THE INTELLIGENCE OF ANIMALS.[1]

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IN the immense realm of the invertebrates, the highest psychical development is, by general acknowledgment, met with among the social Hymenoptera; and the capital representatives of this group are the ants. To these we may confine ourselves. Despite their tiny size, their brain, particularly among the neuters, is remarkable in structure—"one of the most marvellous atoms," says Darwin, "in all matter, not excepting even the human brain." Injuries to this organ, which are frequent in their sanguinary combats, cause disorders quite analogous to those observed in mammals. It is useless to recall what every one knows of their habits their organisation of labor, varied methods of architecture, their wars, plundering and rape, practice of slavery, methods of education, and (in certain species) their agricultural labors, harvesting, construction of granaries, etc.[2] We, on the contrary, must examine the exceptional cases in which the ants depart from their general habits; for their ability to abstract, to generalise, and to reason, can only be established by new adaptations to unaccustomed circumstances. The following may serve as examples:

"A nest was made near one of our tramways," says Mr. Belt, "and to get to the trees, the leaves of which they were harvesting, the ants had to cross the rails, over which the cars were continually passing and re-passing. Every time they came along a number of ants were crushed to death. They persevered in crossing for some time, but at last set to work and tunnelled underneath each rail. One day, when the cars were not running, I stopped up the tunnels with stones; but although great numbers carrying leaves were thus cut off from the nest, they would not cross the rails, but set to work making fresh tunnels underneath them."

[1] Translated from the French by Frances A. Welby.

[2] For details see Romanes, *Animal Intelligence*, Chapters III. and V.

Another observer, Dr. Ellendorf, who has carefully studied the ants of Central America, recounts a similar experience. These insects cut off the leaves of trees and carry them to their nests, where they serve various purposes. One of their columns was returning laden with spoils.

"I placed a dry branch, nearly a foot in diameter, obliquely across their path, which was lined on either side by an impassable barrier of high grass, and pressed it down so tightly on the ground that they could not creep underneath. The first comers crawled beneath the branch as far as they could, and then tried to climb over, but failed owing to the weight on their heads. . . . They then stood still as if awaiting a word of command, and I saw with astonishment that the loads had been laid aside by more than a foot's length of the column, one imitating the other. And now work began on both sides of the branch, and in about half an hour a tunnel was made beneath it. Each ant then took up its burden again, and the march was resumed in the most perfect order."

They also show considerable inventiveness in the construction of bridges. It appears from numerous observations that they know how to place straws on the surface of water, and to keep them in equilibrium or unite their several ends together with earth, moisten them with their saliva, restore them when destroyed, and to construct a highway made of grains of sand, etc. (Réaumur.) They even employ living bridges: "The ground about a maple tree having been smeared with tar so as to check their ravages, the first ants who attempted to cross stuck fast. But the others were not to be thus entrapped. Turning back to the tree they carried down aphides which they deposited on the tar one after another until they had made a bridge over which they could cross the tarred spot without danger."[1]

I shall cite no observations on the intelligence of wasps and bees, but I wish to note one rudimentary case of generalisation. Huber remarked that bees bite holes through the base of corollas when these are so long as to prevent them from reaching the honey in the ordinary way. They only resort to this expedient when they find they cannot reach the nectar from above; "but having once ascertained this, they forthwith proceed to pierce the bottoms of all the flowers of the same species." Doubtless association and habit may be invoked here, but before these were produced, was there not an extension of like to like?

For the higher animals I shall also restrict myself to the upper

[1] Romanes. *Animal Intelligence*, Chapter III.

types. We shall of course reject all observations relating to "performing" animals, all acquirements due to education and training by man, as also the cases in which, as in the beaver, there is a perplexing admixture of instinct so called (a specific property), and adaptation, varying according to time and place.

