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Demonstration of Piaget's techniques with the rhesus monkey

Kathryn Lee Wise

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A DEMONSTRATION OF PIAGET'S TECHNIQUES WITH THE RHESUS MONKEY

By

Kathryn L. Wise

B.A., Linfield College, 1968

Presented in partial fulfillment of the requirements for the degree of

Master of Arts

UNIVERSITY OF MONTANA

1973

Approved by:

[Signatures and dates]

Date

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Chapter 1

INTRODUCTION

Intellectual development in the child may be described by a developmental sequence that begins at birth and culminates at about 12 or 13 years of age. Jean Piaget has divided this sequence into the following four stages:

I. Sensorimotor stage (birth to 2 years). Innate reflexes are integrated and differentiated, and acquired behavior patterns appear. Object permanence is developed; space, causality, and time are objectified.

II. Preoperational stage (2 to 7 years). The symbolic function is developed, and language appears. Judgment is based on perception rather than reason.

III. Stage of concrete operations (7 to 12 years). Reasoning appears at a concrete level; the child acquires the logical operations of reversibility, classification, seriation, and numbering.

IV. Stage of formal operations (begins around 12 years). The youth is capable of abstract thinking and conceptualization. Hypotheticodeductive reasoning appears.

The sensorimotor period is especially important to the total developmental sequence because the motor actions of this stage are the source of later complex mental operations that will emerge as the child develops.
According to Piaget (1952), all intellectual development comes from complex integration and differentiation of innate reflexes, resulting from their interactions with the environment. In the sensorimotor stage such integration and differentiation are essential for the gradual progression that occurs as the reflex activity of the newborn infant becomes the 2-year-old child's invention of new means in goal situations through the representation and reorganization of past actions.

Piaget (1954) presented evidence that suggests that as the child progresses through the sensorimotor period, he gradually constructs the concept of the permanent object. Object permanence is the concept that objects continue to exist when they are no longer perceived, and furthermore, that they are external entities completely independent of the activities of the self. The concepts of space, time, and causality are elaborated for the child in terms of external, permanent objects. Space is conceived of in terms of movements of objects, time is understood through sequences of displacements of objects, and causality has meaning only in terms of the relations between objects. The concepts of space, time, and causality are in turn basic to the most sophisticated abstract reasoning. Thus, the concept of objects as constant entities that do not depend on the activities of the self is a major stepping stone in the development of later complex cognitive processes.

Piaget (1954) attempted to measure object permanence in the child. He observed his three children's behaviors in relation to objects from their time of birth until they were approximately 2 years of age. He also carried out informal experiments with the children, which predominantly involved hiding objects through various manipulations. By
observing the kinds of behaviors the children evidenced in relation to objects that were made to disappear in different ways, Piaget came to the conclusion that object permanence develops gradually in the child and progresses through a series of stages during the first 2 years of life. The developmental sequence of object permanence begins with the newborn infant's picture of the world as consisting of objects that suddenly exist when they are perceived and then cease to exist when they are no longer perceived and ends with the 2-year-old child's conception of objects as permanent, external entities.

Piaget's (1954) results led him to hypothesize and describe a sequence in the development of object permanence that consists of the following six stages:

**Stages One and Two (birth to 3-6 months).** In these first two stages there is no object permanence but only recognition of the object. Piaget emphasized that the recognition or discrimination of objects in these first two stages does not necessarily imply object permanence. He based this inference on his observations of the very young infant who appeared capable of discriminating the nipple from other sucking substitutes yet did not show behaviors that suggested an underlying conception of object permanence. Piaget postulated that an object may be recognized when it is perceived yet still have no conceptual permanence for the perceiver after it disappears.

Intercoordination of heterogeneous schemas was another kind of behavior that Piaget observed in these two early stages. For example, he observed the infant trying to grasp what it saw and trying to see what it grasped. He felt that such intercoordination of two or more
heterogeneous schemas is related to object permanence in that it inv-
volves the expectation or anticipation of assimilating objects to a
schema. Piaget pointed out that these kind of anticipations do not
necessarily presuppose object permanence because in this situation the
object is not conceived of as external to the child's actions.

Piaget suggested that extensions of acts of accomodation also play
a part in the development of object permanence during these first two
stages. An example of this kind of behavior was the child's continued
looking at the place where an object disappeared. He believed, however,
that this behavior and others like it do not indicate object permanence
because they do not involve true search for the disappearing object.

Stage Three (3-6 months to 9-10 months). This stage begins with the
coordination of sight and prehension and ends with active search for the
vanished object. Piaget observed the following five object-related be-
behavior patterns emerging in this stage:

1. Visual accommodation to rapid movement. This behavior pattern
is seen when the trajectory of a moving object is anticipated by the child.

2. Acts of interrupted prehension. This behavior pattern consists
of the child's grasping an object without visual assitance after losing
contact with it, but the child grasps it in different ways and places than
those in which it was held initially.

3. The deferred circular reaction. The child is involved in a cir-
cular reaction such as shaking a rattle over and over again. After an
interruption of this pattern, he goes back to the same circular reaction
with seemingly no external influence.
4. **Reconstruction of an invisible whole from a visible fraction.**

In Stage Three the child will not uncover a desired object entirely hidden by a screen; he will remove the screen, however, if certain parts of the desired object are visible.

5. **Removal of obstacles preventing perception.** The child will remove a screen blocking his view of an object only if the screen is closer to him than it is to the object.

Piaget referred to all of these behaviors as prolongations of accommodation movements in relation to objects. In each behavior pattern the child appears to be prolonging his actions upon the object after the object has perceptually disappeared. Piaget pointed out that in these behaviors the child acts as if he attributes permanence to objects to the extent that he appears to believe that his actions upon objects are permanent. Since, in his observations, the Stage Three child did not exhibit search behaviors for totally hidden objects, Piaget summarized Stage Three as the stage in which the object has only subjective permanence for the child.

**Stage Four (9-10 months to 12-18 months).** Stage Four is characterized by the child's active search for an object but his inability to follow visible displacements of the object. It begins when the child actively searches for a completely hidden object. However, Piaget did observe a transitional reaction between Stages Three and Four, in which a completely hidden object would be searched for only if it was covered after the child had begun reaching for it.

At the first of Stage Four, Piaget noted a behavior pattern in his children which he referred to as the "typical" reaction. In the "typical"
reaction an object is hidden behind screen A; the child lifts this
screen and takes possession of the object. The object is then hidden
behind screen B, but the child returns to screen A and searches there.

Later in Stage Four, Piaget observed the "residual" reaction. In
this reaction an object is hidden behind screen A, and the child finds
it. The object is then hidden behind screen B, and the child goes to
this screen and lifts it. However, if for some reason the object can
not be seen by the child under screen B, he will return immediately to
screen A and look there. Another type of "residual" reaction also ap­
peared towards the end of Stage Four. In this reaction the object is
hidden in A, and the child looks and finds it. It is then hidden in B,
and the child searches correctly. But if it is now hidden in C, the
child will search under screen A or B.

Stage Five (12 to 18 months). When the child can account for
visible sequential displacements of the object, Stage Five begins. The
child can now search for the object at the point of its last visible
displacement.

Piaget observed that at the beginning of Stage Five, the child
could not follow an invisible displacement of the object. In his ex­
periments with his children, a visible displacement took the form of
completely covering a visible object with a screen. An invisible dis­
placement was always carried out by hiding an object in some type of con­
tainer and then covering the container with a screen. The object was
left under the screen, and the empty container was removed and shown to
the child. Towards the end of Stage Five, after a certain number of
trials involving invisible displacement procedures, Piaget observed that
the child began to look for the object correctly if only one invisible
displacement was involved. The child was still incapable of following
sequential invisible displacements. When the child was confronted with
sequential invisible displacements, he again demonstrated the errors of
the "typical" and "residual" reactions.

**Stage Six (16 months to 20-24 months).** Stage Six begins when se­
quential invisible displacements can be followed with no "typical" or
"residual" reactions. The child can also systematically find an object
after it has been through a series of successive invisible displacements
within the same trial. Objects hidden under a series of superimposed
screens are also found by the child during Stage Six. Piaget suggested
that for the child to solve problems such as these, he must represent the
hidden object and direct his procedures according to this representation.
According to Piaget, object permanence is complete in the sixth stage in
that the child's behaviors indicate that the object and its displacements
are conceived of by him as independent of his actions and his perceptions.

In the last 10 years several studies modeled after Piaget's (1954)
work on object permanence have been carried out under more stringent ex­
ergimental conditions, with larger number of subjects, and occasionally
with the purpose of investigating the effects of other variables on the
development of object permanence.

Gouin Decarie (1965) administered an object scale consisting of five
tests that were similar to those used by Piaget to 90 subjects ranging
in age from 3 to 20 months. A subject was classified as having already
attained a certain stage level if he was capable of performing on a test
item at the developmental level described by Piaget as characteristic of
that stage. The results supported Piaget's description of the developmental sequence of behaviors related to object permanence. Not one of the 90 subjects passed a stage that was considered more advanced than one that he had failed.

Another cross-sectional study, similar to Gouin Decarie's (1965) investigation on object permanence, was done by Miller, Cohen, and Hill (1970) using a sample of 84 infants. Their results supported Piaget's description of the sequence of development of object permanence in that they found younger infants (10-12 months) could follow visible displacements of objects while they could not follow invisible displacements, and older infants (14-18 months) could follow both types of displacements. In addition, Miller et al. found that infants (10-18 months) performed better on tests where the object was hidden under only one screen than on comparable tests that involved moving the object under several screens within one trial (successive movement problems). They also found that infants 10 months and older performed better on successive movement problems than infants less than 8 months of age. These results led the authors to hypothesize that children's performance on successive movement problems also progresses through a specific sequence of development.

The authors suggested that invisible displacement problems and successive movement problems are more difficult for younger subjects because in these problems the object is out of sight for a long period of time. They hypothesized that the older infant's more developed memory system may be responsible for his better performance on these tests. They also suggested that in successive movement problems the older infant's greater
ability to switch his attention from the object's first hiding place may account for his more efficient solutions to these problems.

Golden and Birns (1968) investigated the effect of social class on the development of object permanence. Their results based on a sample of 192 Negro children from three different age levels and three different socio-economic status (SES) levels showed no differences in performance on object permanence tests among the three SES groups at any of the age levels.

Corman and Escalona (1968) investigated object permanence in both a cross-sectional and a longitudinal study. They administered an object permanence scale to 113 subjects and found that the tasks in their scale were scalable or had a high degree of ordinality. Thus, their data confirmed Piaget's description of the sequence of development involved in object permanence. In the longitudinal study all 15 subjects progressed in accordance with the anticipated sequence.

Corman and Escalona (1969) suggested that environment may not be an important variable in the appearance of the sequence of stages of object permanence. They based this conclusion on Golden and Birns' (1968) results and on their finding that all their subjects, although predominately from working class and lower middle class families, appeared to be progressing in the development of the object concept in the expected sequence. The authors hypothesized, however, that environment will play a more important part in the degree to which the infant generalizes stage-appropriate behaviors to problem solving situations.

Tessier (1970) administered an object permanence test to normal and cerebral palsied children. Both groups of subjects showed the sequence of
stage level development hypothesized by Piaget. Although quantitative results of the test showed that cerebral palsied children progressed through the various stages of the same rate as normals, qualitative differences in performance were found for the two groups. This finding may be related to Corman and Escalona's suggestion that there may be considerable variability in the degree to which individuals apply stage-specific behaviors even though these individuals all progress according to the same developmental sequence.

White (1969) found that normal, institutionalized infants reared under conditions designed to increase sensorimotor development showed accelerated coordination of heterogeneous schemas as compared with a control group. From these data one might predict that the development of object permanence also might be accelerated in the experimental group, given Piaget's (1954) hypothesis that coordination of heterogeneous schemas is an essential factor leading to the development of the object concept.

Landers (1969) investigated the effect of specific experience involving finding an object at A on the "typical" reaction described by Piaget. His results supported Piaget's description of the "typical" reaction and showed that infants given a high amount of experience of finding an object at A made significantly more errors when attempting to find an object at B than infants given a high amount of experience of only watching an object hidden at A or than infants given a low amount of experience concerned with hiding objects at A.

