the parent "OK, this is the part where I'm going to ask you to close your eyes."

Test trials: Expected Color condition: Five identical test trials followed the familiarization trials. Each test trial began like the familiarization trials, with the two objects sequentially pulled out from and then replaced behind the screen. Unlike the familiarization trials, however, each object was only pulled out and replaced once, and then the experimenter shook her hand to ring the bells, and grasped the top of the screen. As the experimenter began lifting the screen, she called out "Now" to signal to the observer to begin recording the baby's looking time. When the screen was removed, the two objects shown during the familiarization trials were revealed, sitting next to one another at the center of the stage. The trial ended when the baby had looked away for two consecutive seconds, calculated by the computer from the observer's button-presses. When the trial ended, the computer turned off the stage lights, and the experimenter removed the objects, then set up the stage for the next trial. The order of object presentation (red first or green first) and side of stage which objects were pulled out onto (left or right) were counterbalanced across subjects.

Test trials: Drop Color condition: The Drop color condition was identical to the Expected Color condition except that, when the screen was removed, two identical objects (e.g. two red circles) were presented to the subject, sitting next to one another at the center of the stage. This was achieved by using the hidden door in the back wall to exchange one of the objects for another during the test trials. The color of the first object presented (red or green), the side of stage which objects were pulled out onto (left or right), and the color which was "dropped" in the test display (red or green) were counterbalanced across subjects.

Familiarization trials: Add Color & Object and Add Object Only conditions: Once again, there were three identical familiarization trials. These trials were identical to those of the replicated conditions, except that two identical objects (e.g. two red circles) were pulled out from and then replaced behind the screen, one at a time.

Figure 2



Test trials: Add Color & Object condition: Five identical test trials were presented. Each began like a familiarization trial, with each of the two identical objects (e.g. red circles) pulled out from and then returned behind the screen once. Then, as in the two replicated