The elephant has a reputation for intelligence which may be somewhat exaggerated. His psychology is fairly well known. We may cite a few characteristic traits that bear upon our subject. He will tear up bamboo canes from the ground, break them with his feet, examine them, and repeat the operation until he has found one that suits him; he then seizes the branch with his trunk and uses it as a scraper to remove the leeches which adhere to his skin at some inaccessible part of his body. "This is a frequent occurrence, such scrapers being used by each elephant daily." When he is tormented by large flies he selects a branch which he strips of its leaves, except at the top, where he leaves a fine bunch. "He will deliberately clean it down several times, and then laying hold of its lower end he will break it off, thus obtaining a fan or switch about five feet long, handle included. With this he keeps the flies at bay. Say what we may, these are both really *bona fide* implements, each intelligently made for a definite purpose."

"What I particularly wish to observe," says an experienced naturalist, "is that there are good reasons for supposing that elephants possess abstract ideas; for instance, I think it is impossible to doubt that they acquire through their own experience notions of hardness and weight, and the grounds on which I am led to think this are as follows. A captured elephant, after he has been taught his ordinary duty, say about three months after he is taken, is taught to pick up things from the ground and give them to his mahout sitting on his shoulders. Now for the first few months it is dangerous to require him to pick up anything but soft articles, such as clothes, because the things are often handed up with considerable force. After a time, longer with some elephants than others, they appear to take in a knowledge of the nature of the things they are required to lift, and the bundle of clothes will be thrown up sharply as before, but heavy things, such as a crowbar or piece of iron chain, will be handed up in a gentle manner; a sharp knife will be picked up by its handle and placed on the elephant's head, so that the mahout can also take it by the handle. I have purposely given elephants things to lift which they could never have seen before, and they were all handled in such a manner as to

convince me that they recognised such qualities as hardness, sharpness, and weight."

Lloyd Morgan, who, in his books on comparative psychology, is evidently disposed to concede as small a measure of intelligence to animals as possible, comments upon the above observation as follows:[1]

"Are we to suppose that these animals possess abstract ideas? I reply—That depends upon what is meant by abstract ideas. If it is implied that the abstract ideas are *isolates*; that is, qualities considered quite apart from the objects of which they are characteristic, I think not. But if it be meant that elephants, in a practical way, 'recognise such qualities as hardness, sharpness, and weight,' as *predominant* elements in the constructs they form, I am quite ready to assent to the proposition."

I agree fully with this conclusion, adding the one remark that between the pure abstract notion and the "predominant" notion so called, there is only a difference of degree. If the predominant element is not isolated, detached, and fixed by a sign, it is certainly near being so, and deserves on this ground to be called an abstract of the lower order.

The observation of Houzeau has been frequently quoted respecting dogs, which, suffering from thirst in arid countries, rush forty or fifty times into the hollows that occur along their line of march in the hope of finding water in the dry bed. They could not be attracted by the smell of the water, nor by the sight of vegetation, for these are wanting. They must thus be guided by general ideas, which are doubtless of an extremely simple character, and, in some measure, supported by experience."

It is on this account that the term "generic image" would in my opinion be preferable for describing cases of this character.

"I have frequently seen not only dogs, but horses, mules, cattle, and goats, go in search of water in places which they had never visited before. They are guided by general principles, because they go to these watering places at times when the latter are perfectly dry.[2] Undoubtedly it may be objected that association of images here plays a preponderating part. The sight of the hollows recalls the water which, though absent, forms part of a group of sensations which has been perceived many times; but since the generic image is, as we shall see later, no more than an *almost*

[1] C. Lloyd Morgan. *Animal Life and Intelligence*, Chapter IX., p. 364.

[2] Houzeau, *Etudes sur les facultés mentales des animaux*, Vol. II., p. 264 et seq. The same author gives an example of generalisation in bees.

passive condensation of resemblances, these facts clearly indicate its nature and its limits.

