Instinct

WERE it merely for the sake of reiterating my views, I should not feel justified in commenting upon Mr. Romanes' letter on instinct in last week's NATURE (p. 379). He seems, however, to have understood my "subjective verification" in a sense somewhat different to that which I intended to convey by that expression. I venture, therefore, to beg a little space in these columns for explanation.

There is but one method in human psychology—that of introspection. By this method I obtain certain results. These results I communicate to my neighbour, and he by introspection verifies them for himself. This I call "submitting the results to the test of subjective verification." In this way and in no other can a science of human psychology be constituted.

I remember once seeing a schoolfellow caned. He did not flinch, but grew deadly pale. "Did it hurt much?" I asked afterwards, in schoolboy fashion. "Hurt! Who cares for pain? I was caned for a lie that I never told." I can remember to this day the indignation that his words roused within me. I could verify to some extent the true nature of his feelings. How can I verify the feelings of my dog? The feeling that I infer may be as wide of the mark as the mere pain I fancied my schoolfellow smarted under. Without myself becoming a dog, I can never know the true nature of my dog's feelings.

Mr. Romanes contends that "the involuntary groan of pain, the pallor of fear, and a thousand other unintended expressions of emotions, as well as a thousand other unintended expressions of thought, are, as it is proverbially said, 'more eloquent than words.'" In this I cannot agree. The groan, the pallor, tell plainly of some intense feeling; of its nature they can tell us little. So do the actions of animals testify to some corresponding mental states; of their nature we can form but a dim conception. Out of such dim conceptions no science of comparative psychology can, as it seems to me, be constituted.

Whether this is common sense (for which, by the way, in these matters I have not quite so much reverence as Mr. Romanes) or "an ingeniously constructed argument of scepticism," I must leave others to judge.

In conclusion let me thank Mr. Romanes for his letter, and assure him that I shall give to his objections to my physiological theory of instinct that weight which I feel to be due to the opinions of one from whose writings I have learnt much and hope to learn more.

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University College, Bristol, February 25

Protection by Mimicry—A Problem in Mathematical Zoology

UNDER the above heading in the *Japan Weekly Mail* of February 3, 1883, we drew attention to what appeared to us an error made by Mr. Alfred R. Wallace in a letter to NATURE regarding the protection gained by two distinct species of insects of distasteful nature assimilating in appearance when subject to the attacks of young and inexperienced birds. The article was sent to Mr. Wallace, who by letter, and in an article in NATURE, vol. xxvii. p. 481, without hesitation, acknowledged the correction, saying that he had misstated Dr. Müller's proposition. He then gives Dr. Müller's own words, which are:—"If both species are equally common, then both will derive the same benefit from their resemblance—each will save half the number of victims which it has to furnish to the inexperience of its foes. But if one species is commoner than the other, then the benefit is unequally divided, and the *proportional advantage* for each of the two species which arises from their resemblance is *as the square* of their relative numbers." This alters the question altogether. Mr. Wallace had stated it, through an oversight, quite otherwise. He said:—"The number of individuals sacrificed is divided between them in the proportion of the square of their respective numbers." Such was what we took objection to; and we showed that it was not according to the squares, but to the simple numbers.

Mr. Wallace carries out his article, which is accompanied by one by Mr. Meldola (p. 482), to show by examples how it is that, notwithstanding the *loss* is in direct ratio to the numbers of each species, the proportional *saving* through resemblance is inversely as the squares; and he further says:—"The advantage will be measured solely by the fraction of *its own numbers* saved from destruction, not by the proportion this saving bears to that of the other species." On this Mr. Meldola remarks:—"The fact that these numbers stand to one another in the ratio of" the squares, "is a mathematical necessity from which I do not see how we can escape." Now even if this latter statement were strictly correct, we fail to see how it affects Mr. Wallace's statement. We shall show, however, that it is not correct but only an approximation when the number eaten by the birds is a small percentage, for as this becomes greater the ratio of proportional advantages increases considerably above that of the squares.