Bower (1967, 1971) recently published results that appear at first to be discrepant with Piaget's description of the development of object
permanence. Piaget (1954) found that before reaching the fourth stage of the object concept which began at approximately 9 or 10 months of age, the child reacted to an object that was completely covered by a screen as if it had vanished. Bower (1967) using operant techniques demonstrated that 49- to 55-day-old infants responded as if they conceived of an object that served as a conditioned stimulus as still existing after a screen was dragged over the object at a speed of 5 centimeters per second. Bower (1970) also reported that infants as young as 20 days of age showed surprise, measured in terms of heart rate change, if an object did not reappear when a screen that had moved across it and occluded it for a period up to 3 seconds moved away.

In his work on object permanence, Piaget did not include such variables as the rate of disappearance or the duration of disappearance of the object. Bower (1967) studied the effects of these variables on existence constancy behavior in infants from 12 to 50 weeks of age. In his experiment a screen moved in to cover an object by traveling across the object at various speeds between 25 and 150 centimeters per second. In one other condition, through an optical illusion, the entire object appeared to suddenly disappear. The author described this condition as representing an infinitely fast disappearance of the object and wrote that the object "'imploded' from view." The object reappeared after various occlusion intervals ranging from 5 to 540 seconds.

In the 12-week-old infants existence constancy behavior was inferred from characteristic patterns in non-nutritive sucking. Duration of search for the object after it had disappeared and latency of reaching for the
object after it reappeared were used as measures of existence constancy behavior in the older infants.

Bower found that as the age of the subject increased, he reacted with constancy behaviors to a faster rate of disappearance of the object and to longer durations of disappearance of the object. Only the 50-week-old infants showed existence constancy behaviors in the infinitely fast disappearance situation.

From these results Bower concluded that there are two types of existence constancy. Perceptual constancy is a prediction about an event and is a statement made by the perceptual structures that objects continue to exist if they disappear in certain ways. Conceptual constancy is a prediction about an object and is a statement that can overrule perceptual information. This statement carries the information that objects having certain properties are permanent objects.

Bower (1967) suggested that perceptual constancy appears very early in infants. He hypothesized that a gradual covering of an object with a screen gives perceptual existence constancy in very young infants and in adults while a sudden disappearance of an entire object never gives perceptual constancy regardless of the age of the subject.

Bower (1967) concluded that the younger infants did not react with perceptual constancy to the more rapid coverings of the object with the screen because the resolving power of their visual systems did not lead to differentiation between these instances and the situation involving the optical illusion of implosion. He explained that the younger infants did not react with constancy behaviors to long occlusions of the object.
because they do not extend the trace of perceptual constancy for long periods of time.

Bower believed that only the 50-week-old infants appeared to have conceptual existence constancy as they were the only subjects who reacted to the infinitely fast disappearance of the object with constancy behaviors.

Bower suggested that conceptual constancy is developed much later than perceptual constancy and is developed piecemeal as the infant experiences the reappearance of objects that disappeared fast enough or long enough for his immature perceptual system to label them annihilated.

Piaget (1954) did not intentionally cover his objects gradually with a screen and probably more often used hiding techniques where the entire object was covered suddenly. If Piaget was, in fact, measuring conceptual existence constancy instead of perceptual constancy, then he and Bower are in agreement that the appearance of this type of constancy to a completely covered object occurs in the infant at 50 weeks or about 9 or 10 months of age.

Most of the studies cited above have given overwhelming support to Piaget's description of the developmental sequence of object permanence in the child. Many of these studies have included considerations of the effects of other variables such as attention, memory, perceptual processes, environmental background and specific experiences, on the rate of development of object permanence or on the degree to which the object concept will affect problem solving behaviors. Information on variables relevant to object concept development becomes important as one considers
the key position that the concept of the permanent object holds in the child's total cognitive development.

One study has recently been done on the development of the object concept in the cat. Gruber, Girstus, and Banuazizi (1971) developed eight behavioral tasks suitable for cats, similar to those used by Piaget when he investigated object permanence in the child. Gruber et al. used these tasks in a cross-sectional and a longitudinal study investigating object permanence in alley cats. The results of their study suggested that there are four stages in the developmental sequence of object permanence in the cat and that the sequence is similar to the one described by Piaget (1954) for the child. The sequence appears to be completed between 16 and 24 weeks and culminates with the kittens engaging in true search for an object after it has undergone one visible displacement. Thus, in the kitten the developmental sequence involved in object permanence is completed in a shorter period of time than for the child, but the kitten's object-related behaviors never reach the level of complexity that they attain in the child. Another general finding from this study was that house-reared kittens progressed more rapidly than cage-reared kittens in the development of object permanence.

Some data have been collected on object-related behaviors in the rhesus monkey, the Japanese monkey, and the squirrel monkey. Research reported by Zimmermann and Torrey (1965), Zimmermann and Hochberg (1971), and Fantz (1965) with rhesus monkeys shows that, like the child, the rhesus monkey is capable of recognizing and discriminating different stimuli and objects at a very young age.
Zimmermann and Torrey (1965) reported that rhesus monkeys can learn to discriminate between two-dimensional stimuli when they are very young. In this study a discrimination problem involving stimuli that differed in color, form, and size was learned to criterion by 5-, 10-, 20-, and 30-day-old animals in 4.75, 5.00, 2.00, and 1.75 days respectively with 25 trials per day.

Zimmermann and Hochberg (1971) demonstrated that four 20-day-old infant rhesus monkeys could learn difficult object discrimination problems to criterion in an average of 11.25 days.

Fantz (1965) discussed a study carried out with rhesus monkeys who were visually deprived from birth for various periods of time ranging from 4 to 16 weeks before being given unrestricted visual experience. Tests for recognition of the feeding bottle were given on the first day of visual experience and periodically thereafter. Three monkeys visually deprived for the first 3, 9, and 14 days of life showed recognition of the bottle after 11, 26, and 19 days of visual experience, respectively. Thus, even with deprivation experience in their history, these subjects were showing recognition of an object at 14, 35, and 33 days of age.

Harlow, Harlow, Rueping, and Mason (1960) found that although 60-day-old rhesus monkeys could learn to solve an object discrimination problem involving one stimulus pair in the Wisconsin General Test Apparatus (WGTA), the number of errors made before criterion decreased as a function of age in 60- to 150-day-old monkeys. However, there was no difference in number of errors before criterion between 150- and 360-day-old monkeys. These data suggest that the rhesus monkey's ability to discriminate between objects may reach a maximum around 150 days of age.
Harlow et al. (1960) found that 90-, 120-, and 150-day-old rhesus monkeys learned a zero-second delay problem in the WGTA at similar rates and showed more rapid learning of the problem than 60-day-old subjects. Adult rhesus monkeys, however, attained a high level performance on the problem more rapidly than any of the infants. These results suggest that there may be some type of developmental break in the rhesus' ability to learn such a problem between the ages of 60 and 90 days.

Tsumori (1967) demonstrated in an experimental field study that a substantial percentage of three troops of Japanese monkeys evidenced successful search behavior on the first trial for a peanut that they had observed being buried in the sand.

Vaughter, Smotherman and Ordy (1972) found that three infant squirrel monkeys at 6, 9, and 12 months of age showed differential performances on object permanence tasks carried out in a modified WGTA. All the subjects failed to perform (retrieve the food) on an initial set of trials involving invisible displacements that consisted of baiting and completely covering a foodwell while the tray was outside the subject's view. However, if the baited foodwell was only partially covered, all subjects performed on trials involving invisible displacement procedures. On a subsequent set of trials, the foodwell was baited and covered in view of the subject. On these visible displacement trials the 6-month-old subject failed to perform. The 12-month-old subject performed on all these trials, and the 9-month-old subject showed progressive improvement over blocks of trials, performing on 20% of the trials on the first block and 80% on the final block. After experience with visible displacement procedures, invisible displacements were again presented to each subject. Again, the
6-month-old subject failed to perform while the 9- and 12-month-old subjects performed on 95% and 100% of the trials respectively. Performing on the less complex visible displacement task appeared to facilitate subsequent performance on the more complex invisible displacement problem in the two oldest subjects.

The subjects in the visual deprivation study mentioned earlier and described by Fantz (1965) were given visual preference tests as well as recognition tests during the unrestricted visual period. The results of these tests showed that all animals deprived for 8 weeks or less fixated patterned stimuli two or three times as much as plain surfaces at the beginning of the unrestricted visual period. This preference, however, did not show a significant increase as more time was spent in the lighted environment. At the beginning of unrestricted experience, these same monkeys showed little preference for three-dimensional objects as compared to flat surfaces. However, differential fixation of solid objects increased as a function of time spent in a lighted environment, and solid objects were fixated 65% of the time at the end of 16 weeks of visual experience. From these data Fantz (1965) postulated that infant rhesus monkeys are innately predisposed to attend selectively to patterned stimuli, and that with visual experience they develop a preference for the type of patterns that accompany objects.

Fantz's prediction that rhesus monkeys visually attend selectively to objects would in turn suggest a large amount of motor interaction with objects as vision and prehension are coordinated. One would expect learning about object qualities including the characteristic of permanence
to be facilitated in organisms that develop a preference for interactions with objects.

In a pilot study object permanence was investigated in a female infant rhesus macaque when she was between 5 and 6 months of age. Experiments used on the subject were designed to be similar to the ones used by Piaget when studying the development of object permanence in his children. The following behaviors, corresponding to behaviors described by Piaget in the child's development of object permanence, were shown by the infant rhesus: (a) accommodation to rapid movement, (b) following one visible displacement of an object, (c) following sequential visible displacements of an object, (d) following one invisible displacement of an object, and (e) following a displacement of the object under two superimposed screens. In this study, however, no reliable data were collected concerning the age of appearance of these behaviors.

On the basis of the above results and those of the studies cited, it was hypothesized that:

I. The appearance of specific stable behaviors related to object permanence can be dated in a longitudinal study of infant rhesus monkeys in which the procedures used are modeled after those described by Piaget (1954), but modified in such a way as to be appropriate to the behavioral and structural characteristics of these subjects.

II. Behaviors related to object permanence will appear in the rhesus monkey in some type of developmental sequence.
Chapter 2

GENERAL METHOD

Subjects

Two male rhesus monkeys (Macaca mulatta), Number 37 and Number 38, served as Ss. Number 37 was removed from his mother at 5 days of age, and Number 38 was removed from his mother at 6 days of age. The weights for both Numbers 37 and 38 were recorded directly after they were removed from their mothers and were found to be 480 and 446 grams, respectively.

Ss were housed individually in expanded metal cages that were 60.96 cm. long, 46.99 cm. wide, and 48.26 cm. high. The Ss' cages were stacked and kept in a testing room that contained no other animals.

Initially, both Ss' cages were supplied with heating pads, diapers, surrogates, and toys. The heating pads were removed when the Ss reached 14 days of age, and the diapers were removed when the Ss reached 30 days of age. The Ss' toys were rotated throughout the experiment; a different set of four toys was placed biweekly in each S's cage.

Both Ss were fed at least six times daily until they were 10 days old and five times daily for the following 5 days. At 15 days of age, they were put on a schedule of four feedings per day, and this schedule was continued until gradual weaning procedures were introduced when the Ss reached 90 days of age. At each feeding Ss were offered 60 ml. of Prosobee (Mead Johnson Laboratories; Evansville, Indiana), a commercial infant formula.
Beginning at 30 days of age and continuing until WGTA testing was begun, both Ss were given arrays of four pieces of different solid foods daily. Purina Monkey Chow and bread covered with honey were kept in the Ss' cages from the time the Ss were 50 days of age until the end of the experiment. Each S was periodically hand fed these various solid foods.

Design

Three types of tests, informal tests, Object Apparatus tests, and WGTA tests were used to investigate the development of object permanence in the Ss. In the informal tests object permanence was investigated in a play situation that involved a great deal of interaction between the E and the S. The Object Apparatus tests and the WGTA tests took place in formal settings allowing for more controlled experimental conditions. The Object Apparatus tests and informal tests were applicable to the Ss when they were as young as 10 days of age while WGTA testing involving solid food objects was not possible until the Ss were 50 days of age. Thus, the development of object permanence was investigated in each S in three different experimental settings through tests designed to be appropriate to the structural and behavioral characteristics of infant rhesus monkeys.