I shall merely allude without detailed comment to the numerous observations on the aptitude of dogs and cats for finding means to accomplish their aims, the anecdotes of their mechanical skill, and the ruses (so well described by G. Leroy) which the fox and the hare employ to outwit the hunter, "when they are old and schooled by experience; since it is to their knowledge of facts that they owe their exact and prompt inductions." The most intelligent of all animals, the higher orders of monkeys, have not been much studied in their wild state, but such observations as have been made, some of which have been contributed by celebrated naturalists, fix with sufficient distinctness the intellectual level of the better endowed. The history of Cuvier's orang-outang has been quoted to satiety. The more recent books on comparative psychology contain ample testimony to their ability to profit by experience[1] and to construct instruments. A monkey, not having the strength to lift up the lid of a chest, employed a stick as a lever. "This use of a lever as a mechanical instrument is an action to which no animal other than a monkey has ever been known to attain." Another monkey observed by Romanes, also "succeeded by methodical investigation, *without assistance*, in discovering for himself the mechanical principle of the screw; and the fact that monkeys well understand how to use stones as hammers, is a matter of common observation." They are also skilful in combining their stratagems, as in the case of one who, being held captive by a chain, and thus unable to reach a brood of ducklings, held out a piece of bread in one hand, and on tempting a duckling within his reach, seized it by the other, and killed it with a bite in the breast."[2]

One mental operation remains which must be examined separately, and in its study we shall pursue the same method, wherever it occurs, throughout this work. The process in question has the advantage of being perfectly definite, of restricted scope, completely evolved, and accessible to research in all the phases of its development, from the lowest to the highest. It is that of *numeration*.

Are there animals capable of counting? G. Leroy is, I believe, the first who answered this question in the affirmative, in a passage which is worth transcribing, although it has been often quoted.

[1] Darwin, *The Descent of Man*, Vol. I., Chapter III.

[2] Romanes, *loc. cit.*, Chapter XVII.

"Among the various ideas which necessity adds to the experience of animals, that of number must not be overlooked. Animals count, —so much is certain; and although up to the present time their arithmetic appears weak, it may perhaps be possible to strengthen it. In countries where game is preserved, war is made upon magpies because they steal the eggs of other birds. . . . And in order to destroy this greedy family at a blow, game-keepers seek to destroy the mother while sitting. To do this it is necessary to build a well-screened watch-house at the foot of the tree where the nests are, and in this a man is stationed to await the return of the parent bird, but he will wait in vain if the bird has been shot at under the same circumstances before. . . . To deceive this suspicious bird, the plan was hit upon of sending two men into the watch-house; one of them passed on while the other remained; but the magpie counted and kept her distance. The next day three went, and again she perceived that only two withdrew. It was eventually found necessary to send five or six men to the watch-house in order to put her out of her calculation. . . . This phenomenon, which is repeated as many times as the attempt is made, is one of the most extraordinary instances of the sagacity of animals." Since then the question has been repeatedly taken up. Lubbock devotes to it the three last pages of his book *The Senses of Animals*. According to his observations on the nests of birds, one egg may be taken from a nest in which there are four, but if we take away two the bird generally deserts its nest. The solitary wasp provisions its cell with a fixed number of victims. Sand wasps are content with one. One species of *Eumenes* prepares five victims for its young, another species ten, another fifteen, another twenty-four; but the number of the victims is always the same for the same species. How does the insect know its characteristic number?[1]

An experiment, methodically conducted by Romanes, proved that a chimpanzee can count correctly as far as five, distinguishing the words which stand for one, two, three, four, five, and at command deliver the number of straws requested of her.[2]

Although the observations on this point are not yet sufficiently varied and extended to enable us to speak of them as we should wish, it must be remarked that the cases cited are not alike, and

[1] At the end of the passage in question there is an extraordinary account of the arithmetical powers of a dog, which Lubbock explains by "thought reading." I omit this instance, since we are deliberately rejecting all rare or doubtful cases.

[2] *Mental Evolution in Man*, Chapter III., p. 58.

that it would be illegitimate to reduce them all to one and the same psychological mechanism.

1. The case of insects is the most embarrassing. It is but candid to state a *non liquet*, since to attribute their achievements to unconscious numeration, or to some special equivalent instinct, is tantamount to saying nothing. Besides, we are not concerned with anything relating to instinct.

2. The case of the monkey and his congeners stands high in the scale: it is a form of *concrete* numeration which we shall meet again in children, and in the lowest representatives of humanity.

