

SPACE PERCEPTION OF TORTOISES.

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The Sense of Support in Animals.

A number of investigators have noticed that the young of many animals possess a sense of support, and that their behavior is adapted to the spatial conditions in which they happen to be placed. It is this sense of support that saves the sightless kitten or puppy from falls; but in case of the young chick which similarly hesitates when it approaches the edge of a void visual stimuli apparently determine the reaction. These reactions to spatial conditions are controlled by a *complex* of sense impressions which is still unanalyzed. In certain animals visual impressions seem to be all-important; in others organic data are chiefly significant, and again in other organisms there are indications of degrees of sensitiveness, if not modes of sense, of which we have no direct knowledge. And so, strange as it may seem, the "spatial worth" of sense data, as JAMES would call it, is no more a matter of accurate knowledge than is the development of the sense of space, or the modes of behavior in different spatial conditions exhibited by any animal.

THORNDIKE ('99, p. 284), who has studied the behavior of young chicks with reference to spatial relations, says "If one puts a chick on top of a box in sight of his fellows below, the chick will regulate his conduct by the height of the box." A chick 95 hours old does not hesitate to jump off at heights of 1 to 10 inches; at 22 inches it often hesitates a long time, and at 39 inches it usually does not jump at all. Furthermore, immediately after hatching, young chicks are able to peck at objects with considerable accuracy, and they apparently estimate distances fairly well before they have had much experience outside the shell.

The behavior of young pigeons, chicks, kittens and puppies in unusual spatial conditions has been studied most fully by MILLS ('98, p. 150), who in discussing the "sense of support" writes: "I have found in the case of all puppies, and several other kinds of animals examined, that even on the first day of birth they will not creep off a surface on which they rest, if elevated some little distance above the ground. When they approach the edge they manifest hesitation, grasp with their claws or otherwise attempt to prevent themselves falling, and, it may be, cry out, giving evidence of some profound disturbance in their nervous system.

"It would seem that there is no more urgent psychic necessity to young mammals than this sense of being supported. All their ancestral experiences have been associated with *terra firma*, so that it is not very surprising that when *terra firma* seems about to be removed they are so much disturbed. To my own mind this is one of the most instructive and striking psychic manifestations of young animals, though I am not aware that any attention has been called to it before; and instead of referring to it under any of the usual divisions of sense, as the muscular sense, pressure sense, etc., I prefer to treat the subject under the above general heading (Sense of Support), for it seems to me that the feeling is a somewhat complex one.

"It is interesting to note that a water tortoise I have had for a number of years will at any time walk off a surface on which he is placed. But this is not a creature that always is on *terra firma* in the same sense as a dog, but it frequently has occasion to drop off logs, etc., into the water. But again, I find this sense of support well marked in birds which drop themselves into 'thin air'. Nevertheless, a consideration of ancestral experiences throws light on most cases, and perhaps on this one also."

Concerning white rats, SMALL ('99, p. 93) states that "as early as the second day (after birth) they show an uneasiness when on the edge of a void—sometimes drawing back, sometimes manifesting their dominant trait of curiosity by leaning over and sniffing. At the age of four or five days the presence

of this sense (the sense of support) is unmistakable, and is not due to experience, as I have found by trying rats that have had no such experience." And WATSON ('03, p. 40) remarks that a rat that wanted to get down from the top of the food box "would usually stretch his head down two or three times, then pull himself back, as though he feared to attempt such a dangerous a feat."

The observations quoted indicate the possibility of interesting studies of the development of space perception in animals, and of such analyses of the sensory complex as shall exhibit the 'spatial worth' of each kind of sense data. Partly for the purpose of making an approach to the comparative study of space perception, partly for the solution of the following specific problems I have observed the behavior of several species of tortoises with respect to spacial conditions. The question which really led to the investigation was, What relation do the reactions of tortoises to space bear to their habits? Does the water species behave in essentially the same manner as does the land-inhabiting form? The attempt to answer this question led to the study of the general behavior of different species, and of the importance of vision and the 'sense of support' in reactions to space.

Relation of Reactions to Space to Habits in Tortoises.

My method of experimentation was to place a tortoise in the middle of a board 30 cm. by 60 cm. which was elevated 30 cm., 90 cm. or 180 cm. above a net of black cloth into which the animal fell when it crawled or plunged over the edge of the board. The fall was thus rendered harmless to the animals, and they gave no evidence, by increased hesitancy in crawling off, that it was disagreeable to them. The observer carefully noted the behavior of the tortoise while it was on the board, and recorded the time that it remained there. It would seem that the time from the noticing of the edge of the board till the fall should be recorded rather than the total time spent on the board, but as it was found that some species notice the spatial conditions while they are still in the middle of the board, whereas

others give no evidence of perception of the height until they have reached the edge, it was necessary to make the record as described. Since in these experiments it was necessary that time as well as space should be considered, 60 minutes was fixed as the duration of the experiment, and in case the animal remained on the board longer than that period the test was recorded as a failure. Failures in this case have positive value, to be sure, but they do not give us the accurate measurement of the time of reaction which indefinite prolongation of the period of observation would furnish.