Informal Tests

Apparatus

The apparatus consisted of a vinyl chair with a seat measuring 35.56 cm. square and positioned 50.80 cm. above the floor; an assortment of screens, made of light weight flexible materials; containers; and small
test objects, including the feeding bottle and pieces of fruit. Food objects were not used as test objects until the Ss reached 80 days of age but were used exclusively after that time. Test objects were selected so as to maximize the amount the Ss visually oriented towards the object at the beginning of a trial. Although high initially, visual orientation towards the toy objects by the Ss began to attenuate in the testing situation when the Ss were approximately 75 days of age. The introduction of food objects renewed the amount the Ss visually oriented towards the test object, and the Ss continued to orient towards the food objects throughout the experiment. The surrogate mother was occasionally removed from S's cage and used as a testing object. The surrogate consisted of a wire ramp mounted at approximately a 30 degree angle on a base 26.67 cm. long, 15.24 cm. wide, and 27.30 cm. high. The base was mounted on four small metal coasters. This ramp led to a bottle holder that had a hole for a nipple at its base. The entire ramp was covered with a soft, shaggy material. The bottle holder was always empty when the surrogate served as a test object in the informal tests.

Procedure

Trials on all of the informal test items involved E's presenting S with an object or objects, one of which was considered to be the test object, and performing some manipulation with the objects. S's behavior was observed for a specified time, and each trial was evaluated according to two mutually exclusive and exhaustive categories as either a plus trial or a minus trial. If S received a plus or passed a trial, all the apparatus were removed except the test object, and S was allowed an additional...
30 seconds to interact with the test object. However, if S received a minus or failed a trial, all the apparatus, including the test object, were removed at the end of the trial. On some items trials were discontinued if E could not induce S to orient visually towards the test object, before the manipulation was carried out, in a specified period of time, while on other items trials were discontinued if E observed that S had not been visually oriented toward the apparatus during the entire manipulation. On discontinued trials all of the apparatus was removed immediately. During one session of any item, E continued giving trials until 5 trials had been completed or 10 trials had been begun. The informal tests were carried out in the S's home room. However, the cages were wheeled out of the room during testing.

The items were as follows:

1. **Informal recognition.** E began each trial by placing two objects approximately equidistant from and in front of S. One of these objects, the test object, was always S's surrogate, and the other object was unfamiliar to S. E attempted to induce S to orient visually toward the objects and discontinued the trial if S did not visually orient towards the objects within 30 seconds. Each trial lasted 30 seconds after S had once visually oriented towards the objects or until he touched one of the objects. The position of the surrogate over trials was determined by the use of a Gellerman sequence. Each trial was evaluated according to the following two categories: (a) plus--S touched the surrogate; and (b) minus --S did not touch the surrogate.

2. **Informal assimilation of vision to prehension.** E began each trial when S's hands were outside of S's visual field by holding a test
object slightly above and in front of S's eyes. E attempted to induce S to orient visually towards the object and discontinued the trial if S did not visually orient towards the object within 30 seconds. Each trial lasted 30 seconds after S began to orient visually towards the object or until he grasped the object (took hold of some part of it with his hand) while visually oriented towards it or until he stopped visually orienting towards the object. Each trial was evaluated according to the following two categories: (a) plus--S grasped the object while visually oriented towards it; and (b) minus--S did not grasp the object while visually oriented towards it.

3. Informal assimilation of prehension to vision. E began each trial by placing a test object in S's hand (wrapping his fingers around the object) when the hand was outside of S's visual field. A trial was discontinued unless S grasped the object briefly. A trial lasted 30 seconds after S grasped the object or until he visually oriented towards the object while he grasped it or until he dropped the object. Each trial was evaluated according to the following two categories: (a) plus--S visually oriented towards the object while he grasped it; and (b) minus--S did not visually orient towards the object while he grasped it.

4. Informal accommodation to rapid movement. E began each trial by holding a test object in her right hand above and in front of S's eyes when S was situated on a chair. E attempted to induce S to orient visually towards the object, and discontinued the trial if S did not orient towards the object within 30 seconds. E dropped the object to the floor as soon as S appeared to be orienting towards it, leaving her right hand in the same position for 3 seconds after the object was dropped. On this item S was
allowed the 30 second interaction period only on plus trials where he bodily followed the object to the floor. Each trial was evaluated according to the following two categories: (a) plus—S looked to the floor within 3 seconds after the object was dropped; and (b) minus—S made any other visual response.

5. Informal reconstruction of an invisible whole from a visible fraction. E began each trial by setting one screen and a test object before S. While attempting to induce S to orient visually towards the object, E picked up the screen and covered one-half of the object with it. S was restrained, if necessary, to prevent him from reaching for the object while it was being partially covered. A trial was discontinued if S did not orient visually towards the partial covering manipulation. Each trial lasted 30 seconds from the partial covering of the object or until S manipulated the object. Each trial was evaluated according to the following two categories: (a) plus—S manipulated the object; and (b) minus—S did not manipulate the object.

6. Informal visible displacement with reaching. E began each trial by setting one screen and a test object before S. E attempted to induce S to reach for the object and discontinued the trial if S did not reach for the object within 30 seconds. Just as S was reaching for the object, E completely covered it with the screen. Each trial lasted 30 seconds from the covering of the object or until S uncovered some of the object. Each trial was evaluated according to the following two categories: (a) plus—S uncovered some of the object; and (b) minus—S uncovered none of the object.
Trials of informal test Items 7 through 13 involved a manipulation of the test object resulting in the object's being completely hidden from $S$. On all of these trials, $E$ carried out the appropriate manipulation while attempting to induce $S$ to orient visually towards the apparatus during the manipulation; she discontinued a trial if $S$ did not appear to orient towards the apparatus during the entire manipulation. While performing the procedures described in Items 7 through 13, $E$ restrained $S$, if necessary, to prevent him from interfering with the manipulation or reaching for the object while it was being hidden. All trials on these items lasted 30 seconds from the completion of the manipulation or until $S$ uncovered some of the test object or, on items involving more than one screen, until $S$ moved an incorrect screen. All trials of Items 7 through 13 were evaluated according to the following two categories: (a) plus—$S$ uncovered some of the object; and (b) minus—$S$ uncovered none of the object.

7. Informal visible displacement. $E$ began each trial by placing one screen and a test object before $S$. $E$ picked up the screen and completely covered the object with it.

Before each scheduled presentation of Item 8, one session of 5 completed or 10 initiated preliminary trials was given. Item 8 was presented after these preliminary trials only if $S$ received a plus on three or more preliminary trials. The procedure of the preliminary trials was identical to the procedure described for trials of Item 7 with the stipulation that on all trials of one session, the same test object and screen were used in the same positions.
8. Informal sequential visible displacement. E began each trial by placing the screen used just previously in the preliminary session in the same position that it occupied during trials of that session. E added two additional screens, one on either side and approximately equidistant from the first screen. These additional screens were designated as the right screen and left screen for an entire session on the first trial of that session with reference to S. E moved the test object used in the preliminary session directly in front of one of the new screens, picked up that screen, and completely covered the object with it. The same screens were used in the same positions on all trials of one session. Over trials the object was hidden under either the left or right screen according to a Gellerman sequence.

9. Informal successive visible displacement. E began each trial by placing three screens in a row before S. The screens were designated as the right screen (R), middle screen (M), and left screen (L) for an entire session on the first trial of that session with reference to S. E picked up the test object in one hand in such a way that it remained visible to S and moved the object under and out from two of the screens. E moved the object under the third screen, left it under this screen, and removed her hand in an open position. The order of movement of the object under the screens was determined by using a repetition of the following six sequences: (a) L, R, M; (b) R, M, L; (c) M, L, R; (d) R, L, M; (e) M, R, L; and (f) L, M, R. On all trials of one session, the same test object and screens were used; the screens were placed in the same positions on each trial of a session.
10. **Informal invisible displacement.** E began each trial by placing one screen before S. E held up a test object and a container in front of S and placed the object into the container so that it was completely concealed from S. E moved the container under the screen and when it was covered by the screen, turned it until the object was left on the floor beneath the screen. E brought out the empty container in an upright position, tipped it, and showed it to S.

Before each scheduled presentation of Item 11, one session of 5 completed or 10 initiated preliminary trials was given. Item 11 was presented after these preliminary trials only if S received a plus on three or more preliminary trials. The procedure of the preliminary trials was identical to the procedure described for trials of Item 10 with the stipulation that on all trials of one session the same test object, container, and screen were used; the screen was placed in the same position at the beginning of each trial of a session.

11. **Informal sequential invisible displacement.** E began each trial by placing the screen used just previously in the preliminary session in the same position that it occupied in the trials of that session. E added two additional screens one on either side of and approximately equi-distant from the first screen. These additional screens were designated as the right screen and left screen for an entire session of the first trial of that session with reference to S. E held up the same test object and container used in the preliminary session and placed the object into the container so that it was completely concealed from S. E moved the container under one of the new screens and when it was covered by the screen,
turned it until the object was left on the floor beneath the screen. 
E brought out the empty container in an upright position, tipped it, and showed it to S. The same screens were used in the same positions on all trials of one session. The object was hidden under either the left or right screen according to a Gellerman sequence.

12. **Informal successive invisible displacement.** E began each trial by placing three screens in a row before S. The screens were designated as the right screen (R), middle screen (M), and left screen (L) for an entire session on the first trial of that session with reference to S. E held up a test object and a container in front of S, placed the object into the container so that it was completely concealed from S, and moved the container under and out from two of the screens. E moved the container under the third screen and when it was covered by this screen, turned it until the object was left on the floor beneath the screen. E brought out the empty container in an upright position, tipped it, and showed it to S. The order of movement of the object under the screens was determined by using a repetition of the following six sequences: (a) L, R, M; (b) R, M, L; (c) M, L, R; (d) R, L, M; (e) M, R, L; and (f) L, M, R. On all trials of one session, the same test object, container, and screens were used; the screens were placed in the same positions on each trial of a session.

13. **Informal superimposed screens.** E began each trial by placing three screens and a test object before S. E picked up one screen and completely covered the object with it. E picked up the second screen and dropped it over the first one, completely covering it. Similarly, E covered the second screen with the third one.
Experimentation with informal test items began when the Ss were 10 days of age. Item 1 was introduced to each S on the first day of experimentation, and new items were introduced at 3 day intervals in the following order: (a) Items 2 and 3, (b) Item 4, (c) Item 10, (d) Item 7, (e) Item 6, and (f) Item 5.

When an S passed three or more trials during a session of Item 7, Item 8 was introduced immediately afterward, while Item 13 was introduced on the following day. Item 9 was introduced to each S on the day after he passed three or more trials during a session of Item 8. Item 11 was introduced to each S immediately following a session of Item 10 in which he had passed three or more trials, and Item 12 was introduced to each S on the day following an Item 11 session in which he had passed three or more trials.

If during a session of an item none of the trials were passed by an S, one session of that item was presented to him 1 week later. However, if during the session one or more trials were passed, a session of the item was presented to him on the following day.

Criterion was reached on an item when an S passed 8 out of 10 trials (disregarding discontinued trials) on the item. Items were discontinued as an S met criterion on them.

Object Apparatus (OA) Tests

Apparatus

An apparatus 127.00 cm. long, 98.42 cm. wide, and 36.83 cm. high that will be referred to as the Object Apparatus (OA) was designed for use in these tests (see Figure 1). Functionally, there were three parts to the
FIG. 1. Object Apparatus.
OA; a start box, centrally located; a choice chamber, adjacent to the start box; and a goal area, divided into a right and a left goal chamber. The start box, the choice chamber, and the goal area were individually covered with plexiglas lids. S was restrained in the start box, 24.50 cm. square, by a clear plexiglas guillotine door. When this door opened, S could enter the choice chamber, an open area separating the start box and the goal areas by a 31.75 cm. span. Each goal chamber was 62.86 cm. long and 45.72 cm. wide and was constructed in the shape of an inverted U with the inside arm of the U being open forming a 24.13 cm. wide entryway to the goal chamber. The opening to the outside arm of the U was permanently blocked by an opaque wall. After S entered the inside arm of the U, he ran beside an opaque wall 27.94 cm. long, shielding his view of the front of the outside arm of the U. This shielded part of the outside arm of the U was referred to as the hiding compartment, and it was 20.32 cm. wide. When S reached the end of the wall blocking his view of the hiding compartment, he could make a 180 degree turn and enter the hiding compartment. The left and right goal chambers were completely separated by an opaque wall and were mirror images of one another.

Two opaque guillotine doors, one that blocked the entryway to both goal chambers and the other that blocked the entryway to only one goal chamber, could be inserted between the choice chamber and the goal chambers. When the entryway of a goal chamber was open, S, restrained in the start box, could see the entire inside arm of the U. However, the hiding compartment was not within his view. When the entryway of the goal chamber was blocked by one of the opaque doors, none of the goal chamber was visible to S.
The mother surrogate described in the apparatus section of the informal tests was the stimulus object used in the OA. In the OA tests, however, the surrogate always held a nursing bottle filled with formula. A wooden hiding box 27.94 cm. long, 17.78 cm. wide, and 27.94 cm. high with a handle on the top was designed to fit over and conceal the surrogate.