3. All the other cases resemble the alleged "arithmetic" of G. Leroy's magpie and similar observations. I see here not a numeration, but a perception of plurality, which is something quite different. There are in the brain of the animal a number of co-existing perceptions. It knows if all are present, or if some are lacking; but a consciousness of difference between the entire group, and the diminished defective group, is not identical with the operation of counting. It is a preliminary state, an introduction, nothing more, and the animal does not pass beyond this stage, does not count in the exact sense of the word. We shall see in a subsequent article that observations with young children furnish proofs in favor of this assertion, or at least show that it is not an unfounded presumption, but the most probable hypothesis.

We may now without further delay (while reserving the facts which are to be studied in the sequel to this article) attempt to fix the nature of the forms of abstraction, and of reasoning, accessible to the higher animal types.

1. The generic image results from a *spontaneous* fusion of images, produced by the repetition of similar, or very analogous, events. It consists in an almost passive process of assimilation; it is not intentional, and has for its subject only the crudest similarities. There is an accumulation, a summation of these resemblances; they predominate by force of numbers, for they are in the majority. Thus there is formed a solid nucleus which predominates in consciousness, an abstract appurtenant to all similar objects; the differences fall into oblivion. Huxley's comparison of the composite photographs (cited in the last article) renders it needless to dwell on this point. Their genesis depends on the one hand on experience; (only events that are frequently repeated can be condensed into a generic image;) on the other hand on the effective dispositions of the subject (pleasure, pain, etc.), on inter-

est, and on practical utility, which render certain perceptions predominant. They require, accordingly, no great intellectual development for their formation, and there can be no doubt that they exist quite low down in the animal scale. The infant of four or five months very probably possesses a generic image of the human form and of some similar objects. It may be remarked, further, that this lower form of abstraction can occur also in the adult and cultivated man. If, e. g., we are suddenly transported into a country whose flora is totally unknown to us, the repetition of experiences suggests an unconscious condensation of similar plants; we classify them without knowing their names, without needing to do so, and without clearly apprehending their distinguishing characteristics, those namely which constitute the true abstract idea of the botanist.

In sum, the generic image comes half way between individual representation, and abstraction properly so called. It results almost exclusively from the faculty of apprehending resemblances. The rôle of dissociation is here extremely feeble. Everything takes place, as it were, in an automatic, mechanical fashion, in consequence of the unequal struggle set up in consciousness between the resemblances which are strengthened, and the differences, each of which remains isolated.

2. It has been said that the principal utility of abstraction is as an instrument in ratiocination. We may say the same of generic images. By their aid animals reason. This subject has given rise to extended discussion. Some writers resent the mere suggestion that ants, elephants, dogs, and monkeys, should be able to reason. Yet this resentment is based on nothing but the extremely broad and elastic signification of the word reasoning—an operation which admits of many degrees, from simple, empirical consecutiveness to the composite, quantitative reasoning of higher mathematics. It is forgotten that there are here, as for abstraction and for generalisation, *embryonic* forms—those, i. e., which we are now studying.

Taken in its broadest acceptation, reasoning is an operation of the mind which consists in passing from the known to the unknown; in passing from what is immediately given, to that which is simply suggested by association and experience. The logician will unquestionably find this formula too vague, but it must necessarily be so, in order to cover all cases.

Without pretending to any rigorous enumeration, beyond all criticism, we can, in intellectual development, distinguish the following phases in the ascending order: perceptions and images

(memories) as point of departure; association by contiguity, association by similarity; then the advance from known to unknown, by reasoning from particular to particular, by analogical reasoning, and finally by the perfect forms of induction and deduction, with their logical periods. Have all these forms of reasoning a common substrate, a unity of composition? In other words, can they be reduced to a single type—of induction according to some, of deduction according to others? Although the supposition is extremely probable, it would not be profitable to discuss the question here. We must confine ourselves to the elementary forms which the logicians admit, or despise, for the most part, but which, to the psychologists, are intellectual processes as interesting as any others.

