CHICK'S AVOIDANCE OF VISUAL PITFALLS: A REEXAMINATION OF FINDINGS BY THE VISUAL CLIFF TECHNIQUE

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Chick's avoidance of visual pitfalls was observed in a freely explorable open field situation. Fifty-one naive male chicks from 26 to 36 hours of age were used. After habituation a group of three animals was assigned to each of seventeen conditions and observed for five minutes. Conditions were classified into three; homogeneous non-pitfall, heterogeneous non-pitfall and pitfall situations. Animals successfully avoided pitfalls when motion parallax existed between two surfaces. Density difference was shown to be ineffective as avoidance cue when isolated from motion cue. Animals locomoted vivaciously and speedily, covering a long distance in the non-pitfall and the pitfall situations without motion parallax, while in the pitfall situation with motion cue their locomotion was reduced and they stayed at a position for a long time. Such findings reconfirmed the previous ones obtained by Gibson, Walk and others.

Comprehensive studies which Gibson, Walk, and their collaborators made by means of the visual cliff technique have provided us with much suggestive information on visual depth perception. Their experiments made use of a sort of optical testing situation which permitted comparative studies and which allowed the same essential stimulus variables to be applied to a number of different animal species (Gibson, E. J. & Walk, 1960; Routtenberg & Glickman, 1964; Walk, 1972). Moreover, their data have a direct bearing on the nature-nurture problem of depth perception, since the technique could be applied without any special training even when the animal had had no previous visual experience at all (Lashley & Russell, 1934; Walk & Gibson, E. J., 1961).

Their findings may be summarized as follows: (1) All of the animals studied (human infants, monkeys, kittens, dogs, pigs, lambs, kids, rats, chicks, land and aquatic turtles, so on) discriminated depth visually by the time on which locomotion became possible, but this time varied widely among species. (2) Analysis of the cues

on which animal's preference depended suggested that motion perspective is essential for visual depth perception, while density perspective is acquired as a cue on the basis of contingency with the motion cue. (3) Observation of animal's behavior on the edge of cliff suggested that it depended on fear. Response to the loss of visual support seems to be unlearned, a reflex, and may be related to its own way of life. The strongest reaction was the reflex-like backing response accompanied by forelimb rigidity which was observed among ungulates like lambs or kids. Loss of visual support failed to produce any remarkable reaction with animals like rats or aquatic turtles whose behavior is not guided so dominantly through visual perception as ungulate's one. Such a difference in reactions, therefore, might indicate differences in the degree of fear generated by the visual cliff and in the importance of visual perception in the adaptation.

Though Gibson and others' studies gave us much on the genesis of depth perception, some problems remain still unsolved.

First, their visual cliff situation consisted

of two surfaces, deep and shallow sides and forced an animal to step down to either side from a centerboard. If an animal perceives depth visually in such a situation, he would naturally hesitate or resist to step down to either side, thus stay on the centerboard. In spite of that, the frequency of no responses was discarded in their data-processing.

Secondly, linear perspective was not separated completely from motion perspective because the visual cue generated from side walls of the cliff seems to act inevitably as one of the determinants for choice response. When one proceeds to inquire the process in which density perspective acquires the cue value for visual depth perception, such a separation will be basically required.

Thirdly, the kind of animals used could be questioned. In their cue analysis they used hooded rats as subjects. Rat, however, is a kind of animal whose behavior is steered mainly by the aid of tactual and

olfactory cues, not by the visual one. In fact, rats showed poor performance as well as just insensitive reactions to the loss of visual support. Thus the adequacy of rat as a 'tester' remains doubtful.

Finally cited were the measurement of fear and the interpretation of species differences from it. They ranked the degree of fear generated by the loss of visual support or the behavior observed on the edge of visual cliff, and asserted that such a rank-order might be corresponded with relative dominancy of visual perception in the adaptation. Such an inference, however, may be doubtful when one consider that each species has its unique response repertoire. Some physiological measures would make such a comparison among species easier.

The present authors mainly aim at tracing the process in which depth perception is elaborated from its beginning ontogenetically. Before setting up it, problems just cited above will have to be discussed. In this article the authors at-

FIG. 1. Visual pitfall situation.

FIG. 2-a. Apparatus (Side view).

FIG. 2-b. A schematic representation of the visual pitfall situation.