For detailed study three species were chosen: *Chrysemys picta* Schneider, as a representative of the water inhabiting forms; *Nanemys guttata* Schneider, to represent those species which spend part of their lives in water and part on land, and *Terrapene carolina* Linnaeus, as a strictly land inhabiting form.

Several individuals of each of the species were studied. In the tables the results for four individuals of each are presented. Each individual was given one trial a day at each of the three heights, 30, 90 and 180 cm. for ten days. In Table I we have a summary of the results, which are given in detail for the various individuals in Table II. From an examination of the records the following facts appear: (1) The time spent on the board is shortest for the water species, longest for the land species. This indicates that the hesitation in the presence of a void increases as we pass from the strictly water forms to

TABLE I.

Reactions to Spatial Conditions of Tortoises of Different Habits.
Summary of Results.

Height.	<i>Chrysemys picta.</i>		<i>Nanemys guttata.</i>		<i>Terrapene carolina.</i>	
	Average Time.	Failures	Average Time.	Failures.	Average Time.	Failures.
30 cm.	0.57'	0	27.6'	11	42.7'	9
90 cm.	6.30'	0	49.1'	30	54.2'	33
180 cm.	10.10'	1	60.0'	40	59.2'	39

TABLE II.
Reactions to Spatial Conditions of
Chrysemys picta.

Subject No. 3.			No. 7.		No. 8.		No. 9.	
Height.	Average Time.	Failures	Average Time.	Failures.	Average Time.	Failures.	Average Time.	Failures.
30 cm.	0.37'	0	0.69'	0	0.74'	0	0.47'	0
90 cm.	12.80'	0	4.80'	0	3.10'	0	4.60'	0
180 cm.	17.50'	1	4.00'	0	2.30'	0	16.60'	0

Nanemys guttata.

Subject No. 1.			No. 2.		No. 3.		No. 5.	
30 cm	32.0'	5	9.4'	0	38 5'	5	30.4'	1
90 cm	60.0'	10	30.8'	4	53.6'	8	52.0'	8
180 cm	60.0'	10	60.0'	10	60.0'	10	60.0'	10

Terrapene carolina.

Subject No. 1.			No. 2.		No. 3.		No. 5.	
30 cm.	36.1'	0	38.1'	1	55.3'	7	41.4'	1
90 cm.	60.0'	10	40.7'	4	56.3'	9	60.0'	10
180 cm.	60.0'	10	56.8'	9	60.0'	10	60.0'	10

those which are land inhabiting ; (2) Total inhibition of the reaction, i. e., failure to crawl over the edge of the board in the 60 minutes, appears at a much less height for the land species than for the water-land and water forms.

This quantitative expression of the amount of hesitation exhibited by different species of tortoises under the same spatial conditions clearly indicates a close relation between the demands of the natural environment of the species, so far as spa-

tial relations are concerned, and the behavior of the animals. A land tortoise has cause to notice heights and to react to them in a manner different from that of a water form. The former plunges over a precipice and is dashed to pieces, the latter plunges into the water from an equal height without injury. It is interesting to note, too, that there are intermediate forms between the two extremes, for the "spotted" tortoise *N. guttata* is more careful in its reactions to space than *C. picta*, but less so than *T. carolina*.

We may now turn from the roughly quantitative facts of this study to the observations of the general behavior of the animals when placed in unusual spatial conditions.

Of the three species of tortoises under consideration *Chrysemys picta* is the most active. At a height of 30 cm. it usually plunges off without hesitation; at 90 cm. it frequently stops at the edge, looks about carefully, and sometimes draws back and seeks another part of the edge. There can be no doubt that it senses the spatial relations in visual terms. At 180 cm. this species is manifestly afraid of the edge. Some individuals hesitate for long intervals before pushing off into space; others rush off at once. Usually, however, at this height the edge of the board is carefully explored, and abortive attempts to push off are made repeatedly. There is no evidence that the unusual conditions are perceived until the animal reaches the edge of the board.

Nanemys guttata hesitates even at the height of 30 cm. Most individuals carefully examine the board and look intently toward the net and surrounding objects before pushing off. They crane the neck over the edge to a greater extent than does *C. picta*. When 90 cm. or more above the net this species seldom approaches the edge without manifestations of fear. Frequently an individual pushes itself almost over, then stops suddenly and draws back, or attempts to catch the edge with its claws to save itself from falling. This striking conflict of impulses sometimes occurs repeatedly before the animal finally goes over the edge. The tortoise is impelled by the narrowness of its confines on the board, and by its isolated and exposed posi-

tion to seek escape, and, in the case of the water tortoises, to seek the water, but as it is pushing over the edge the visual impressions of distance initiate a conflicting motor impulse which causes the animal to draw back. This species manifests fear much more markedly, frequently, and at a less height than does *C. picta*. On the whole we may say that its behavior to spatial relations would ordinarily be interpreted as indicative of more accurate space perception.

At none of the three heights used in the experiments does *Terrapene carolina* push over the edge without some hesitation and manifestations of fear. At 30 cm. almost all individuals

TABLE III.

