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OPERATIONISM AND THE CONCEPT OF PERCEPTION [1]

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The attitude of contemporary operationists toward perceptual research has been well characterized recently by Allport. He has described their attitude by stating "that a perception can be regarded as nothing more nor less than a discriminatory response" (1, p. 53). In even simpler terms, the "reaction is the perception," and thus the role of the researcher is simply to determine the conditions under which a discriminatory response is obtained. These conditions then define perception. Unfortunately, we have to agree that many psychologists who consider themselves operationists do in fact accept this position toward perception. However, this position is not necessary from the tenets of operationism. In fact, we believe that this viewpoint is a perversion of the fundamentals of operationism as stated by its originators.

The essence of the above position is that a concept of perception is not distinguishable from the operations on which it is based, and thus that perception is indistinguishable from the responses which indicate its existence and character. This idea springs from a restricted interpretation of Bridgman's writings. For example, Bridgman states that "The concept is synonymous with the corresponding set of operations" (4, p. 5). This widely quoted statement has been used by psychologists to justify their unwillingness to distinguish between perceptions and responses, and to support their position that any set of responses leads to a concept about the properties of the perceptual system. However, to state that a concept is synonymous with a set of operations is not to state that any operation can produce a concept.

Furthermore, psychologists have ignored the fact that Bridgman is talking about a *set* of operations, not a single experimental operation. He later emphasizes this distinction, stating that

> Operational definitions, in spite of their precision, are in application without significance unless the situations to which they are applied are sufficiently developed so that at least two methods are known of getting to the terminus. Definition of a phenomenon by the operations which produced it, taken naked and without further qualification, has an entirely specious precision, because it is a description of a single isolated event (3, p. 248).

Many operationists accept the sterile point of view described by Allport, and consider perception not to have any operationally determinable properties other than discrimination. It seems to us that the above quotations from Bridgman do not require such a narrow point of view. It is true that if the only op-

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eration allowed were the discriminating reaction, then it would be impossible to determine whether the perceptual process had any properties other than discrimination. But it is equally unjustifiable to state that perception is nothing more than the discriminating reaction, since other possibilities have not been excluded. Surely the perceptual process has more richness than simple discrimination.

It seems clear that many operationists who nominally subscribe to the narrow operational position also feel that perception is more than discrimination, since they do in fact ascribe other properties to the perceptual process. It is equally unjustifiable to ascribe such additional properties, when they are ascribed on the basis of single experiments whose designs are inadequate to determine the nature of these additional properties. It is our contention that additional properties of the perceptual system can and must be considered, but that operational experiments of a particular type are necessary to determine the nature of these properties.

PERCEPTION AS A CONCEPT

We conceive of perception as an intervening process between stimuli and responses, as schematically illustrated in Fig. 1. We can directly observe only stimuli and responses and, therefore, perception can be known only as a concept whose properties are induced from

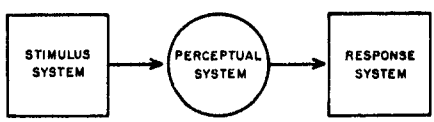

FIG. 1. A schematic of the perceptual problem. The three systems operate in a causal relationship as indicated, although there may be interdependencies. Each system, however, may have independent properties. The properties of the stimulus and response systems can be directly observed; those of the perceptual system must be inferred.

objectively determined relations between stimuli and responses. This statement does not in any sense imply that perception is identical to responses (or to stimuli). Indeed it is the purpose of this paper to indicate the kinds of operations which make it possible to distinguish perception from responses, and to show that these operations are necessary if the concept of perception is to have any use or meaning.

The discriminating reaction. We agree with contemporary operationists that the fundamental and prerequisite operation in any experiment on perception is to demonstrate a discrimination between stimuli on the basis of responses. In other words, it must be demonstrated that there is a contingency relationship between stimuli and responses. If such a relation is demonstrated, we know that a subject can use the same label for the same stimulus within a certain error tolerance.

This operation alone, however, assures us only that we have a system which is operating and which is reliably assigning responses to the various stimuli. This operation provides us with so little information about perception that indeed we cannot distinguish between perceptual and response processes. However, if perception is considered a concept separate from the response system, there are rules for inductively determining the properties of that concept, and they are the same as those for determining the properties of any concept.

Converging operations. The necessary condition which makes possible the determination of particular characteristics of any concept (including the concept of perception) is the use of what have been called converging operations (6). Converging operations may be thought of as any set of two or more experimental operations which allow the selection or elimination of alternative hypotheses or concepts which could

explain an experimental result. They are called converging operations because they are not perfectly correlated and thus can converge on a single concept.