Procedure

Trials on all OA test items began with $S$ confined in the start box and the surrogate positioned in the entryway of one of the goal chambers behind the large opaque door that blocked the entryways to both goal chambers. After $E$ removed the large opaque door, making the surrogate visible to $S$, she either directly opened the start box door or induced $S$ to orient toward the surrogate, performed some manipulation with it, and then opened the start box door. Manipulations of the surrogate were carried out through the top of the apparatus. However, the top of the apparatus was closed before the start box door was opened. All trials lasted 60 seconds from the opening of the start box door or until $S$ entered an incorrect goal chamber or until $S$ touched the surrogate. On items where both goal chambers were accessible to $S$, the entryway to the goal chamber that he entered was immediately blocked with the small opaque door. If $S$ touched the surrogate within the trial, he was allowed or helped to drink approximately 10 ml. of formula. After each trial $S$ was removed through the top of the apparatus, the large opaque door that blocked the entryways to both goal chambers was inserted, the apparatus were appropriately arranged for the next trial, and $S$ was returned to the
start box. All trials were evaluated according to the following two categories: (a) plus—$S$ touched the surrogate within the trial; and (b) minus—$S$ did not touch the surrogate within the trial.

Each of the OA test items involved a different procedure. Within each item, however, the basic procedure varied over trials only as to the final position of the surrogate in the goal chamber. Over trials the surrogate was left in position A, beside the hiding compartment in the entryway of one of the goal chambers visible to $S$; position B, halfway behind the hiding compartment of one of the goal chambers partially visible to $S$; or position C, inside the hiding compartment of one of the goal chambers concealed from $S$. Trials of an item were designated as type A, B, or C trials with reference to the final position of the surrogate.

One session of any item consisted of presenting two sets of three trials each. Each set included one type A, one type B, and one type C trial. For all sessions of an item, the order of presentation of type A, B, and C trials was determined by using a repetition of the following three sequences: (a) A, B, C—B, A, C; (b) C, B, A—A, C, B; and (c) B, C, A—C, A, B. On items where the final position of the surrogate also varied between the left (L) and right (R) goal chambers the order of presentation for the type A, B, and C trials and for the left, right position of the surrogate were determined per session by using a repetition of the following six sequences: (a) L,A; R,B; L,C—L,B; R,A; R,C; (b) R,C; L,B; R,A—L,A; L,C; R,B; (c) L,B; R,C; R,A—L,C; L,A; R,B; (d) R,A; L,B; L,C—R,B; L,A; R,C; (e) L,C; L,B; R,A—L,A; R,C; R,B; and (f) R,B; L,C; L,A—R,C; R,A; L,B.
The items were as follows:

1. **OA visible displacement.** At the beginning of each trial, the surrogate was beside the hiding compartment in the entryway of the goal chamber to which S had been shaped to run in a previous adaptation period. After E blocked the entryway to the unoccupied goal chamber with the small opaque door, she left the surrogate in position A and opened the start box door or moved it to position B or C in the same goal chamber that it occupied at the beginning of the trial and opened the start box door.

2. **OA sequential visible displacement.** At the beginning of each trial, the surrogate was beside the hiding compartment in the entryway of the left or right goal chamber according to the sequences described earlier. E left the surrogate in position A and opened the start box door or moved it to position B or C in the same goal chamber that it occupied at the beginning of the trial and opened the start box door.

3. **OA successive visible displacement.** At the beginning of each trial, the surrogate was beside the hiding compartment in the entryway of one of the goal chambers. E moved the surrogate in and out of the hiding compartment of the goal chamber that it occupied at the beginning of the trial, pushed it forward through the entryway of this goal chamber, and pulled it back into the second goal chamber. The surrogate was left at position A, B, or C in the second goal chamber, and the start box door was opened. The surrogate was finally placed in the left or right goal chamber according to the sequences described earlier.

4. **OA invisible displacement.** At the beginning of each trial, the surrogate was beside the hiding compartment in the entryway of the goal chamber to which the S had been shaped to run in a previous adaptation
period. After E blocked the entryway to the unoccupied goal chamber with the small opaque door, she placed the hiding box over the surrogate and left them in position A or moved them to position B or C in the same goal chamber that the surrogate occupied at the beginning of the trial. E removed the box from the surrogate, showed the inside of the box to S, and opened the start box door.

5. OA sequential invisible displacement. At the beginning of each trial, the surrogate was beside the hiding compartment in the entryway of the left or right goal chamber according to the sequences described earlier. E placed the hiding box over the surrogate and left them in position A or moved them to position B or C in the same goal chamber that the surrogate occupied at the beginning of the trial. E removed the box from the surrogate, showed the inside of the box to S, and opened the start box door.

6. OA successive invisible displacement. At the beginning of each trial, the surrogate was beside the hiding compartment in the entryway of one of the goal chambers. E placed the hiding box over the surrogate and moved them in and out of the hiding compartment of the goal chamber that the surrogate occupied at the beginning of the trial. She pushed them forward through the entryway of this goal chamber and pulled them back into the second goal chamber. After the surrogate and box were left at position A, B, or C in the second goal chamber, E removed the box from the surrogate, showed the inside of the box to S, and opened the start box door. The surrogate was finally placed in the left or right goal chamber according to the sequences described earlier.
In Items 1, 2 and 3, all involving visible displacement procedures, the delay between the disappearance of the surrogate into the hiding compartment on type C trials and the opening of the start box door was approximately 4.5 seconds. On Items 4, 5, and 6, all involving invisible displacement procedures, the delay on type C trials between the disappearance of the surrogate and hiding box and the opening of the start box door was 8.5 seconds. However, the delay between when S was shown the inside of the box and the opening of the start box door was 4.5 seconds on these items.

Experimentation in the OA began when Number 37 was 12 days of age and Number 38 was 10 days of age. In the 5 days prior to testing, each S was adapted to the OA, and Number 37 was shaped to run from the start box to the surrogate in the entryway of the left goal chamber, while Number 38 ran to the surrogate in the right goal chamber.

Throughout experimentation in the OA, each S was given four daily feedings at approximately 4 hour intervals in the OA testing situation. (The fifth feeding, given until an S was 15 days of age, was hand fed to the S outside of the testing situation.) Each feeding or testing period constituted one six-trial session of an OA test item. If an S did not receive an adequate amount of formula in the testing situation, he was hand fed additional formula outside the testing situation after a brief delay in his home cage.

Items 4 and 1 were introduced to each S on the first and second testing periods, respectively. Items 5, 2, 6, and 3 were introduced on the testing period following the one in which an S had completed a sequence of four plus trials out of six type C trials on Items 4, 1, 5,
and 2, respectively. Items were presented in a sequence (one six-trial session of an item per testing period) so that one session of each item that had been introduced was given once before a session of any other item was repeated.

Criterion was reached on all items when an \( S \) passed 8 out of 10 type C trials. Items were discontinued as the \( S \) reached criterion on them.

**WGTA Tests**

**Apparatus**

The apparatus included a modified WGTA; a cup, 3.18 cm. in diameter and 3.18 cm. high; and two wooden blocks, each measuring 5.72 cm. square and 5.08 cm. high. The modified WGTA (see Meyer, Treichler, & Meyer, 1965, for a description of the standard WGTA and its operation) consisted of a platform 50.80 cm. long and 38.10 cm. wide that was attached at a right angle to the base of a panel of vertical bars spaced 2.54 cm. apart. This panel could be attached to the \( S \)'s home cage and covered the entire face of the cage. An opaque screen that could be placed on the platform and rested against the panel of bars was designed to cover the face of the cage. The test tray was mounted on wheels 6.35 cm. in diameter and was 38.10 cm. long and 16.51 cm. wide. The two foodwells on the test tray were spaced 25.40 cm. apart and were positioned 6.35 cm. from the edge of the test tray that faced \( S \).

**Procedure**

Trials on all WGTA test items began with \( S \) confined in his home cage behind the modified WGTA and the opaque screen. Shielded by the screen,
E had already placed one-third of a raisin at the center of the test tray and had covered one or both of the foodwells with the wooden blocks. Preceding invisible displacement trials, the cup was also positioned at the center of the tray.

After removing the opaque screen, E pushed the tray halfway forward, induced S to orient towards the raisin, and through various manipulations placed the raisin into one of the foodwells. The foodwell was uncovered, partially covered, or fully covered by a block, and the tray was pushed forward to S. All trials lasted 60 seconds after the tray was pushed forward to S or until S moved the block over the incorrect foodwell or until S grasped the raisin. At the end of each trial, the tray was pulled away, and the opaque screen was replaced in front of the cage. On all items the intertrial interval was approximately 120 seconds. All trials were evaluated according to the following two categories: (a) plus--S grasped the raisin within the trial; and (b) minus--S did not grasp the raisin within the trial.

Each of the WGTA test items involved a different procedure. Within each item, however, the basic procedure varied over trials only as to the final position of the block with reference to the baited foodwell. Over trials the block was finally placed in position A, to the left of the baited foodwell; position B, halfway over the baited foodwell; or position C, completely covering the baited foodwell. Trials of an item were designated as type A, B, or C, trials with reference to the final position of the block.

One session of any item consisted of presenting two sets of three trials each. Each set included one type A, one type B, and one type C
trial. For all sessions of an item the order of presentation of type A, B, and C trials was determined by using a repetition of the following three sequences: (a) A, B, C—B, A, C; (b) C, B, A—B, A, C; and (c) B, C, A—C, A, B. On items where the final position of the baited foodwell also varied between the left (L) and right (R) foodwells, the order of presentation for the type A, B, and C trials and for the left, right position of the baited foodwell were determined by using a repetition of the following six sequences: (a) L, A; R, B; L, C—L, B; R, A; R, C; (b) R, C; L, B; R, A—L, A; L, C; R, B; (c) L, B; R, C; R, A—L, C; L, A; R, B; (d) R, A; L, B; L, C—R, B; L, A; R, C; (e) L, C; L, B; R, A—L, A; R, C; R, B; and (f) R, B; L, C; L, A—R, C; R, A; L, B.

The items were as follows:

1. WGTA visible displacement. At the beginning of each trial, the foodwell that had been baited in S's previous adaptation trials was covered by one of the blocks, and the other foodwell was uncovered. After E pushed the tray halfway forward, she took the raisin from the center of the tray, moved the block to the left of the foodwell that it covered, and placed the raisin into the foodwell. Before pushing the tray forward to S, E left the block in position A or moved it to position B or C.

2. WGTA sequential visible displacement. At the beginning of each trial, both foodwells were covered with blocks. After E pushed the tray halfway forward, she took the raisin from the center of the tray, moved one of the blocks to the left of the foodwell that it covered, and placed the raisin into this foodwell. Before pushing the tray forward to S, E left the block in position A or moved it to position B or C. Over trials,
the raisin was placed in the left or right foodwell according to the sequences described earlier.

3. **WGTA successive visible displacement.** At the beginning of each trial, both foodwells were covered with blocks. After E pushed the tray halfway forward, she took the raisin from the center of the tray, moved one of the blocks to the left of the foodwell that it covered, moved the raisin into and out of this foodwell, and replaced the block over the foodwell. She moved the other block to the left of the second foodwell and placed the raisin into this foodwell. Before pushing the tray forward to S, E left the block in position A or moved it to position B or C. Over trials the raisin was finally placed in the left or right foodwell according to the sequences described earlier.

4. **WGTA invisible displacement.** At the beginning of each trial the foodwell that had been baited in S's previous adaptation trials was covered by one of the blocks, and the other foodwell was uncovered. After E pushed the tray halfway forward, she took the raisin and the cup from the center of the tray and placed the raisin into the cup. She moved the block in front of the foodwell that it covered, moved the upright cup behind the block, dropped the raisin into the foodwell, removed the upright cup from behind the block, and showed S the inside of the cup. Before pushing the tray forward to S, E moved the block to position A, B, or C.

5. **WGTA sequential invisible displacement.** At the beginning of each trial, both foodwells were covered with blocks. After E pushed the tray halfway forward, she took the raisin and the cup from the center of the tray and placed the raisin into the cup. She moved one of the blocks in front of the foodwell that it covered, moved the upright cup behind the
block, dropped the food into the foodwell, removed the upright cup from behind the block, and showed S the inside of the cup. Before pushing the tray forward to S, E moved the block to position A, B, or C. Over trials the raisin was placed in the left or right foodwell according to the sequences described earlier.