The proportional advantage that either species has after imitation over its former state (before imitation), appears to be according to the fraction of its original number remaining. Because while in its former state, should it lose one half its number, it would have one-half left, while if it after imitation lost only one-fourth, it would have three-fourths remaining; a clear advantage of one-fourth over one-half, or 50 per cent. This, however, is not a simple case for an example when we come to consider the relative numbers of the two species; we will therefore put it thus:—A has double the number of B. Supposing that when dissimilar A loses 30 per cent. then B loses 60 per cent. But after assimilation both lose in the same proportion, namely, 20 per cent. A has consequently an advantage, over its former state, of 10, and similarly B of 40. But in the former state the remainder of A not lost was 70 per cent., while that of B was 40 per cent., so that A's real advantage is 10 on 70 or 14·2857 per cent., and B's 40 on 40, or 100 per cent. These two numbers do not bear Dr. Müller's ratio of 1 to 4 (the squares of the numbers) but a greater, namely, 1 to $7 = 1^2 \times 40$ to $2^2 \times 70$.

The following examples will illustrate the increasing ratio:—

1. A to B as 2 to 1.

If when dissimilar A loses 20 per cent. then B loses 40 per cent., the remains being for A, 80 per cent.; for B, 60 per cent. When similar each loses $13\frac{1}{3}$ per cent., leaving remains of $86\frac{2}{3}$ per cent.

The advantage to A therefore is the excess of $86\frac{2}{3}$ over 80 on 80 = 8·33 per cent., and the advantage to B is the excess of $86\frac{2}{3}$ over 60 on 60 = 44·44 per cent. These advantages compared to each other are as 1 to 5·33 (according to Dr. Müller 1 to 4).

2. A to B as 3 to 1.

Dissimilar A loses 20 per cent.; B, 60 per cent. Remains 80—40.

Similar A loses 15 per cent.; B, 15 per cent. Remains 85—85.

Advantage to A excess of 85 over 80 on 80 = 6·25 per cent.

Advantage to B excess of 85 over 40 on 40 = 112·5 per cent.

Ratio 1 to 18 (Müller 1 to 9).

3. A to B as 4 to 1.

Dissimilar A loses 20 per cent.; B, 80 per cent. Remains 80—20.

Similar A loses 16 per cent.; B, 16 per cent. Remains 84—84.

Advantage to A excess of 84 over 80 on 80 = 5 per cent.

Advantage to B excess of 84 over 20 on 20 = 320 per cent.

Ratio 1 to 64 (Müller 1 to 16).

Dr. Müller's squares require to be multiplied by the remains per cent. (taken also inversely) of the two species when dissimilar, to bring out the proper ratios. Thus: 1 to 4 (the squares) in the first example, multiplied by 60 and 80 respectively, give 60 to 320 or 1 to 5·33. In the second 1×40 to $9 \times 80 = 40$ to 720 or 1 to 18. And in the third, 1×20 to $16 \times 80 = 20$ to 1280 or 1 to 64.

It will be understood therefore that, whether we reckon the proportionate advantage that each species obtains over its previous state of existence by the mimic, or calculate the ratio of proportionate advantage of mimicry between the two, the comparison has to be made with the state each would have been in had not mimicry taken place, indicated by the proportion of survivors each would then have had. If we ignore this, the comparison is untrue. What we want is the advantage a species which adopts mimicry has over one which fails to do so. So that if we speak of one numerous species A, and two equal non-numerous species B and B′; if B mimics A, while B′ mimics no species, B receives protection, and thus has an advantage over B′, which in particular cases may amount to so much that, while B survives, B′ may become exterminated. This is perhaps the simplest way of putting it.

It must be remembered, however, that B does no harm to A by mimicking it; on the contrary, the act of mimicry is of advantage to A over its former state of existence as well as to B; but A being the more numerous the advantage is less. Still after the assimilation neither has an advantage *over the other*.