To illustrate, let us assume an experiment similar to one reported by McGinnies (11) in which visual thresholds are determined for words with different emotional content. In our hypothetical experiment, we present four alternative stimulus words, tachistoscopically—fire, save, shit, fuck. The responses to these words are the verbal pronunciation of them. We find that the two vulgar words have higher thresholds than the two nonvulgar words. Such a result has usually been interpreted as indicating that the perceptual system differentially discriminates on the basis of the emotional content of the perceived stimuli. There is, however, at least one other alternative explanation of these results—namely, that the difference in threshold is a result of a characteristic of the response system, which inhibits the verbalizing of some of these words. A converging operation which would discriminate between the two alternative hypotheses would be to present the same stimuli as before, but to pair these stimuli with responses such that vulgar responses are used for nonvulgar stimuli, and vice versa. This experiment in conjunction with that of the first would allow us to decide which of the two hypotheses is correct, or if some combination of them is. It should be noted that the two operations taken together provide the convergence. One experiment does not converge on the other, but rather the two converge on a mutually acceptable result.

Ideally, converging operations would be orthogonal (completely independent), since such operations are the most efficient. In practice, however, it is difficult to obtain truly orthogonal operations, because the world is so organized that all variables cannot be controlled completely independently. This fact does not seriously change the nature of the problem, because a sufficient number of partially converging operations can still provide precise delimitation of alternative concepts.

Nevertheless, sets of operations can be considered more or less efficient in allowing the formation of definitive concepts. One class of operations can be excluded entirely from consideration. This class can be called *parallel operations*. These operations select among alternative hypotheses along the same dimension, and thus cannot converge to a single concept. In our example above, we could do the entire experiment again using different words, but in which two are still vulgar and two nonvulgar. If this experiment produces the same result as the first, we still do not know whether the difference in threshold is due to a characteristic of the perceptual system or of the response system.

There are two special types of parallel operation which deserve mention. One of these is the *repeat operation,* in which the same experiment is repeated at another time. Such an experiment does not allow convergence to a single concept unless the concept involves time as a variable. Another special type of parallel operation is the *transform operation,* in which one variable is simply a transformation of another. Again, in the illustration we have been using, suppose we retain the original set of words as the stimuli, but use four synonyms as responses—burn, keep, crap, screw. These synonyms used as responses can be considered transforms of the original words used as responses, and this experiment will not allow us to determine whether the differential effect exists in the perceptual system or in the response system.

It should be obvious from the above discussion that the value of a set of converging operations depends less on

the nature of the operations themselves than on the alternative hypotheses or properties which are being considered. For example, we mentioned above the use of synonyms as an example of a transform operation. If, however, the synonyms were used as the stimuli, this experiment in conjunction with the first would converge to determine whether the differential thresholds were due to the letter configurations of the original words, rather than to their meanings. Thus these two experiments would be converging for that purpose, but would not be converging for purposes of determining whether the effect was in the perceptual system or in the response system.

Although a minimum of two converging operations may define a concept, in practice it is rare that two are sufficient. In the first place, there are usually more alternative hypotheses than can be delimited with two converging operations. In the second place, converging operations are rarely orthogonal, but are usually only partially converging. If there are enough partially converging operations, we can still arrive at a single, well-defined concept, but more than two such operations will be necessary.

It is quite legitimate to use assumed converging operations in place of operations actually carried out. We know from previous research that many of the possible converging operations would work in a particular way if we actually tried them, and thus there is little point in trying them again. The fact that we use assumptions, however, should not allow us to lose sight of the fact that the validity of our concepts rests entirely on the validity of the operations, whether carried out or assumed. A concept has no meaning other than that derived from the operations on which it is based, and unless these operations are known, the concept cannot be known either.

OPERATIONAL DISTINCTION BETWEEN RESPONSE AND PERCEPTION

An important use of converging operations is to distinguish effects which exist in the response system from those which exist in the perceptual system. Since the primary function of perceptual research is to determine something about the properties of the perceptual system, a major requirement in such research is to use converging operations which will eliminate the possibility that the outcome of an experiment is due to properties of the response system rather than of the perceptual system.

One of the more important properties of the response system which can affect the outcome of a perceptual experiment (and possible interpretations about properties of the perceptual system) is that of *response differentiation.* For example, if only one response is available to a subject, it is clearly impossible to demonstrate anything about perceptual discrimination. This principle is quite obvious when stated in such an extreme form, but it can also operate in other less obvious ways. For example, if the number of response categories is too small to demonstrate the perceptual discrimination capacity of a subject, then the outcome of the experiment will be limited by a property of the response system rather than by a property of the perceptual system. Thus, a converging operation which is required in many experiments is one which demonstrates that discrimination is invariant with respect to the number of response categories and with respect to the discriminability or differentiation of these categories. Such converging operations must either be carried out or be assumed before we can state anything about the limits of perceptual discrimination; if they are assumed, then the validity of the conclusion is limited by the validity of the assumption.

