The flat gradients obtained from the subjects who learned to discriminate without errors indicate that S− did not acquire any differential control over the tendency not to respond. However, responding and other behavior cannot be considered as symmetrical opposites. The generalization gradients shown in Fig. 1 clearly indicate that the number of responses to the wavelength test stimuli was generally much lower than the number of responses that occurred to S+, and that the gradients of inhibition were not as steep as the gradients of excitation. Jenkins (*10*) has suggested that this asymmetry between responding and other behavior stems from two different ways of classifying other behavior. The first class includes responses antagonistic to key-pecking, for example, turning away from the key or jerking back the head after the onset of S−. The second class of other behavior includes "anything else" or what Skinner would refer to as the absence of excitation, for example, grooming, brooding, or pecking at objects on the floor of the experimental chamber. This second type of nonresponse is controlled by the absence of S+, rather than by a specific value of S−. In testing for the generalization of the tendency not to respond, the experimenter is only able to record when responses occur, but there is no way to determine which type of nonresponse was involved. Only when the responses which define a gradient of inhibition are entirely transferred from the first type of nonresponse (antagonistic) will the gradients of excitation and inhibition be symmetrically opposite. The gradients of inhibition shown in Fig. 1 indicate that this was not the case. These gradients were presumably flattened by the prevalence of the second type of nonresponse.

Although it is not possible to differentiate between the two types of nonresponse, it is nonetheless clear that S− controls the tendency not to respond, that is, it functions as an inhibitory stimulus only after a subject has learned to discriminate with errors. Thus, different things are learned after a subject learns to discriminate with and without errors. After learning to discriminate with errors, the subject learns to respond to S+ and not to respond to S−. This finding was demonstrated by gradients of excitation and inhibition, each of which had a slope greater than zero. After learning to discriminate without errors, the subject learns to respond to S+ and not to its absence. S− does not specifically control the tendency not to respond.

The differences between the gradients of inhibition of those subjects who learned to discriminate with errors and those who learned to do so without errors are consistent with the finding that a peak shift occurs only after a subject has learned to discriminate with errors. As Spence's model of discrimination learning suggests (*5*), if an inverted U-shaped gradient of inhibition centered around S− is subtracted from a larger gradient of excitation centered around S+, then the peak of the gradient of excitation will be displaced away from S−. Since discrimination learning without errors results in a flat gradient of inhibition, no peak shift would result when the gradient of inhibition is subtracted from the gradient of excitation.

The occurrence of contrast, however, cannot be accounted for in terms of interacting gradients of excitation and inhibition. An algebraic combination of peaked gradients of excitation and inhibition would result in a divergence rather than a convergence of the rates of response to S+ and S−. The occurrence of contrast after a subject has been trained to discriminate between stimuli from two different continua suggests, however, that responses which are not reinforced may have an effect that is uniformly distributed over all stimuli. According to this view, elaborated by Amsel (*15*) and Lawson (*16*), a nonreinforced response to S− results in a general elevation of the gradient of excitation. Subtracting a U-shaped gradient of inhibition from this elevated gradient of excitation would still displace the peak away from S−. This appears to be the simplest way to account for the fact that the peak shift, contrast, and U-shaped gradients of inhibition occur only after a subject has learned to discriminate with errors.

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Curiosity and Play: Basic Factors in the Development of Life

The article on "Curiosity and Exploration" by Berlyne (*1*) contains observations on curiosity and exploratory behavior in animals which appeal to anyone who has observed young animals at play. I believe that this topic and the questions connected with it ("Why do animals play and explore?" and "What do they gain by it?") will take on an interesting perspective if we begin with the assumption that play is a basic feature of life and a main factor in its evolution.

Play involves the recognition that there is a possibility for making choices. The current picture of physics does not admit subjective feelings, and has no place for deliberate choice. The physical laws concerning molecular processes leave open alternatives at each step; the quantum theory makes possible the calculation of statistical weights, but it does not predict the outcome of an individual experiment. To have an instrument for exploring what supplemental relations may be introduced, it is suggested that in living systems there is active a faculty not recognized in the current physical picture, which induces decisions or choices between the alternatives. Such a hypothesis will enable us to construct a link with mental activities if we assume that the decisive faculty is the carrier of subjective aspects such as we find in the activities of the mind. In view of the continuity of all forms of life, we assume that forms of these activities are also present in other living beings. Within ourselves, we notice that not all these processes penetrate the "master mind;" evidently processes go on at various levels, and it is appropriate to suppose that some forms are active in every living cell, perhaps even in parts of cells.