6. WGTA successive invisible displacement. At the beginning of each trial, both foodwells were covered with blocks. After E pushed the tray halfway forward, she took the raisin and the cup from the center of the tray and placed the raisin into the cup. She moved one of the blocks in front of the foodwell that it covered, moved the upright cup behind and out from this block, and replaced the block over the foodwell. She placed the second block in front of the foodwell that it covered, moved the upright cup behind this block, dropped the food into the foodwell, removed the upright cup from behind this block, and showed S the inside of the cup. Before pushing the tray forward to S, E moved the block to position A, B, or C. Over trials the food was finally placed in the left or right foodwell according to the sequences described earlier.

Adaptation trials were began using the modified WGTA when Number 37 was 52 days of age and Number 38 was 50 days of age. For 2 days prior to the initiation of adaptation trials, the modified WGTA was periodically attached to each S's cage. Adaptation trials followed the same general procedures described for the other WGTA test items except that no cup or blocks were used. The appropriate foodwell was baited in view of S, and he was allowed 60 seconds to grasp the raisin. For Number 37 the raisin was always placed in the right foodwell, and for Number 38 the raisin was always placed in the left foodwell. Six adaptation trials constituted one adaptation session.
Adaptation sessions as well as WGTA test item sessions were given four times daily at two different testing times. Two testing periods separated by a 15 minute rest period were given to each S each morning, and two similarly separated testing periods were given to each S each afternoon with a six-trial adaptation session or a six-trial WGTA test item session given during each testing period. Both testing times were approximately 3 hours after S's last feeding.

Adaptation trials were given until an S grasped the raisin within the 60 second interval for 10 consecutive trials. After the completion of adaptation trials, Items 4 and 1 were introduced to each S on the first and second testing periods, respectively. Items 5, 2, 6, and 3 were introduced on the testing period following the one in which the S completed a sequence of four plus trials out of six type C trials on Items 4, 1, 5, and 2, respectively. Items were presented in a sequence (one six-trial session of an item per testing period) so that one session of each item that had been introduced was given once before a session of any other item was repeated.

Criterion was reached on all items when an S passed 8 out of 10 type C trials. Items were discontinued as the S reached criterion on them.
Chapter 3

RESULTS

The results from informal items for Number 37 are summarized in Table 1. The data in terms of Number 37's age through criterion on each informal item are illustrated in Figure 2. As can be seen in Table 1 and Figure 2, Number 37 met criterion on Item 1 — recognition — at 12 days of age. Two days later he met criterion on Item 2 — assimilation of vision to prehension. He completed the next test, Item 5 — reconstruction of an invisible whole from a visible fraction — 15 days after meeting criterion on Item 2. Six and 7 days after finishing Item 5, Number 37 met criterion on Item 4 — accommodation to rapid movement — and Item 3 — assimilation of prehension to vision, respectively. Twenty-three days passed between the completion of Item 3 and that of Item 6 — visible displacement with reaching. Criterion was met on Item 7 — visible displacement — 13 days after criterion was met on Item 6. Item 10 — invisible displacement — and Item 8 — sequential visible displacement — were completed 12 and 18 days, respectively, after Number 37 met criterion on Item 7. Item 13 — superimposed screens, Item 9 — successive visible displacement, Item 11 — sequential invisible displacement, and Item 12 — successive invisible displacement — were finished 2, 4, 7, and 8 days, respectively, after the completion of Item 8.

A history of each informal item can be seen in Figure 3 where the percentage of trials passed per test day by Number 37 is plotted. In
Table 1

Data Tabulation for Number 37 from Informal, OA, and WGTA Test Items

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<th>Item</th>
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<th>Age in Days through Criterion</th>
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FIG. 2. Age in days through criterion of Number 37 for informal test items 1—13.
FIG. 3. Percentage of trials passed per test day through criterion on informal test items 1--13 over days of age for Number 37.
these graphs and in the description of Number 37's progression on each informal item given below, only completed trials (not discontinued ones) are considered.

Number 37 met criterion on the first two informal items when he was 12 through 14 days of age. He met criterion on Item 1 after the presentation of 13 trials given over 3 test days, failing only four trials on the first test day by exhibiting a freezing response to the testing situation. On the remaining trials he ran immediately to the surrogate. He met criterion on Item 2 by passing all eight trials presented to him over 2 test days.

Number 37 met criterion on informal Items 3 through 6 when he was 29 through 59 days of age. He failed all 15 trials presented to him on the first 3 test days of Item 3, carrying the object to his mouth without looking at it on most of the minus trials, and he passed 40%, 80%, and 67% of the trials presented to him on the fourth through the sixth test days of Item 3, passing 8 out of 13 trials in all. On Item 4 he passed 40% or less of the trials presented to him on each of the first 4 test days, failing 16 out of 20 trials by either continuing to look at E's empty hand or looking to the side when the object was dropped, and he passed 80% and 100% of the trials presented to him on the fifth and sixth test days of this Item, passing six out of seven trials over these days. Criterion was met on Item 5 within 2 test days with Number 37 passing 100% of the trials presented to him each day. Number 37 passed 40% or less of the trials presented to him per day on the first 8 test days of Item 6 except on the fourth test day on which he passed all five trials by jumping on the screen. During this interval he failed 26 out of 36
trials usually by ignoring the screen. On the ninth through the eleventh test day of Item 6, he passed 60%, 80%, and 100% of the daily trials presented to him, passing 8 out of 11 trials over these days.

Criterion was met on informal Items 7, 8, 10, and 13 when Number 37 was 72 through 92 days of age. On Item 7 he passed 60% or less of the trials presented to him on each of the first 13 test days, failing 51 out of 65 trials by either ignoring the screen or attending to it without uncovering the object. On the fourteenth and fifteenth test days of Item 7, he passed 100% of the trials presented to him, removing the screen from the object on all seven trials. On Item 8 Number 37 passed 40% or less of the daily trials presented to him on the first 5 test days, failing 20 out of 25 trials usually by moving an incorrect screen; he passed 100% of the trials of this item presented to him on the sixth and seventh test days, passing all six trials presented over these days. The middle screen that was used in the preliminary session to Item 8 was moved by Number 37 on 7 out of 23 trials presented to him on Item 8, disregarding the last eight plus trials. Number 37 failed all 37 trials presented to him on Item 10 over the first 9 test days, ignoring the cup and screen on most trials but occasionally attending to one or both of them, but on the tenth through the twelfth test days of Item 10, he passed 80%, 60% and 100% of the trials presented to him, failing only 3 out of 11 trials over these days. On Item 13 he passed 40% or less of the trials presented on each of the first 10 test days, failing 45 out of 50 trials by ignoring the screens or manipulating them without displacing one, and on the eleventh through the thirteenth test day, he passed 60%, 60%, and 100% of the daily trials failing only 4 out of 14 trials in all.
Number 37 met criterion on informal items 9, 11, and 12 when he was 94 through 98 days of age. On the first 3 test days of Item 9, he passed 60% or less of the trials presented each day, failing 8 out of 15 trials by moving an incorrect screen on each minus trial, and on the fourth and fifth test days of this item, he passed 100% of the trials presented to him, lifting the correct screen on all seven trials. On Item 11 he passed 60% or less of the trials presented to him on each of the first 8 test days, failing 26 out of 40 trials by moving an incorrect screen on each minus trial, but on the ninth test day he passed all five trials presented to him. On Item 11 he moved the middle screen that was used in the preliminary session on 16 out of 37 trials, not counting the last eight plus trials. Number 37 passed only 20% of the daily trials presented to him on the first and second test days of Item 12, failing 8 out of 10 trials by either touching none of the screens or moving an incorrect screen; he passed all eight trials presented to him on the third and fourth test days of Item 12.

The results for OA tests for Number 37 can be found in Table 1. His age through criterion for each OA item is graphed in Figure 4. Number 37 met criterion on Item 4 -- invisible displacement -- when he was 15 days of age, and 1 day later he met criterion on Item 1 -- visible displacement. Nine days passed before criterion was met on the next item, Item 2 -- sequential visible displacement. Two days after he completed Item 2, Number 37 met criterion on Item 5 -- sequential invisible displacement, and 2 days after finishing Item 5, he met criterion on both Item 3 -- successive visible displacement -- and Item 6 -- successive invisible displacement.
FIG. 4. Age in days through criterion of Number 37 for OA and WGTA test items 1--6.
The percentage of trials passed by Number 37 per test day for each OA item is graphed in Figure 5. On these graphs and in the description of Number 37's behavior on individual OA items below, unless specified otherwise, only type C trials are considered.

Number 37 met criterion on OA Items 1 and 4 when he was 15 through 16 days of age. On Item 1 he passed 50% or less of the daily trials presented on the first 2 test days, failing four out of six trials by running to the entryway of the left goal chamber and remaining there. Over the third through the fifth test days of this item, he ran directly to the surrogate on all six trials. He passed all 12 type B trials of Item 1 presented to him by running directly to the partially visible surrogate. Number 37 passed only one out of four trials presented to him on Item 4 on the first test day, remaining in either the choice chamber or the entryway of the left goal chamber on the minus trials, but over the second through the fourth test days of this item, he passed all eight trials presented to him.

Criterion was met on OA Items 2, 3, 5, and 6 when Number 37 was 25 through 29 days of age. He passed 100% of the daily trials presented to him on the first 2 test days of Item 2 and 50% of them on the next 6 test days, passing 10 out of 16 trials over these first 8 test days and running to the left goal chamber that was used exclusively for him during adaptation, and Items 1 and 4 on all 10 trials presented on the fourth through the eight test days. On the ninth through the twelfth test days of Item 2, he performed at the 100% level on all test days except one, passing seven out of eight trials over these days. Number 37 passed 50% or less of the daily trials presented to him on Item 3 on each of the first 9 test
FIG. 5. Percentage of type C trials passed per test day through criterion on OA and WGTA test items 1–6 over days of age for Number 37.
days, passing 8 out of 18 trials. On the third through the ninth test
day he ran to the left goal chamber on all 14 trials presented to him
except for two in which he remained in the start box. On the tenth
through the fourteenth test days of Item 3, he performed at the 100%
level on 3 test days but at the 0% and 75% level on the other 2 test
days, passing 10 out of 13 trials over these days. Number 37 passed 0%
or 100% of his daily trials on the first 3 test days of Item 5, and from
the fourth through the ninth test days, he passed 50% of his daily trials
perseverating to the left goal chamber on all 12 trials. Over these first
9 test days he passed 10 out of 18 trials, however, on the tenth through
the fourteenth test days of this item, he passed seven out of nine trials,
performing at the 100% level on 3 test days and at the 50% level on 2 test
days. On Item 6 Number 37 passed 50% or less of the daily trials pre-
sented to him on the first 11 test days, passing 8 out of 22 trials, run-
ing to the left goal chamber on all 22 trials except seven in which he
remained in the choice chamber or start box. On the twelfth through the
fourteenth test days of Item 6, he passed 50%, 100%, and 75% of the daily
trials, passing 8 out of 10 trials in all.

Results on WGTA tests for Number 37 are also summarized in Table 1.
His age in days through criterion on each item is graphed in Figure 4.
Number 37 met criterion on Item 1 -- visible displacement -- and Item 4 --
invisible displacement -- when he was 56 days of age. One day later he
had also passed 8 out of 10 trials on Item 2 -- sequential visible dis-
placement. He met criterion on Item 3 -- successive visible displacement --
6 days after completing Item 2. Ten and twelve days after Item 3 was fin-
ished, criterion was met on Item 5 -- sequential invisible
displacement — and Item 6 — successive invisible displacement, respectively.

The percentage of trials passed per day for each WGTA item is graphed for Number 37 in Figure 5. Again, in these graphs and in the discussion of the individual items below, only type C trials are considered.

Number 37 met criterion on WGTA Items 1, 2, and 4 when he was 56 through 57 days of age. He failed both trials of Item 1 presented to him on the first test day, never touching the block positioned over the right foodwell, but he passed all eight trials of this item presented to him on the second through the fourth test days. He passed all 10 type B trials of Item 1 except for the first two presented on the first test day. Criterion was met on Item 2 within the first 4 test days with Number 37 passing all eight trials presented over these days. He failed all four trials of Item 4 presented over the first 2 test days, never touching the block positioned over the right foodwell on three of these trials; he passed all eight trials of this item presented over the third through the fifth test days.