TABLE 1
Conditions used in the experiment

Condition	Basal surface	Lower surface	Side walls	Situation
1. W-O-O	white	no	no	non-pitfall with uniform basal surface
2. B-O-O	black	no	no	
3. C-O-O	checker	no	no	
4. W-B-O	white	black	no	non-pitfall with heterogeneous basal surface
5. W-C-O	white	checker	no	
6. B-W-O	black	white	no	
7. C-W-O	checker	white	no	
8. C-C-O	checker	checker (small)	no	
9. W-B-B	white	black	black	pitfall with homogeneous inside
9. W-D-D	white	dark	dark	
10. W-W-W	white	white	white	
11. B-W-W	black	white	white	
12. C-W-W	checker	white	white	pitfall with heterogeneous inside
13. W-W-C	white	white	checker	
14. W-C-W	white	checker	white	
15. W-C-C	white	checker	checker	
16. C-C-W	checker	checker	white	
17. C-C-C	checker	checker	checker	

tempted to reexamine Gibson and others' findings by modifying their technique to meet our requirements.

As mentioned above, their visual cliff situation is a forced choice one. The authors devised a kind of visual pitfall shown in Fig. 1 and attempted to see whether animals avoid pitfalls in such a freely explorable situation. Our pitfall situation has an advantage of isolating motion parallax more easily from linear perspective formed by side walls than a visual cliff situation. Therefore, effect of each cue can be isolated more fully and systematically in our situation. For the subject used, chicks were chosen because they are visually guided and can locomote freely shortly after birth (Fishman & Tallarico, 1961). Their locomotive activities may be convenient for behavior observation.

Method

Apparatus. Behavior space is a sort of freely explorable open field on which six visual pitfalls are scattered randomly to block an animal from

moving straightward (Figs. 2-a, 2-b). As easily seen, animal's avoidance of visual pitfall can be observed during an unforced or free exploration period, while visual cliff situation forced an animal to step down to either side, deep or shallow one. Moreover, pitfall situation makes linear perspective which probably acts as one of cues in discriminating depth isolate from motion perspective which is considered as a primary cue. The latter advantage, however, was not attained satisfactorily, for too small height of chicks made our device not so effective; if an animal stands near the edge of pitfall and peeps into it, he can see the lower part of side walls which form linear perspective.

The basal surface on which animals locomoted, the lower (bottom) surface and side walls were independently varied as shown later. The basal surface was covered with a plain transparent plexiglass which kept animals from falling into pitfalls. Pitfall areas amounted to 13% of the total basal area and were illuminated at 120 lux while the basal surface at 170 lux. The whole apparatus was covered

TABLE 2-a
Results obtained in the uniform non-pitfall situations

Measure	Latency of intrusion			Frequency of intrusion			Total time of stay			Impression of avoidance				
Subject	A	B	C	A	B	C	A	B	C	A	B	C	T	R*
1. W-O-O	42"	229	—	6	2	0	52"	31	0	—	—	=	—	
2. B-O-O	—	44	—	0	1	0	0	2	0	?	?	?	?	—
3. C-O-O	24	41	158	8	7	2	187	92	94	—	—	—	—	

* T: total, R: reexamined

TABLE 2-b
Results obtained in the heterogeneous non-pitfall situations

Measure	Latency of intrusion			Frequency of intrusion			Total time of stay			Impression of avoidance				
Subject	A	B	C	A	B	C	A	B	C	A	B	C	T	R
4. W-B-O	10	—	3	1	0	2	75	0	134	—	?	—	—	
5. W-C-O	20	56	61	6	4	6	85	90	71	—	—	—	—	
6. B-W-O	32	32	67	2	6	4	31	63	55	—	—	—	—	
7. C-W-O	15	12	—	2	3	0	12	6	0	=	=	?	=	—
8. C-C-O	49	265	21	2	1	3	71	35	27	—	—	—	—	

TABLE 2-c
Results obtained in the pitfall situations

Measure	Latency of intrusion			Frequency of intrusion			Total time of stay			Impression of avoidance				
Subject	A	B	C	A	B	C	A	B	C	A	B	C	T	R
9. W-B-B	97	66	54	2	2	6	131	75	114	—	—	—	—	
9. W-D-D	—	162	—	0	1	0	0	97	0	?	?	?	?	—
10. W-W-W	141	50	152	4	10	3	111	113	114	—	—	—	—	
11. B-W-W	—	131	132	0	1	7	0	172	84	?	—	—	—	
12. C-W-W	172	176	47	1	3	7	2	37	26	—	—	—	—	
13. W-W-C	—	31	—	0	1	0	0	62	0	=	=	?	=	+
14. W-C-W	—	—	—	0	0	0	0	0	0	+	?	+	+	
15. W-C-C	—	259	—	0	1	0	0	4	0	?	?	?	?	?
16. C-C-W	—	—	—	0	0	0	0	0	0	+	?	+	+	
17. C-C-C	—	—	—	0	0	0	0	0	0	?	+	?	?	+

with white curtain to eliminate external cues. Room temperature was kept at approximately 80°F.

Condition. The basal surface, the lower surface and side walls were independently varied among conditions. Homogeneous black (B), homogeneous white (W) and checker (C) were used as stimulus patterns of these surfaces and walls. The conditions used are shown in Table 1. They are denoted like

C-B-B, which means checker basal surface, black lower surface and black side walls. Likewise, W-O-O means uniformly white surface without pitfalls, W-B-O black-spotted white basal surface, for examples. O in the last term means lack of side walls, i. e. non-pitfall situation.

