The Journal of Genetic Psychology, 1983, **142**, 283-291.

PERSEVERATION AND SEARCH ON A FIVE-CHOICE VISIBLE DISPLACEMENT HIDING TASK*[1]

National Institute of Mental Health and University of California, Los Angeles

E. MARK CUMMINGS AND ELIZABETH LIGON BJORK

SUMMARY

Infants eight to ten months old ($N = 30$) were presented with visible displacement hiding tasks at a first location (A), a second location (B), and, finally, a third location (C). Infants had to choose among five alternative locations on each trial. Infants seldom searched perseveratively during either B or C hiding trials. Instead, infant search attempts tended to cluster around the actual hiding location during all hiding trials. The findings are interpreted as additional evidence for a memory explanation of infant search behavior. According to this hypothesis, infants comprehend the objective nature of spatial relationships but are less effective information processors than older individuals. These results challenge Piaget's notion that infants are incapable at this age of objectively representing the spatial location of hidden objects.

A. INTRODUCTION

Piaget (12) observed that 8- to 12-month-old infants, having successfully located an object hidden at a first location A, often continued to search at A when the object is hidden at a second location, B. Numerous studies have replicated this finding (2, 5, 7, 10, 13). According to Piaget, this perseverative pattern of search occurs because infants define the position of objects in space in terms of their own actions upon objects. Infants are said to be incapable of objectively representing the spatial location of hidden objects. Instead, when faced with the task of finding an object hidden at B, infants use practical schemes linking the object with the first place they acted upon it, A.

* Received in the Editorial Office, Provincetown, Massachusetts, on December 30, 1981.

[1] Authorship in the paper is equally shared. Requests for reprints should be sent to either the first or second author at either the first or second address shown at the end of this article.

Recent research (3, 4) has challenged the notion that infant errors on hiding tasks are perseverative. This work suggests that the previously observed perseveration on these tasks is largely a result of the virtually universal use of two-choice hiding procedures which constrain infants during B-hiding trials to either search correctly or make perseverative errors by searching at the A location. When infants are presented with more than two search alternatives, they do not tend to make perseverative errors during B-hiding trials, but, on the contrary, tend to orient their search towards the actual hiding location. For example, when infants were presented with a five-choice hiding procedure (3) in which the A and B locations were positioned on opposite sides of the apparatus, search attempts formed a spatial gradient around the actual hiding location; i.e., search attempts at a given location became progressively more frequent the nearer that location was to the actual hiding location.

The tendency to orient search towards the currently correct location on unconstrained hiding tasks suggests that infants are capable of objectively representing spatial location information and is inconsistent with the Piagetian contention that infants do not understand fundamental properties of objects or space. It is, however, consistent with the memory account of search behavior proposed by Cummings and Bjork (3) in which it is assumed that infants comprehend the objective nature of objects and space, and that their search errors can be accounted for in terms of deficits in encoding, storage, and/or retrieval processes. In this memory account, variations in search accuracy in different hiding situations are attributed to differences in the information processing demands of tasks. Cummings and Bjork (3) have argued that the results of previous two-choice studies can be reinterpreted in terms of this memory hypothesis.

The present study broadens the investigation of infant search behavior to include visible displacement tasks and situations in which objects are hidden at a third location, C. Piaget contends that infants should search perseveratively at previous hiding locations during C hiding trials. Early in Stage IV, infants should search at only the A location. However, at a later point in Stage IV, infants may alternate search between A and B. It follows from Piaget that perseverative errors should be more likely during C hiding trials than during B hiding trials because of the greater cognitive development necessary to extend object schemes to include three locations.

Piaget (12) and Webb, Massar, and Nadolny (14) have produced evidence to indicate that infants perseverate during C hiding trials. However, these findings may have been a result of the task situations. Webb *et al.*'s infants

were constrained by the task situation on C-hiding trials either to search correctly or to perseverate by searching at A or B. Piaget's infants were presented with hidings in several locations within the natural environment. We would argue that in this task situation only the previous and correct hiding locations were recognizable by infants as possible search locations and that, in effect, infant errors may have been constrained to be perseverative.

In the present study, infants were presented with a task situation in which there were salient alternative search locations in addition to the correct and previous hiding locations. This paradigm allows a determination of whether infant tendencies towards perseveration during C hiding trials are more than a result of task constraints. Contrary to the predictions of a perseveration hypothesis, the memory hypothesis being examined here would predict that when alternative choices are available infant search attempts should tend to cluster around the actual hiding location. This follows from the contention of the memory hypothesis that infants at this age understand the objective nature of spatial relationships. In addition, it would be expected that infant search accuracy should decline on the first C hiding trial relative to the last B hiding trial. This prediction stems from an analysis of the relative information processing demands of each trial. On the first hiding trial at C, infants must perform a more difficult information processing task than on the last trial at B. They must (*a*) notice that the object is no longer hidden at two previous locations, and (*b*) encode, store, and retrieve information about the actual hiding location.