Criterion was met on WGTA Items 3, 5, and 6 when Number 37 was 63 through 75 days of age. He performed, in general, at the 50% level on Item 3 on the first 7 test days, failing 8 out of 18 trials usually by moving an incorrect block; he performed at the 100% and 75% level on the eighth and ninth test days, respectively, passing five out of six trials presented on this item over these days. He showed little position perseveration on this item, never responding to a block positioned over the same foodwell on more than four trials in a row. Number 37 passed
anywhere from 0% to 100% of the daily trials presented to him on the first 16 test days of Item 5, failing 34 out of 54 trials usually by moving an incorrect block. On the seventeenth through the nineteenth test days, he passed 75%, 75%, and 67% of the daily trials of Item 5, passing 8 out of 11 trials in all. As in Item 3, he showed little position perseveration on this item, never responding to a block over the same foodwell on more than five consecutive trials. On Item 6 Number 37 passed anywhere from 0% to 100% of the daily trials presented to him on the first 15 test days, failing 31 out of 52 trials by moving an incorrect block on most of the minus trials. He passed seven out of nine trials over the sixteenth and seventeenth test days, performing at the 75% and 100% level on these days. He showed more of a tendency to perseverate on Item 6, pushing the block over the left foodwell that was not used in adaptation or in Items 1 and 4 on 12 trials in a row occurring on the twelfth through the fifteenth test days.

The results for Number 38 on the informal items are summarized in Table 2. The age at which he met criterion on each informal item is graphed in Figure 6. Number 38 met criterion on Item 1 -- recognition -- at 12 days of age. Two days later he met criterion on Item 2 -- assimilation of vision to prehension. Eight days after completing Item 2, he met criterion on Item 4 -- accommodation to rapid movement, and 7 days after finishing Item 4, he met criterion on Item 5 -- reconstruction of an invisible whole from a visible fraction. Seven days passed between the completion of Item 5 and the completion of Item 6 -- visible displacement with reaching, and 12 days passed between the completion of Item 6 and the completion of Item 3 -- assimilation of prehension to vision. Number 38 did
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FIG. 6. Age in days through criterion of Number 38 for informal test items 1--13.
not meet criterion on any of the items after the completion of Item 3 for 47 days; at that time he passed 8 out of 10 trials on Item 7 -- visible displacement, and 7 days later he met criterion on Item 13 -- superimposed screens. Two and 5 days after finishing the superimposed screen test, he met criterion on Item 8 -- sequential visible displacement -- and Item 10 -- invisible displacement, respectively. Criterion was met on Item 9 -- successive visible displacement, Item 11 -- sequential invisible displacement, and Item 12 -- successive invisible displacement -- 1, 2, and 3 days, respectively, after criterion was met on Item 10.

For each informal item the percentage of trials passed per test day by Number 38 is graphed in Figure 7. Again, discontinued trials are not included in the data description in the graphs or in the discussion of individual informal items below.

Number 38 completed the first two informal items when he was 12 through 14 days of age. He met criterion on Item 1 within 13 trials presented over 3 test days, failing only four out of five trials on the first test day by investigating a brightly colored unfamiliar object rather than running to the surrogate. On the remaining trials he ran immediately to the surrogate. Criterion was met on Item 2 within the first 2 test days with Number 38 passing four out of five trials on the first test day and all four trials presented on the second test day.

Criterion was met on informal Items 3 through 6 when Number 38 was 22 through 49 days of age. On Item 3 he passed anywhere from 0% to 80% of the daily trials on the first 11 test days, failing 38 out of 55 trials by either grasping and dropping the object or carrying it to his
Fig. 7. Percentage of trials passed per test day through criterion on informal test items 1–13 over days of age for Number 38.
mouth without looking at it. He performed at the 80% level on the
twelfth and thirteenth test days of Item 3, passing 8 out of 10 trials
over these days. He passed 40% or less of five trials presented to him
on each of the first 5 test days of Item 4 except for the second test
day on which he passed both trials that were not discontinued. Over
these days he failed 13 out of 22 trials presented to him on Item 4,
either looking to the side or continuing to look at E's empty hand
when the object was dropped. On the sixth and seventh test days of
Item 4, he passed 100% and 50%, respectively, of the trials presented
to him, passing six out of seven trials. Criterion was met on Item 5
within the first 2 test days with number 38 passing all eight trials
presented over these days. Number 38 passed 40% or less of the trials
presented to him on Item 6 on each of the first 5 test days, failing 19
out of 25 trials, either ignoring the screen after the object was cov­
ered or manipulating the screen but not uncovering the object, and on
the sixth and seventh test days of Item 6, he passed 100% and 67%, re­
spectively, of the trials presented, passing seven out of eight trials
over these days.

Informal Items 7, 8, 10, and 13 were completed by Number 38 when
he was 96 through 108 days of age. He passed 20% or less of the trials
presented to him on each of the first 12 test days of Item 7, failing
58 out of 60 trials, usually ignoring the screen although sometimes
manipulating it without uncovering the object. On the thirteenth
through the fifteenth test days of Item 7, he passed 40%, 60%, and 100%
of the daily trials, passing 8 out of 13 trials. Number 38 passed 40%
or less of the trials of Item 8 presented to him on each of the first 3
test days, failing 11 out of 15 trials, usually moving none of the screens but occasionally moving an incorrect screen, and on the fourth and fifth test days of Item 8, he passed 100% and 67%, respectively, of the trials presented to him, passing seven out of eight trials. He moved the middle screen that was used in the preliminary session on 3 out of 15 trials presented to him on Item 8, not counting the last eight plus trials.

Number 38 passed 20% or less of the daily trials presented to him on Item 10 for the first 14 test days, failing 63 out of 66 trials by ignoring the cup and screen on all but a few trials. On the fifteenth through the eighteenth test days of Item 10 he passed 80%, 0%, 100%, and 100% of the daily trials, passing 12 out of 18 trials. He performed anywhere from the 20% through the 60% level on Item 13 on the first 6 test days, failing 17 out of 30 trials by manipulating the screens without uncovering the object on the majority of the minus trials. On the seventh and eighth test day of Item 13, he performed at the 100% and 50% level, respectively, passing six out of seven trials.

Criterion was met on informal Items 9, 11, and 12 when Number 38 was 109 through 111 days of age. On Item 9 he passed 60% or less of the daily trials presented on the first 3 test days, failing 8 out of 15 trials usually by moving an incorrect screen, and he passed all six trials presented to him over the fourth and fifth test days of this item. On Item 11 only 20% of the daily trials were passed on the first 3 test days with Number 38 failing 12 out of 15 trials usually by moving an incorrect screen, but 60% and 100% of the daily trials were passed on the fourth and fifth test days, respectively, with Number 38 passing seven out of nine trials.
Number 38 moved the middle screen that was used in the preliminary session on 6 out of 16 trials on Item 11, disregarding the last eight plus trials. Criterion was met on Item 12 within 2 test days with Number 38 failing two trials by moving an incorrect screen on the first test day and passing the other eight trials presented over these days.

Results for Number 38 on OA items are summarized in Table 2. Number 38's age through criterion on each OA item is graphed in Figure 8. He met criterion on Item 4 -- invisible displacement -- at 13 days of age, finishing Item 1 -- visible displacement -- 1 day later. Twenty-four days passed before he met criterion on another item, however, at that time he completed both Item 2 -- sequential visible displacement -- and Item 3 -- successive visible displacement. Two days later he met criterion on Item 5 -- sequential invisible displacement and Item 6 -- successive invisible displacement.

The percentage of trials passed per day by Number 38 on OA items is plotted in Figure 9. Only type C trials are included in these graphs and in the discussion of Number 38's performance on OA items below.

Number 38 met criterion on OA Items 1 and 4 when he was 13 through 14 days of age. He failed all four trials of Item 1 presented to him on the first test day, running to the entryway of the right goal chamber and remaining there, but he passed all eight trials presented to him over the second through the fifth test days. He passed all 12 type B trials of Item 1 presented to him. His performance on Item 4 was similar to his performance on Item 1 with him failing all four trials presented on the first test day by remaining in the entryway of the right goal chamber and
FIG. 8. Age in days through criterion of Number 38 for OA and WGTA test items 1--6.
FIG. 9. Percentage of type C trials passed per test day through criterion on OA and WGTA test items 1--6 over days of age for Number 38.
passing the last eight trials presented over the second through the fourth test days.

Criterion was met on OA Items 2, 3, 5, and 6 when Number 38 was 38 through 40 days of age. On Item 2 he passed 50% of his daily trials on all of the first 22 test days except for 2, passing 22 out of 44 trials and running to the right goal chamber that was used exclusively for him during adaptation and Items 1 and 4 on all 36 trials presented on the fourth through the twenty-first test days except four. He passed 8 out of 10 trials over the twenty-third through the twenty-seventh test days of Item 2, performing at the 100% level on 3 of these days and at the 50% level on 2 of these days. Number 38 passed 50% of his daily trials on Item 3 on all of the first 20 test days except for the first one, passing 19 out of 40 trials and running to the right goal chamber on all 40 trials but one. However, on the twenty-first through the twenty-fourth test days he passed six out of seven trials, performing at the 100% level on 3 test days and at the 50% level on 1 test day. On Item 5 Number 38 passed from 50% to 100% of his daily trials on the first 27 test days, passing 31 out of 54 trials and perseverating to the right goal chamber on all 40 trials presented on the fourth through the twenty-third test days except four but perseverating to the left goal chamber on all eight trials presented on the twenty-fourth through the twenty-seventh test days. He passed all six of the trials presented on the twenty-eighth and twenty-ninth test days of Item 5. He passed 50% of the trials presented to him on each of the first 24 test days of Item 6 except 4, passing 22 out of 48 trials and running to the right goal chamber on all 36 trials presented on the third to the twentieth test day except for three trials
in which he entered neither goal chamber. However, he ran to the left goal chamber on all six trials presented on the twenty-second through the twenty-fourth test days. He passed all six trials presented over the twenty-fifth through the twenty-seventh test days of Item 6.

The results for Number 38 on WGTA items can also be found in Table 2. His age through criterion on each WGTA item is graphed in Figure 8. He met criterion on Item 1 -- visible displacement -- when he was 56 days of age and finished Item 4 -- invisible displacement -- and Item 2 -- sequential visible displacement -- 8 and 9 days later, respectively. Nine days passed before he met criterion on another item, however, at that time he completed Item 3 -- successive visible displacement, Item 5 -- sequential invisible displacement, and Item 6 -- successive invisible displacement.

Number 38's progress on each WGTA item is graphed in Figure 9 in terms of the percentage of trials passed per test day. The graphs and the descriptions of his behavior on each WGTA item below are concerned only with type C trials.

Number 38 met criterion on WGTA Items 1, 2, and 4 when he was 56 through 65 days of age. He passed 50% of the trials presented to him on each of the first 3 test days of Item 1, failing 5 out of 10 trials by either not touching the block positioned over the left foodwell or moving it so that he could not grasp the raisin, and he passed all five trials presented on this item over the fourth and fifth test days. He passed all 15 type B trials of Item 1 presented to him by grasping the partially covered raisin. On Item 2 Number 38 passed anywhere from 0% to 75% of the daily trials presented to him on the first 8 test days, failing
12 out of 22 trials usually by moving an incorrect block, and he passed all five trials of this item presented on the ninth through the eleventh test days. He showed little position perseveration on this item never responding to a block position over the same foodwell on more than three trials in a row. He passed anywhere from 0% to 100% of the daily trials of Item 4 presented to him on the first 8 test days, failing 19 out of 26 trials either by never touching the block positioned over the left foodwell or by moving it so that he could not grasp the raisin. He passed 100% of the daily trials presented to him on the ninth through the thirteenth test days except for the twelfth test day and passed 8 trials out of 10 over these days.