Subject. 51 male chicks from 26 to 36 hours of age were used. They had been raised in an incubator under dimly lighted condi-

tion after birth. Temperature inside the incubator was kept at 104°F.

Procedure. Animals were permitted to explore the basal surface under one of conditions, C-O-O, W-O-O, or B-O-O for a ten-minute habituation period. This was given to release animals from fear which was probably induced by a novel situation.

After habituation they were put back to the incubator till they were again brought to the apparatus for observation. A group of three animals was assigned to each condition for observation of pitfall avoidance behavior. They were put on the places dotted in Fig. 2-b and were observed for five minutes.

Adopted measures were (1) latency of intrusion in a pitfall, (2) frequency of intrusion, (3) total time of stay in pitfall. Subject's behavior was also recorded by a video recorder and total impression of pitfall avoidance was rated as avoidance (+), non-avoidance (−), neutral (=) or unratable (?). When his behavior was rated equivocally, same condition was replicated.

Result

Results are shown in Tables 2-a, 2-b and 2-c.

Conditions 1–3 are control situations to appreciate the pitfall avoidance behavior. It can clearly be seen that animals locomoted so freely that they often intruded the areas which would be used for the pitfalls in Conditions 9–17. Conditions 4–8 are also non-pitfall situation. In all of those conditions animals showed no indication of avoiding heterogeneous areas differed only in density or brightness. It was thus demonstrated that a difference in density or brightness, when isolated from motion perspective, was ineffective. Though the result of Condition 7 were not clear at the first observation shown in Table 2-b, non-avoidance was confirmed by reexamining the same condition. Such an inference would be more convincing when we take it into considerations that our findings were obtained in spite of the incomplete control of subject's early visual

experience.

All of Conditions 9–17 are pitfall situations in which an optical fall exists between the basal surface and the lower one. In Conditions 9–12 among them, inside of the pitfall is homogeneously white or black—darkened in Condition 9—and provides no positive cues for depth perception if 'emptiness' itself does not generate animal's avoidance behavior. The authors have ordinarily experienced that 'empty darkness' often induces impressions of depth for human eyes and therefore had expected that pitfall would be avoided also by chicks in those conditions. The results, however, were against the authors' expectation and animals failed to avoid pitfall, which might suggest that existence of any distinct cue is essential for depth perception.

Conditions 13–17 except 13 are the situation in which the lower surface has checker patterns so that motion parallax would occur between the basal surface (or its edge) and the lower one when an animal moves his head.

Condition 13 was designed to give only a cue of linear perspective generated from patterns on side walls, but actually motion parallax was not eliminated completely.

As expected, it was clearly shown that pitfalls were successfully avoided in Conditions 14, 16 and 17.

In Condition 13, one of three animals was pushed into a pitfall and stayed there for nearly one minute once for the observation period, while other two did not. To confirm the result, the same condition was replicated putting seven animals together. The increase in the number of subjects from three to seven was to stimulate their locomotive behavior. Almost all of them avoided pitfalls, though only one retreated to intrude a pitfall twice. Therefore, animal's behavior in this condition could be judged as avoidance. From the result, this condition are considered to have been perceived in different ways like W-W-C or W-W-W, depending upon the animal's

position to a pitfall.

In Condition 15, one of three animals passed through a pitfall, but overall locomotion was reduced. According to the reexamination of the condition, only one animal passed through a pitfall twice, but overall locomotion was again reduced. Thus total impression was unratable.

Additionally, difference in animal's locomotive behavior was clearly observed between Conditions 1-12 and 13-17. Animals locomoted vivaciously and speedily, covering a long distance in the former conditions, as compared with latter ones in which their overall behavior was reduced and they often stayed at a position for a long time. Such a decrease in freedom of behavior would be attributed to the drive state like fear which was induced by the pitfall situation.

Discussion

As mentioned, results obtained in the pitfall situation also reconfirmed the conclusion Gibson, Walk and others had led with their visual cliff technique. That is to say that motion perspective is an essential cue innately built in the organism for discriminating depth.

Some problems, however, remain still untouched in this article. First, as we already mentioned, our pitfall situation failed to separate motion perspective from linear perspective completely. The result of Condition 13 was unclear in tendency

and we are now planning to devise an apparatus to fulfill that purpose.

Secondly, we have to demonstrate that such an avoidance of visual pitfall depended upon chick's fear by means of more direct measure. Heart rate is to be one of such indices. Though there seemed to be some difficulties in recording ECG from young chicks, we have recently succeeded in getting a comparatively stable record in the pitfall situation. For the finding readers should refer to our next article.

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