Without examining whether, as maintained by J. S. Mill, all inference is actually from particular to particular (general propositions being under this hypothesis only simple *reminders*, brief formulæ serving as a base of operations) it is clear that we have in it the simplest form of mental progress from the known to the unknown. At the same time it is more than mere association, though transcending it only in degree. Association by similarity is not, as we have seen, identical with formation of generic images; this last implies fusion, mental synthesis. So, too, reasoning from particular to particular implies something more than simple association; it is a state of *expectation* equivalent to a conclusion in the empirical order; it is an anticipation. The animal which has burned itself in swallowing some steaming food, is on its guard in future against everything that gives off steam. Here we have more than simple association between two anterior experiences (steam, burning; and this state "differs from simple associative suggestion, by the fact that the mind is less occupied with the memory of past burns than with the expectation of a repetition of the same fact in the present instance; that is to say, that it does not so much recall the fact of having once been burnt as it draws the conclusion that it will be burnt."[1]

Otherwise expressed, he is orientated less towards the past than towards the future. Granted that this tendency to believe that what has occurred once or twice will occur invariably, is a fruitful source of error, it remains none the less a logical operation (judgment or ratiocination) containing an element more than association: an inclusion of the future, an implicit affirmation ex-

[1] J. Sully, *The Human Mind*, I., 460. The author gives excellent diagrams to represent the difference in the two cases. For reasoning from particular to particular, cf. also J. S. Mill, *Logic*, II., Chapter III., p. 3; Bradley, *Logic*, II., Chapter II., p. 2.

pressed in an act. Doubtless, between these two processes,—association, inference from particular to particular—the difference is slight enough; yet in a study of genesis and evolution, it is just these transitional forms that are the most important.

Reasoning by analogy is of a far higher order. It is the principal logical instrument of the child and of primitive men: the substrate of all extension of language, of vulgar and empirical classifications, of myths, of the earliest, quasi-scientific knowledge.[1] It is the commencement of induction, differing from the latter, not in form, but in its imperfectly established content. "Two things are alike in one or several characteristics; a proposition stated is true of the one, therefore it is true of the other. *A* is analogous to *B*; *m* is true of *A*, therefore *m* is true of *B* also." So runs the formula of J. S. Mill. The animal, or child, which when ill-treated by one person extends its hatred to all others that resemble the oppressor, reasons by analogy. Obviously this procedure from known to unknown will vary in degree,—from zero to the point at which it merges into complete induction.

With these general remarks, we may return to the logic of animals or rather to the sole kind of logic possible without speech. This is, and can only be, a *logic of images* (Romanes employs a synonymous expression, *logic of recepts*), which is to logic, properly so called, what generic images are to abstraction and to generalisation proper. This denomination is necessary; it enables us to form a separate category, well defined by the absence of language; it permits us, in speaking of judgment and ratiocination in animals, and in persons deprived of speech, to know exactly what meaning is intended.

It follows that there are two principal degrees in the *logic of images*.

1. Inference from particular to particular. The bird which finds bread upon the window, one morning, comes back next day at the same hour, finds it again, and continues to come. It is moved by an association of images, *plus* the state of awaiting, of anticipation, as described above.

2. Procedure by analogy. This (at least in its higher forms in animal intelligence) presupposes mental construction: the aim is definite, and means to attain it are invented. To this type I should refer the cases cited above of ants digging tunnels, forming bridges, etc. The ants are wont to practise these operations in

[1] *In re* analogy, consult Stern's monograph, *Die Analogie im volksthümlichen Denken*, Berlin, 1894.

their normal life; their virtue lies in the power of *dissociation* from their habitual conditions, from their familiar ant-heap, and of adaptation to new and unknown cases.