Criterion was met on WGTA Items 3, 5, and 6 when Number 38 was 74 days of age. He passed anywhere from 0% to 100% of the daily trials of Item 3 presented to him on the first 13 test days, failing 16 out of 36 trials usually by moving an incorrect block, and on the fourteenth through the sixteenth test days, he passed seven out of eight trials, performing at the 100% level on 2 test days and at the 75% level on the other test day. He demonstrated mild position perseveration by responding to the block positioned over the left foodwell that was used exclusively for him during adaptation and Items 1 and 4 on eight consecutive trials occurring on the eleventh through the fourteenth test days. On Item 5 Number 38 performed anywhere from the 0% to the 100% level on the first 12 test days, failing 18 out of 34 trials usually by moving an incorrect block, and on the thirteenth and fourteenth test days, he performed at the 75% and 100% level, respectively, passing seven out of eight trials.
over these days. Position perseveration to the block covering the left foodwell was demonstrated by Number 38 on nine consecutive trials, occurring on the ninth through the twelfth test day of Item 5. On Item 6 Number 38 passed 50% of the daily trials on the first 3 test days, failing four out of eight trials usually by moving an incorrect block, and he passed all five trials presented on the fourth through the sixth test days. On this item he never responded to a block over the same foodwell on more than two trials in a row.
Chapter 4

DISCUSSION

In this study the ages at which the subjects demonstrated certain stable behaviors towards objects were found in each testing situation supporting hypothesis I which stated that the procedures used in this study would give the dates of appearance of specific, stable object-related behaviors in the rhesus monkey. For the purposes of this study, a response was assumed to appear as a stable or consistent behavior in a subject at the time he reached criterion on the item designed to reveal the response's presence or absence in his repertoire.

In the formal testing situation both subjects immediately showed assimilation of vision to prehension at 14 days of age and reconstruction of an invisible whole from a visible fraction at 29 days of age, and Number 38 immediately followed successive invisible displacement on Item 12 at 111 days of age in that for these instances criterion was met on the appropriate informal items within the first 10 trials of testing. Recognition of a familiar object was consistently demonstrated by both subjects within the first 13 trials of Item 1 when they were 12 days of age. However, Number 37's freezing response and Number 38's investigation of the colorful, strange object occurring on four out of the first five trials did not provide information as to whether the subjects recognized the familiar object or not in the testing situation. The
appearance of the ability to recognize objects within the first 12 days of life in these subjects is consistent with Zimmermann and Torrey's (1965) report that rhesus monkeys performed at the 80% level on a black-white discrimination task at 7 to 8 days of age. Thus, the dates at which the subjects would have first consistently demonstrated these responses in the informal testing situation are not known, and this aspect of hypothesis I was not fulfilled. If appropriate tests for these responses were given earlier, the ages at which they stabilized might have been found.

Neither subject passed 8 trials out of the first 10 on any of the informal items used to investigate the remaining nine behavior patterns included in the informal part of this study, and Number 37 did not meet criterion on Item 12 until after the presentation of 18 trials. However, both subjects did eventually meet criterion on all nine of these items. Thus, in support of hypothesis I, the ages at which criterion was met on these items can be used as estimates of the dates that these behavior patterns became stable parts of the subjects' behavior towards objects in the informal testing situation. The trend shown by both subjects on most of these items of an abrupt increase in the percentage of trials passed per test day as they approached criterion (see Figures 3 and 7) suggests that most of these behavior patterns emerged suddenly as stable responses. Only on Item 6 for Number 37 and on Items 3, 4, and 13 for Number 38 was there considerable vacillation in the percentage of trials passed per test day over time. Therefore, the age at which criterion was reached on most of the informal items gives the age at which
the behavior pattern being studied appeared as a sudden, consistent 
mode of responding in the informal testing situation.

Results from the OA items also support hypothesis I in that the 
subjects did not meet criterion in the first 10 type C trials of any 
item but did eventually meet criterion on all the items, making possible 
an approximation of the subjects' ages when they were first able to 
follow consistently the various displacements of the surrogate. In the 
OA testing situation, however, Numbers 37 and 38 again immediately showed 
object recognition and reconstruction of an invisible whole or following 
of a partial visible displacement as they ran to the half-hidden surro­
gate on the first eight type B trials of Item 1 at 14 and 12 days of age, 
respectively.

On Items 1 and 4 the subjects suddenly began to run to the surro­
gate on every trial until they met criterion on these items (see Figures 
5 and 9). They failed to run to the surrogate consistently on only 1 or 
2 test days of these items, but on these days they usually passed less 
than 50% of the trials presented to them. Thus, like the behavior pat­
terns investigated with the informal tests, following visible and in­
visible displacements in the OA testing situation emerged suddenly as 
consistent responses in the subjects.

On the other items the subjects did not so abruptly demonstrate the 
ability to follow the various displacements. On these items they showed 
a preference for one goal chamber, running consistently to this goal 
chamber over several trials, thus, passing only 50% of their daily test 
trials. As this position habit disappeared, they began to follow the 
the displacements but would still make occasional incorrect responses.
As in the informal and OA testing situations Numbers 37 and 38 immediately demonstrated reconstruction of an invisible whole from a visible fraction in the WGTA testing situation at 56 and 54 days of age, respectively, reaching for the half-hidden raisin on at least 8 out of the first 10 type B trials of Item 1. However, in the WGTA Number 37 also immediately showed the ability to follow visible displacements and sequential visible displacements at 56 and 57 days of age, respectively, meeting criterion on the appropriate items within the first 10 trials. On the other hand, Number 38 did not show these behaviors immediately in the WGTA testing situation.

On all other WGTA items the subjects eventually passed 8 out of 10 trials after the first 10 trials were presented, and, as suggested in hypothesis I, the ages at which they began to consistently follow the various displacements can be specified. As can be seen in Figures 5 and 9, consistent following of the appropriate displacement was shown abruptly by Number 37 on Item 4 and by Number 38 on Items 1, 2, and 6. On the other items the subjects appeared to push the block randomly over trials, passing 0%, 50%, or 100% of their daily trials in an erratic fashion. However, as they approached criterion on these items, the percentage of trials they passed per day became concentrated above the 75% level.

Hypothesis II, stating that the subjects' behaviors related to object permanence would appear in some type of a developmental sequence, is supported from the results of informal tests, from the results of OA tests, and from the results of WGTA tests when any one of these sets of results is considered by itself. From any one set of results the subjects
can be described as passing through a specific number of stages in the
development of the object concept. In each case the subjects might have
passed through certain stages at different ages, but each one followed
the sequence of development outlined by the stages. Number 37 passed
through several stages at a slightly younger age than Number 38. How­
ever, Number 37 weighed 36 grams more at birth and showed behaviors in­
volving different degrees of motor coordination at earlier age. For
example, Number 37 began to climb at about 4 weeks of age, and Number
38 did not start to climb until about 6 weeks of age. Stages were formed
by grouping object-related behaviors that had been consistently demon­
strated by a subject at approximately the same time and by grouping the
behaviors so that the resulting sequence of development would appro­
priately describe both subjects' development.

On the basis of informal results for Numbers 37 and 38, they can
be described as passing through six different stages of object permanence.
Both subjects had completed the first two stages when they were 2 weeks
old. In these stages they consistently responded as if they could re­
cognize a familiar object on trials of Item 1 and consistently showed
assimilation of vision to prehension or grasped objects that they saw
on trials of Item 2. Since the age at which the subjects responded to
a half-hidden object or showed reconstruction of an invisible whole from
a visible fraction as a stable behavior on Item 5 can only be specified
by its upper limit, 29 days, this behavior pattern may belong in Stage
One and Two or in Stage Three.

Stage Three behaviors were demonstrated by Number 37 at approxi­
mately 5 through 8 weeks of age and by Number 38 at approximately 3
through 7 weeks of age. Accommodation to rapid movement was demonstrated by the subjects in Stage Three on trials of Item 4, and extension of an act of accommodation was also demonstrated by both subjects on trials of Item 4 as they continued to gaze at the experimenter's empty hand after he had dropped the object. This response was shown initially by Number 37 at approximately 3 weeks of age and by Number 38 at approximately 2 weeks of age. It was never demonstrated consistently by either subject, and it dropped out of their repertoires as they began to look consistently to the floor when the object was dropped. Assimilation of prehension to vision was shown by the subject in this stage as they consistently looked at an object that they grasped on trials of Item 3, thus, completing the coordination of vision and prehension, and in this stage the subjects consistently found an object covered by a screen as they reached for it on trials of Item 6.

Stage Four began for each subject when he could consistently follow visible displacements of an object on trials of Item 7. For Number 37 and 38 this behavior occurred at 10 weeks and 14 weeks of age, respectively.

In Stage Five, shown by Number 37 at about 12 through 13 weeks and by Number 38 at about 14 through 15 weeks, the subjects could find the object on trials of Item 10 in which it underwent invisible displacements, on trials of Item 8 in which it underwent sequential visible displacements, and on trials of Item 13 in which it was hidden under a series of superimposed screens. Neither subject showed the "typical reaction" as a strong tendency on early trials of Item 8 with Numbers 37 and 38 moving the middle screen, which never concealed the object on trials of Item 8.
but under which the object was hidden during the preliminary session, on 30% and 20%, respectively, of the trials presented to them, disregarding the last eight plus trials.

Numbers 37 and 38 passed through Stage Six when they were approximately 13 through 14 weeks of age and 15 through 16 weeks of age, respectively. During this stage they demonstrated that they could consistently follow successive visible displacements on trials of Item 9, invisible sequential displacements on trials of Item 11, and successive invisible displacements on trials of Item 12. The "typical reaction" was shown by both subjects on early trials of Item 11 with Numbers 37 and 38 moving the middle screen on 43% and 38%, respectively, of the trials presented to them, not counting the last eight plus trials.

From the results on OA items, the subjects can be described as passing through two different stages of object permanence. In the first stage, shown by both subjects from birth to approximately 2 or 3 weeks of age, they followed visible and invisible displacements of the surrogate on trials of Items 1 and 4. During this period they also consistently ran to the partially visible surrogate on type B trials of Item 1. However, since the date at which this behavior became a stable response can not be specified for either subject, it may actually belong in a separate, earlier stage.

Behaviors clustering in the second stage included running consistently to the surrogate after sequential visible displacements, successive visible displacements, sequential invisible displacements, and successive invisible displacements on trials of Items 2, 3, 5, and 6, respectively. Numbers 37 and 38 showed the behaviors included in Stage Two at
approximately 3 through 4 weeks of age and 5 through 6 weeks of age, respectively. The "typical reaction" was demonstrated by both subjects on Items 2, 3, 5, and 6. Number 37 ran to the goal chamber used for him during adaptation and Items 1 and 4 on 69%, 70%, 74%, and 62% of the trials presented to him, disregarding the last eight plus trials, on Items 2, 3, 5, and 6, respectively. Number 38 ran to the goal chamber used for him during adaptation and Items 1 and 4 on 70%, 95%, 73%, and 80% of the trials presented to him, disregarding the last eight plus trials, on Items 2, 3, 5, and 6, respectively. However, on these items for both subjects, the surrogate was hidden in the preferred goal chamber on only approximately 50% of the trials.

In order to describe the results on WGTA items for each subject with only one developmental sequence, two broad stages of development were formed. Numbers 37 and 38 completed Stage One at approximately 9 weeks of age. In this stage the subjects demonstrated that they could consistently follow visible displacements on trials of Item 1, invisible displacements on trials of Item 4, and sequential visible displacements on trials of Item 2. They also responded to the raisin when it was partially hidden on type B trials of Item 1. Since the subjects consistently demonstrated some of these behaviors in the first 10 trials of the corresponding items, the age at which they entered Stage One can not be specified.

Behaviors demonstrated consistently by the subjects in Stage Two included following successive visible displacements on Item 3, following sequential invisible displacements on Item 5, and following successive invisible displacements on Item 6. The behaviors grouped in this stage were demonstrated by both subjects when they were 9 through 11 weeks of age.
Neither subject showed a strong tendency to exhibit the "typical reaction" on items where the left and right foodwell were both baited over trials. Number 37 moved the block over the foodwell that had been baited for him during adaptation and Items 1 and 4 on 0%, 38%, 47%, and 40% of the trials, disregarding the last eight plus trials, on Items 2, 3, 5, and 6, respectively. Number 38 moved the block over the foodwell that had been baited for him during adaptation and Items 1 and 4 on 37%, 56%, 53%, and 40% of the trials, excluding the last eight plus trials, on Items 2, 3, 5, and 6, respectively. On these items the foodwell that had been baited exclusively in adaptation and Items 1 and 4 was baited on approximately 50% of the trials.

Although hypotheses I and II are clearly supported by the results on informal tests, OA tests, and WGTA tests when they are considered separately, a comparison of the results from the three different testing situations is difficult to interpret as either supporting or refuting these hypotheses. As mentioned above, the appearance of specific object-related behaviors can be dated within each test mode, supporting hypothesis I. However, each of the subjects in this study demonstrated seemingly equivalent object-related behaviors at widely different ages depending on the testing situation in which the behaviors were being investigated.