B. Methods

1. *Subjects*

The *S*s were 30 infants (18 males and 12 females) whose median age was 9 months and 7 days and whose ages ranged from 8 months 3 days to 10 months 10 days; seven were eight months old, 18 were nine months old, and five were 10 months old. Three additional infants were excluded for failing to search correctly during any A location experimental trial. The infants were located by means of birth announcements in a local newspaper which were automatically published whenever a birth certificate was issued.

2. *Apparatus*

A block of white foam rubber, 30 in. (76 cm) long, 12 in. (30 cm) wide, and 4 in. (10 cm) thick, served as the basic apparatus. Five holes, 5 in. (12.7

cm) high, 3 in. (7.62 cm) across, and 1.5 in. (3.81 cm) deep, were cut into the foam rubber block. Each hole was 4.5 in. (11.43 cm) from the hole next to it, measured from center to center, or 1.5 in. (3.81 cm) measured from the two closest edges. Of these five holes, only the far left (FL), middle (M), and far right (FR) holes were used as hiding locations. The middle location was situated 9.5 in. (24.13 cm) from the end location, and the end locations were 18 in. (45.72 cm) apart from each other. Felt pieces, slightly less than 3.75 in. (9.5 cm) wide and 8.75 in. (22.22 cm) long, were used as hiding covers. With the covers in place, adjacent covers were separated by an intervening space of white foam rubber of slightly more than one inch. A red plastic key and a small red plastic octopus acted as hiding objects during warm-up trials. A single toy that could be squeaked or shaken to attract the infant's attention but which made no noise when lowered into the hiding hole (a rubber animal or a rattle) was used as the hiding object during experimental trials. All toys could fit entirely within the hiding hole so that the felt cover hiding the toy would be flat on the apparatus. A stopwatch was used to measure the delay interval during the experimental trials.

3. *Procedure*

*S*s were tested in their own homes on a convenient rug-covered floor. Infants were positioned directly in front of the middle hole of the apparatus. The infant's mother sat behind the infant on the floor while the *E* sat across from the infant on the opposite side of the apparatus. A second adult recorded the infant's responses and timed the delay interval employed.

Warm-up trials consisted of two trials in which the infant found a toy uncovered and two trials in which the infant found a toy partially covered. All infants were able to perform warm-up trials successfully.

Experimental trials began with the complete hiding of a toy two consecutive times in a first location, A. This was followed by two consecutive hidings in a second location, B, and, finally, two consecutive hidings in a third location, C. All possible orders of assigning hiding locations to the A, B, and C hiding trials were used: 1) FL-M-FR; 2) FR-M-FL; 3) FL-FR-M; 4) FR-FL-M; 5) M-FL-FR; and 6) M-FR-FL. Each infant was randomly assigned to one of these orders of hiding, with the constraint that each hiding order be used equally often during the course of the entire experiment. The left *vs* right orientation of hiding locations did not affect search patterns. Thus, the six hiding orders employed were reduced to three more general A, B, C hiding sequences: 1) end-end-middle; 2) end-middle-end, and 3) middle-end-end.

During experimental trials, the *E* shook or squeaked the toy over the hole it was to be hidden in until the infant looked at the toy. The toy was then lowered into the hole and covered. The procedure was repeated if the infant stopped looking at the toy before it was covered. Infants were required to wait three seconds after the toy was covered before searching for the toy. A head nod by the adult recording infants' responses was the signal to the *E* that the three-second interval was completed. If the infant tried to reach for the toy before three seconds had elapsed, the mother would restrain the infant by gently holding his or her shoulders. After successfully finding the toy, the infant was allowed to play with it for several seconds before the next trial was begun. If the infant unsuccessfully searched for the toy, the *E* retrieved the toy for the infant before the infant could search further. The infant was then allowed to play with the toy for several seconds before the start of the next trial.

C. Results

The frequency of search for each location during each hiding trial is presented in Table 1, where underlined numbers represent successful searches. These data retain the relative positioning of search attempts in terms of proximity to the currently correct, previously correct, and nonhiding locations. To illustrate, the first two rows of Table 1 present search frequencies at the A location for those 10 infants whose first and second A trials were in either the FL or FR locations, B trials were in the M location, and the C trials were in the other end location, either FL or FR.

Consistent with the memory hypothesis, infants oriented search towards the currently correct location during C, as well as during B hiding trials. As Table 1 illustrates, search attempts tended to form a spatial gradient around the currently correct location, with the frequency of search attempts generally increasing the nearer a hole was to the correct location. Further, this pattern of search was obtained whether the correct location was located at the midline or at the ends of the hiding apparatus. Infant search attempts at the correct location and the two closest holes to the correct location were more frequent (90% of search attempts or more) than would be expected by chance (60%) during each B and C hiding trial, p's $< .01$, binominal tests.