<i>Terrapene bauri</i> Taylor	Behavior much the same as that of <i>T. carolina</i> . There is careful inspection of the surroundings and long hesitation. One individual was found that plunged off directly at the height of 180 cm.
<i>Xerobates polpyhemus</i> Daudin	Examination of edge as in <i>T. bauri</i> . Hesitation at 30 cm., and great fear at 180 cm.
<i>Testudo vicina</i> Günther	Not afraid to fall 30 to 50 cm. but careful when at greater heights.
<i>Chelopus insculptus</i> Laconte	This species shows greater hesitation than does <i>N. guttata</i> . At 30 cm. it examines the surroundings, and often fails to leave the board.
<i>Emys meleagris</i> Shaw	In this species there is some hesitation at 30 cm. but seldom failure to go off. At 180 cm. there is marked fear as in <i>N. guttata</i> , which it very closely resembles in its behavior.
<i>Chelodina novaehollandiae</i> Dumeril et Bibron	Although this form carefully examines the edge and looks at the floor intently it seldom fails to go off. Its actions are very deliberate in most cases.
<i>Trachemys scabra</i> Agassiz	Many individuals pay no attention to the edge. Little hesitation even at 180 cm. Behaves much like <i>C. picta</i> .
<i>Podocnemis madagascariensis</i> Grandidier	No hesitation, no fear at any height at which it was tried. Pays less attention to spatial conditions than any of the species studied.

will leave the board if given plenty of time. This species is more careful than the others in approaching the edge, and it cranes the neck over even more frequently than does *C. picta*. The inhibition of impulses frequently appears as in case of *N. guttata*. Unlike the other species, *T. carolina* notices the spatial relations from its position in the middle of the board, for when 180 cm. above the net an individual is frequently afraid to move, and will remain for a long time just where the experimenter has placed it.

This study of the reactions to space of the three species of tortoises already considered was supplemented by observations of the behavior of several other species at the heights of 30 and 180 cm. In Table III, a summary statement of the results is presented.

Without knowledge of the name of the species, but solely on the basis of the results of the experiments, I classified the species under the three categories Water, Land-Water, and Land Species in order to determine the value of reactions to space as a sign of habits.

Classification in accordance with reactions to space.

Water Species.	Land-Water Species.	Land Species.
<i>Chrysemys picta</i>	<i>Emys meleagris</i>	<i>Terrapene bauri</i>
<i>Podocnemis mada-</i> <i>gascariensis</i>	<i>Nanemys guttata</i>	<i>Terrapene carolina</i>
<i>Chelodina novaehollandiae</i>		<i>Xerobates polyphemus</i>
<i>Trachemys scabra</i>		<i>Testudo vicina</i>
<i>Polymedusa galeata</i>		<i>Chelops insculptus</i>

This classification agrees fairly well with what is known of the habits of the forms, except that *Chelopus insculptus* is a land-water rather than a land species.

The Spatial Worth of Sense Data.

For the purpose of ascertaining the relative importance for reactions to space of the visual, tactual, muscular and organic sense impressions some experiments were made with blindfolded tortoises. The eyes, in these experiments, were covered with tin-foil caps which effectually excluded visual stimuli.

C. picta when blindfolded usually rushed off a surface at any height without the least hesitation. There is no evidence, from my experiments, that the tactual and muscular impressions received when the legs are stretched over the edge have any inhibitory influence on the movement. From this it is clear that the hesitation of this species observed at heights of 180 cm. is due to visual impressions, not to the unusual organic impressions received. This species at first tries to remove the covering from the eyes by rubbing the fore legs over the head, but failing it soon becomes accustomed to the blindfolded condition.

N. guttata is much disturbed by the obstruction of its vision, and for long periods persistently tries to remove the cap. Most individuals after a time move about freely, but whenever they reach the edge of the board they turn back. Evidently the tactual and muscular impressions inhibit the tendency to move forward. Whereas in case of *C. picta*, we see the blindfolded animal risking falls which it would not have risked in its normal condition, in *N. guttata* we see exactly the reverse, for as a rule the animal when blindfolded does not leave the board.

T. carolina does not struggle so persistently to remove the covering as do the other species, but it is inactive when blindfolded. It behaves in general much as it does when placed at a height of 180 cm. above the floor. This indicates that it depends upon vision for guidance in its movements to such an extent that it is not likely to move about much unless it can see clearly.

Visual impressions are of prime importance in the space perception of tortoises, and tactual, muscular and organic data occupy a position of secondary importance. Yet there are many reasons for believing that we often underestimate the value in the reactions of simple organisms of that complex mass of sense impressions which we are not as yet able to refer to specific organs. JAMES ('90, II, p. 150) has called attention to a fact that is significant in this connection; "Rightness and leftness," "upness and downness," he says, "are again pure sensations differing specifically from each other, and generically from

everything else." We are inclined to lose sight of the organic impressions, and to refer reactions to data received through the so-called special senses. Many experiments have already been made which show that the direction of turning, apart from vision, is extremely important in the motor habits of tortoises and frogs.

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