The subjects were given trials involving visible displacements, sequential visible displacements, successive visible displacements, invisible displacements, sequential invisible displacements, and successive invisible displacements in each of the three testing situations. In the OA testing situation, in the WGTA testing situation, and in the informal testing situation the subjects were able to follow each type of
displacement when they were approximately 2 through 6 weeks of age, 7 through 11 weeks of age, and 10 through 16 weeks of age, respectively. The dates at which the subjects first responded to an object after a partial visible displacement or showed reconstruction of an invisible whole from a visible fraction in the different testing situations cannot be compared since none of them were accurately identified. Thus, the subjects followed a certain kind of displacement in one testing situation, and yet, were not able to follow the same kind of displacement in another testing situation. In relation to hypothesis I, the conclusion made from this study might be that the ages at which object-related behaviors occurred in the subjects could be found, but that these ages were test or situation specific.

For each testing situation a developmental sequence describing the order that object-related behaviors appeared in the subjects was derived, lending support to hypothesis II. Although the ages at which the subjects passed through the three sequences were different for each sequence, the sequences themselves were similar. In each sequence the subjects followed partial visible displacements, visible displacements, and invisible displacements before they followed successive visible displacements, sequential invisible displacements, and successive invisible displacements. In the WGTA and informal testing situations they followed sequential visible displacements before they could follow successive visible displacements, sequential invisible displacements and successive invisible displacements, while in the OA testing situation they followed these four types of displacements at approximately the same time. Only in the informal testing situation did the subjects demonstrate that they
could follow visible displacements before invisible displacements. In the other two testing situations these two types of displacements were followed by the subjects at about the same time.

Therefore, hypothesis II is confirmed in that object-related behaviors did appear in the subjects according to the same general sequence in each testing situation. However, the ages at which they passed through the sequences were specific to the nature of the testing situation.

Thus, the development of object permanence in this study appeared to be situation specific. This conclusion is similar to Bower's (1967) finding with infants. In his study the ages at which infants demonstrated constancy behavior after a visible displacement of an object was a function of the testing situation in terms of the speed and duration of the disappearance of the object and the manner in which the object disappeared. No clear relationship between perceptual variables and the ages at which the subjects in this study demonstrated object permanence can be specified since so many perceptual variables concerning the manner in which the object disappeared in the various kinds of displacements were not held constant across the three different testing situations.

The three testing situations used in this study differed in terms of the responses required by the subjects in order to follow the various displacements of the object as well as in terms of the circumstances under which the object was concealed. In the OA situation the subjects were required to run to the mother surrogate after it had disappeared. In the laboratory and in the wild infant rhesus monkeys as young as 10 to 20 days of age have been observed to break physical contact frequently
with real mothers or mother surrogates and then return to them after a brief period (Harlow, 1965). At approximately 10 days of age, both subjects in this study ran easily and efficiently to their surrogates during adaptation procedures preceding the initiation of OA testing. Therefore, the response required in the OA testing situation appears to be one of low developmental complexity for the rhesus monkey.

The response required in the WGTA testing situation, which included pushing a block and grasping the food object beneath it, appears to be a motor response of somewhat greater developmental complexity for the rhesus. In this study when the subjects were approximately 50 days of age, their first attempts at moving the block away from the foodwell were awkward and slow. Several infant rhesus monkeys at 60 through 120 days of age were reported by Harlow et al. (1960) to need more than one training session per day for 3 consecutive weeks in order to learn to displace a wooden block from a foodwell in the WGTA.

The removal of a flexible screen from an object would appear to involve a more complex motor task than that of pushing a block away from a foodwell. The subjects in this study awkwardly moved the screens in the informal testing situation by jumping on them or pulling on them with their teeth and hands on their first displacement problems. Although they gradually progressed in their efficiency at moving the screens, Number 37 did not begin to remove the screens by quickly lifting them with one hand until he was approximately 85 days of age, and Number 38 did not do so until he was approximately 100 days of age.

Since in this study object permanence was demonstrated by the subjects first in the OA situation, next in the WGTA situation, and last in
the informal situation, the age at which object permanence was shown by the subjects appears to covary with the developmental complexity of the response required in the testing situation. Considering this relationship between the age at which object permanence was demonstrated and the developmental complexity of the response required in the testing situation and the similarity between the sequences of development of object permanence in the three different testing situations, one might hypothesize that the age at which the subjects began to follow their first complete displacements in a testing situation was a function of the developmental complexity of the response required of them in that particular testing situation, and experience in following less complex displacements in a testing situation was necessary for later mastery of more complex displacements in the same testing situation. This hypothesis would be supported by the finding of Vaughter et al. (1972) that performing on the visible displacement problem facilitated subsequent performance on the invisible displacement problem in infant squirrel monkeys. Thus, one possible interpretation of the results of this study would be that object permanence was developed by the subjects separately through similar sequences in each testing situation, and the age at which a particular sequence occurred was a function of the developmental complexity of the response required by the subjects in the testing situation.

All three sequences describing the subjects' development of the object concept in the three different testing situations are similar to Piaget's (1954) description of the developmental sequence of object permanence in the child. The sequence derived from the informal tests in this study can best be compared with the sequence described by Piaget
(1954) since most of the tests used by Piaget with children were included in the informal tests. Examination of the two sequences shows that they are very similar.

In both sequences recognition of familiar objects and assimilation of vision to prehension occurred in the first two stages. Accommodation to rapid movement and searching for an object covered by a screen just before the object was grasped were demonstrated by the rhesus infants and the children in Stage Three, and they both continued to look at the place where the object was last seen before they showed accommodation to rapid movement. Reconstruction of an invisible whole from a visible fraction was included in Stage Three for the child and belongs either in Stage Three or the preceding two stages for the rhesus.

The ability to follow visible displacements was shown by both types of subjects in Stage Four, and they both followed sequential visible displacements and invisible displacements in Stage Five. The final stage of both sequences, Stage Six, included the mastery of sequential invisible displacements and successive invisible displacements.

The main differences between the two sequences are that assimilation of prehension to vision was demonstrated in Stage Three by the rhesus rather than in Stage One or Two as for the child, the mastery of a superimposed screen problem occurred in Stage Four for the rhesus and in Stage Six for the children, and the subjects in this study demonstrated following of invisible displacements and sequential visible displacements at approximately the same time in Stage Five while the children demonstrated these behaviors in two different substages of Stage Five. One more small difference was that the rhesus did not demonstrate the "typical reaction" on
early trials of visible sequential displacements although they did show it on early trials of invisible sequential displacements.

The fact that assimilation of prehension to vision occurred later in the sequences of development of object permanence for the rhesus was apparently due to the predominance of assimilation of prehension to sucking or actually chewing. On several of the first few test days of Item 3, the subjects in this study carried objects that they grasped to their mouth and chewed them rather than visually attending to them. Numbers 37 and 38 were teething at the time trials of Item 3 were presented to them, and this fact may or may not account for the difference in position that this behavior occupied in the sequence for children and in the sequence for the subjects of this study.

Mastery of the superimposed screen problem was demonstrated by the rhesus subjects in Stage Five shortly after they followed visible displacements and at approximately the same time they followed sequential visible displacements and invisible displacements. Piaget (1954) hypothesized that children would master this problem in Stage Six at about the same time as sequential invisible displacements and successive invisible displacements. However, the children in a study by Miller et al. (1970), contrary to Piaget's description, solved a superimposed screen problem at about the same time they were able to solve a visible displacement problem and before they could solve an invisible displacement problem or a sequential invisible displacement problem. Therefore, this difference between the two sequences may be due to an inaccurate description of the sequence for the child by Piaget (1954).
The sequence derived from the OA tests was also like the one described by Piaget. In both sequences partial visible displacements, visible displacements, and invisible displacements were followed before sequential invisible displacements or successive invisible displacements were followed. The "typical reaction" observed by Piaget in the child was also demonstrated by the subjects in this study on OA items involving the surrogate being hidden in the right or left goal chamber over trials. However, in the OA tests the subjects followed visible displacements and invisible displacements at approximately the same time, and they followed sequential visible displacements in a later stage, while Piaget described children as following visible displacements in one stage, sequential visible displacements in the early part of the next stage, and finally invisible displacements in the latter part of that stage.

In the sequence describing the subjects' performance on the WGTA tests, as in the one described by Piaget for children, partial visible displacements, visible displacements, invisible displacements, and sequential visible displacements were mastered before sequential invisible displacements or successive invisible displacements. However, as described above, the children mastered visible displacements, sequential visible displacements, and invisible displacements at different times, while the subjects in this study demonstrated mastery of all three of these types of displacements in the WGTA at approximately the same time. Numbers 37 and 38 did not show the "typical reaction" on WGTA items.

Successive visible displacements were included in each testing situation in this study. In each of the testing situations, the subjects could follow this type of displacement in the last stage of
development of the object concept at approximately the same time they followed sequential invisible displacements and successive invisible displacements. This type of displacement was not included in Piaget's work with children on object permanence, however, it was included in the study by Miller et al. (1970). They found that 14- through 18-month-old infants performed better on an invisible displacement problem and a sequential invisible displacement problem than on a successive visible displacement problem, yet they performed worse on the successive visible displacement problem than on a successive invisible displacement problem. These results indicate that the mastery of successive visible displacement problems appears to occur at approximately the same place in the sequence of development of object permanence for both the rhesus and the child.

Piaget's (1954) description of the development of object permanence in the child as a gradual process in which existing structures are built upon through experience with objects, and the finding of Gruber et al. (1971) that house-reared kittens, presumably given enriched experience with objects, demonstrated object-related behaviors earlier than cage-reared kittens might lead to the hypothesis that the rate of development of object permanence in an organism is at least partially a function of the organism's experience with objects. From this premise one might reason that members of more precocious species would have more opportunities for experience with objects when they are very young and would develop object permanence at earlier ages. However, if as the findings of this study suggest, object permanence is built up separately through similar sequences for each response mode by which an organism interacts
with objects, then individuals of a species who can and do interact with objects through a particular response mode when they are very young should show permanence behaviors at an early age in situations involving this response mode. In support of this prediction, the kittens in the study by Gruber et al. (1971) and the rhesus in this study who would undoubtedly interact with objects through precise motor movements earlier than children both showed object permanence at an earlier age than the children observed by Piaget (1954) when the critical response was the removal of a screen from an object. Perhaps a better conclusion about the rate of development of object permanence in individuals of various species would be that individuals of species that interact with objects at an early age through a large variety of response modes would show permanence in a number of situations when they are still quite young. Further research is needed to determine the relationship between the age at which object permanence is demonstrated by individuals of a species through a particular response mode and the developmental part that this response plays in the species' interactions with objects.

The results of this study suggested that for each response mode through which members of a species interact with objects, object permanence is developed according to a similar sequence and to the same level of complexity. Since the rhesus monkeys in this study, the children observed by Piaget (1954), and the kittens observed by Gruber et al. (1971) all demonstrated similar sequences in the development of object permanence, perhaps this sequence is invariant across species as well as across response modes in which it is developed. However, the sequence of
development of object permanence did not reach the same level of complexity in the kittens as it did in the rhesus or children. Therefore, one could speculate that the complexity of object-related behaviors demonstrated by members of a species is to an extent a function of the phylogenetic complexity of the species. Further elaboration of the interrelationship of object permanence and phylogenetic complexity is needed in the form of developmental research with a variety of species.

Another line of research suggested by the findings of this study would be a systematic investigation of the effects of variables such as environmental background, including amounts of general and specific object experience, diet, and brain damage on the development of object permanence in the rhesus monkey. Future research might also include systematic investigation of the parts played by such processes as attention, memory, and perception in the development of object permanence in the rhesus monkey. Rhesus would be excellent candidates for subjects in these studies given that the sequence of development of object permanence demonstrated by them is so similar to the sequence demonstrated by the child and that they show object-related behaviors as complex as those demonstrated by the child.
Chapter 5

SUMMARY

The development of object permanence in the rhesus monkey was investigated in a longitudinal study of two infant rhesus monkeys in three different testing situations. In each situation the ages that certain object-related behaviors were demonstrated by the subjects as stable responses were found by the presentation of test items involving various manipulations of objects. In the informal testing situation various stimulus objects were used in various settings while the OA and WGTA testing situations involved more controlled experimental conditions. In the WGTA situation the subjects, operating in a modified WGTA, were required to displace blocks in order to uncover raisins. In the OA testing situation the subjects were placed in the Object Apparatus (OA) designed for use in this study and were required to run to their surrogate concealed in a goal chamber of the apparatus. The results indicated that object permanence was developed by the subjects at different ages in each testing situation. However, in each testing situation it was developed according to the same general sequence.
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