The logic of images has characteristics which pertain to it exclusively, and which may be summarised as follows:

1. As material it employs concrete representations or generic images alone, and cannot escape from this domain. It admits of fairly complex constructions, but not of substitution. The tyro finds no great difficulty in solving problems of elementary arithmetic (such as: 15 workmen build a wall 3 metres high in 4 days; how long will it take 4 men to build it?), because he uses the logic of signs, replacing the concrete facts by figures, and working out the relations of these. The logic of images is absolutely refractory to attempts at substitution. And while it thus acts by representation only, its progress even within this limit is necessarily very slow, encumbered, and embarrassed by useless details, for lack of adequate dissociation. At the same time it may, in the adult who is practised in ratiocination, become an auxiliary in certain cases; I am even tempted to regard it as the main auxiliary of constructive imagination. It would be worth while to ascertain, from authentic observations, what part it plays in the inventions of novelists, poets, and artists. In a polemic against Max Müller, who persists in affirming that it is radically impossible to think and reason without words, a correspondent remarks:

"Having been all my life since school-days engaged in the practice of architecture and civil engineering, I can assure Prof. Max Müller that designing and invention are done entirely by mental pictures. I find that words are only an encumbrance. In fact, words are in many cases so cumbersome that other methods *have* been devised for imparting knowledge. In mechanics the graphic method, for instance."[1]

2. Its aim is always practical. It should never be forgotten that at the outset, the faculty of cognition is essentially utilitarian, and cannot be otherwise, because it is employed solely for the preservation of the individual (in finding food, distinguishing enemies from prey, and so on). Animals exhibit only *applied* reasoning, tested by experience; they feel about and choose between several means,—their selection being justified or disproved by the final

[1] *Three Introductory Lectures on the Science of Thought, delivered at the Royal Institution* appendix, p. 6, letter 4; Chicago, 1888. It should, however, be remembered that the writer who thus uses the logic of images has a mind preformed by the logic of signs: which is not the case with animals.

issue. Correctly speaking, the logic of images is neither true nor false; these epithets are but half appropriate. It succeeds or fails; its gauge is success or defeat; and as we maintained above that it is the secret spring of æsthetic invention, let it be noticed that here again there is no question of truth or error, but of creating a successful or abortive work.

Accordingly, it is only by an unjustifiable restriction that the higher animals can be denied all functions beyond that of association, all capacity for inference by similarity. W. James (after stating that, *as a rule*, the best examples of animal sagacity "may be perfectly accounted for by mere contiguous association, based on experience"), arrives virtually at a conclusion no other than our own. After recalling the well-known instance of arctic dogs harnessed to a sledge and scattering when the ice cracked to distribute their weight, he thus explains it: "We need only suppose that they have individually experienced wet skins after cracking, that they have often noticed cracking to begin when they were huddled together and that they have observed it to cease when they scattered."

Granting this assumption, it is none the less true that associations by contiguity are no more than the *material* which serves as a substratum for inference by similarity, and for the act which follows. Again, a friend of James, accompanied by his dog, went to his boat and found it filled with dirt and water. He remembered that the sponge was up at the house, and not caring to tramp a third of a mile to get it, he enacted before his terrier (as a forlorn hope) the necessary pantomime of cleaning the boat, saying: "Sponge, sponge, go fetch the sponge." The dog trotted off and returned with it in his mouth, to the great surprise of his master. Is this, properly speaking, an act of reasoning? It would only be so, says James, if the terrier, not finding the sponge, had brought a rag, or a cloth. By such substitution he would have shown that, notwithstanding their different appearance, he understood that for the purpose in view, all these objects were identical. "This substitution, though impossible for the dog, any man but the stupidest could not fail to do." I am not sure of this, despite the categorical assertion of the author; yet, discussion apart, it must be admitted that this would be asking the dog to exhibit a man's reason. As a matter of fact, notwithstanding contrary appearances, James arrives at a conclusion not very different from our own. "The characters extracted by animals are very few, and always related to

their immediate interests and emotions." This is what we termed above, empirical reasoning.

G. Leroy said: "Animals reason, but differently from ourselves." This is a negative position. We advance a step farther in saying: their reasoning consists in a heritage of concrete or generic images, adapted to a determined end,—intermediary between the percepts and the act. It is impossible to reduce everything to association by similarity, much less by contiguity, alone; since such procedure results necessarily in the formation of unchangeable habits, in limitation to a narrow routine, whereas we have seen that certain animals are capable of breaking through such restrictions.