The perseveration hypothesis was not supported. Twenty percent of search attempts during B hiding trials, and 40% of search attempts during C hiding trials, would be expected at previous hiding locations by chance. In the present study, fewer than 10% of search attempts occurred at previous hiding locations during each B hiding trial, and fewer than 25% of search

CUMMINGS, E. MARK, ***Perseveration and search on a five-choice visible displacement hiding task*** , Journal of Genetic Psychology, 142:2 (1983:June) p.283

TABLE 1
FREQUENCIES OF SEARCH AT EACH LOCATION FOR DIFFERENT HIDING SEQUENCES

A, B, C Hiding sequence	Hiding locations: End	Nonhiding	Middle	Nonhiding	End
1. End-middle-end[a]	A		B		C
Trials					
A1	9	1	0	0	0
A2[b]	8	1	0	0	0
B1	0	2	6	2	0
B2	1	0	9	0	0
C1	1	0	1	2	6
C2	0	1	2	2	5
2. End-end-middle[c]	A		C		B
Trials					
A1	10	0	0	0	0
A2	8	1	0	1	0
B1	0	0	2	1	7
B2	0	0	0	0	10
C1	0	2	8	0	0
C2	0	1	8	0	1
3. Middle-end-end[d]	B		A		C
Trials					
A1	0	0	10	0	0
A2	0	0	10	0	0
B1	7	2	1	0	0
B2	7	2	1	0	0
C1	0	1	2	2	5
C2	0	1	2	1	6

Note: Frequencies of successful searches are underlined.
[a] Combines data obtained using the FR-M-FL and FL-M-FR hiding orders.
[b] One infant failed to search on this trial.
[c] Combines data obtained using the FR-FL-M and FL-FR-M orders.
[d] Combines data obtained using the M-FR-FL and M-FL-FR hiding orders.

attempts occurred at previous hiding locations during each C hiding trial. Thus, not only did infants fail to reveal a significant tendency towards perseveration during B or C hiding trials, but the rate of perseverative search did not even approach the level expected by chance. From the point of view of the memory hypothesis this outcome could have been predicted from the fact that previous hiding locations in the present task were always positioned relatively far from the currently correct location (see Table 1).

Another test of the influence of previous hiding locations on infant search is obtained by comparing the number of errors made at previous hiding locations with the number of errors made at nonhiding locations. A perseveration hypothesis would predict no errors at nonhiding locations. However, as is evident in Table 1, more errors were made at nonhiding locations than at previous hiding locations during both B (11 *vs* 3, respectively) and C (12 *vs* 10, respectively) hiding trials. This outcome is also consistent with a memory hypothesis because nonhiding locations were generally closer to the currently correct location than previous hiding locations.

Search accuracy declined from the last A to the first B hiding trial, $p = .055$, binomial test, and from the last B to the first C hiding trial, $p = .01$, binomial test. Repeated trials produced an improvement in performance during B hiding trials, $p = .046$ binomial test.

There were no sex differences in performance on either A, B, or C hiding trials. There was a general improvement in search accuracy as infants got older. This trend reached statistical significance on the first B hiding trial. $\chi^2(2) = 8.39$, $p < .05$. However, regardless of age, search attempts tended to be directed to locations at or near the correct location. For example, on the first B hiding trial the seven 8-month-old infants in the study searched correctly twice, made four errors at the two incorrect locations closest to the correct location, and only once searched at the two locations farthest from the correct location. On the first C hiding trial, six of seven search attempts were again directed at the correct location or the two closest holes to the correct location.

D. Discussion

The results of the present study show that infants do not perseverate during either B or C hiding trials when presented with a task that does not constrain errors to be perseverative. These results suggest that earlier demonstrations indicating that infants perseverate during C hiding trials were largely an artifact of the constraints of the task situation. Rather than searching at previous hiding locations, infants in the present study tended to search at or near the correct location during both B and C hiding trials.

In addition, consistent with an information processing analysis of task demands, infant performance declined from the last A to the first B hiding trial [see Cummings and Bjork (3) for an information processing analysis of these trials], and from the last B to the first C hiding trial. A tendency towards increasingly accurate search on repeated B hiding trials was also replicated (3, 5, 9). Repeated trials at a single location should tend to improve performance because they provide the infant with more time or capacity to make encoding of the object's location more accurate and/or less vulnerable to loss through distraction. However, this expected increase in search accuracy over trials may not always be evident by only the second trial at a given location (for example, see the data for C hiding trials). The pattern of results provides additional evidence for the memory hypothesis contention that infants comprehend the objective nature of spatial relationships, but are less effective information processors than older individuals.

The present results also do not support several other hypotheses regarding infant search errors. There was no evidence that infant errors can be attributed to reliance on an egocentric spatial reference system (1, 2), or a place-going tendency (5). However, these findings are consistent with the notion that infant improvement on object permanence tasks in the last half of the first year (8) reflects a corresponding rapid development in memory capabilities (6, 11).

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Laboratory of Developmental Psychology
NIMH, Building 15K
Bethesda, Maryland 20205

Department of Psychology
University of California
Los Angeles, California 90024