To discover which features should be attributed to the decisive faculty, we note that within ourselves subjective notions involve evaluations and ideas concerning what seems desirable and undesirable in connection with future possibilities. This does not mean that they are determined by the future (which is not yet in existence); they embody a faculty of expectation, making more or less vague extrapolations connected with feelings which influence the decision. Elsewhere (*2*) I have used the term "conceptual activity" for this faculty. The hypothesis that such an activity is basic for life may be far-reaching. However, to link up our mental activities with physical occurrences such as those connected with the nervous system, we cannot do with much less. Many biologists admit that the relation to a coming future is an essential feature of life.

The most primitive factor in making a choice may be considered as a vague esthetic feeling without much motivation, as it can be found in primitive forms of play. But conceptual activity must be endowed with some subjective awareness of its existence; it must be the basis for a feeling of pleasure, of joy in making choices. From this must have developed the feeling of being a "self." This means that conceptual activity is more or less focused on a certain region of interest; the surroundings are then felt as "something else."

In many instances the physicochemical processes affecting the system involve both the region of interest and the environment. In certain situations the alternatives left open by the quantum rules refer only to the environment, while there are no alternatives within the region of interest. In such a situation no choices are possible within the region of interest, and the decisive faculty finds itself at a dead end. We introduce the hypothesis that so long as this is not the case, the decisive faculty has the possibility of extrapolating its expectations beyond a single step, and it has the capability of making choices which will leave open interesting alternatives in the next step. Mere play can then evolve into a game with the environment, striving to have the game continue, and preventing its being driven into a dead end. Such an assumption is needed in order to understand why a tendency toward self-preservation, with its endless diversity of consequences, is able to exist.

What has been called conceptual activity and choice or decision should not be considered as conscious, although certain features become conscious in man and in some of the higher animals. Berlyne's terms, such as "useful," "reward," and "likely to have beneficial consequences" (*1*, p. 30) can have a sense only if there is some expectation of a future with the implications just enumerated. While the features described by Berlyne refer to the behavior of some of the higher animals, the point of view sketched here extrapolates from there all the way down to the simplest aspects of life. My purpose is to present a set of ideas in which the notion of play becomes primordial in life, and should not be considered as a late invention (late inventions refer to the extent of the domains of alternatives over which it operates). Several features mentioned by Berlyne can be considered against the background which I have indicated. Terms such as "curiosity," "diversive exploration," "disturbance by a lack of information," "attraction emanating from objects which offer more varied or more irregular stimulation," "epistemic curiosity," and "conceptual conflict" appear as consequences of a tendency toward play in which there has developed the business of collecting information for protecting one's chances in the game with the environment.

An encounter with a new feature in the course of the game may induce new evaluations, and may lead to what in game theory is called a change of strategy. Of importance are changes in which certain moves are made to follow a path without alternatives (that is, a path which defines a deterministic course within the region of interest), if it appears that such a path will lead to greater freedom of choice (a larger number of alternatives) at a more advanced stage of the game. Such a partial reliance on deterministic moves is effectively the same as storing some information in a material structure. In this way useful structures may be built up in playing systems, and a memory apparatus may come into being. I believe this to be a fundamental factor in organic evolution, although, of course, the history of life has greatly been influenced by natural selection operating on what had developed.

What I have been proposing is an alternative to the point of view that physical theory can explain all aspects of life. My thesis is that subjective features accompanying reactions in living systems are effective; they are neither a deterministic result of the physical situation nor random phenomena. They are to a certain extent autonomous, but they may be influenced by traditions or rules, and we may be able to find out something about these rules. To assume a tendency toward continuation of the game may afford a helpful point of view. It is possible that applications of information theory in the near future may give indications for the incorporation of new information at various steps in the development of living beings (ontogenetic and phylogenetic). My suggestion is that the incorporation of new information involves a form of conceptual activity which exerts a selective influence on the reaction to physical conditions, and in this way creates information. Terms such as "useful" and "adaptation" can have a sense only when some form of sensitivity for what may come in the future (that is, some form of conceptual activity) has been accepted in the biological picture. When it is asked whether there is demonstrable evidence of this sensitivity I point to the experience collected in our subjective personal lives. Our social structure is built on and operates on the presumption that man can decide between alternative courses, and that he is responsible for his choice. This is an experimental fact, and there is nothing supernatural in it. Between physics and human life lies the domain of biology. Perhaps what we observe in ourselves may give hints that will be helpful in explaining biological phenomena.

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