A second major property of the response system which can affect interpretation of experimental results is that of *response availability*. To some extent this property can be considered as a special case of response differentiation. If a subject fails to use a particular response which is defined as appropriate to a particular stimulus, we cannot state that there was a failure of the perceptual system. The failure of response can be due to sheer motor inability. It can also be due to such things as response inhibition (as in the case of vulgar words). That is to say, the response system can be affected by emotional factors just as well as the perceptual system can.

There are other ways in which response availability can operate. For example, it is known that human subjects (and rats too) have a preference for some responses over others. These preferences can affect the apparent nature of the relation between stimuli and responses, and, unless they are taken into account, can lead to misinterpretations about properties of the perceptual system. Subjects also exhibit sequential effects in their responses and, if preferred sequences of responses conflict with the sequences of stimuli presented, misinterpretations can again occur. This factor is commonly taken into consideration in psychophysical experiments, where truly random sequences of stimuli are rarely used. Rather, modified random sequences are used which prevent long runs, since most subjects do not believe that long runs can occur by chance and thus are unwilling to use them.

In summary, then, there are many ways in which properties of the response system can affect the outcome of a perceptual experiment and, unless converging operations are used to delimit an effect specifically to the perceptual system, properties can be incorrectly ascribed to that system.

CONVERGING OPERATIONS AND SOME CURRENT PROBLEMS IN PERCEPTION

To illustrate more specifically the implications of this discussion for research on perception, we shall discuss three types of experiments in these terms, pointing out the kinds of converging operations which are necessary before the results of experiments can reasonably be ascribed to particular properties of the perceptual system.

Subception. The concept of subception has been introduced by Lazarus and McCleary (10) to explain the results of a certain class of experiments on perception. Typically, in these experiments, subjects make two different but simultaneous responses to stimuli from a set presented one at a time. Usually some of the stimuli have a meaning (frequently anxiety-producing) which is different from that of other stimuli in the set. This different meaning may be inherent in the words, or may be induced by conditioning procedures. One response is overt, usually verbal. The other response is often physiological, nonverbalizable, and presumably indicative of emotion. The GSR has been most frequently used. The result which subception purports to explain is that the nonverbalized response shows discrimination when the verbalized response does not. To explain this result it is assumed that perceptual discrimination occurs subconsciously: thus the term subception, which ascribes a property to the perceptual system.

Underlying this definition of subception is the equation of consciousness with verbal report, a distinction that we are reluctant to accept without more explicit specification of the converging operations on which it rests. But even assuming that these converging operations can be specified, the inference of unconscious perceptual discrimination

from the typical subception experiment is not justified. It is not justified because the converging operations are lacking that would permit us to ascribe the results to properties of the perceptual system as opposed to properties of the response system. The fact that the GSR is a nonverbally reportable response, is not sufficient cause for assuming that the perceptual discrimination is also not verbally reportable.

Eriksen (5) has pointed out that the subception result can be looked at basically as the demonstration of a partial correlation between the stimulus and the GSR, with the verbal response held constant. When the subception experiment is conceived this way, many properties of the response system which could produce the subception result become more obvious. For example, Eriksen has noted that such factors as lack of verbal response differentiation, asynchronous response oscillation, and differential response strengths will satisfy the requirements for the partial correlation.

When the problem is looked at this way it becomes obvious that a demonstrated partial correlation as indicated above does not allow us to infer the property of subconscious discrimination to the perceptual system.

Rather, in order to demonstrate that there is perceptual discrimination which cannot be verbally described, it is necessary to show that the first-order correlation of stimuli with nonverbal responses is greater than that between stimuli and verbal responses. But even if a single experiment gave this result, it would still be necessary to use converging operations which demonstrate that the correlation between stimuli and verbal response was not limited by the size or degree of differentiation of the response set. Bricker and Chapanis (2) have shown that more precise discrimination of stimuli can be accomplished verbally if more alternative responses are allowed. If no verbal response system can be found which gives as good a correlation with stimuli as the GSR, then and only then can we conclude that additional perceptual discrimination is operating at a nonverbal level.

Perceptual set. Many experiments have demonstrated that the nature of the relation between stimuli and responses changes when the response system changes. A common interpretation of such experiments is that the set of responses provided the subject serves to produce a perceptually selective set. In many of these experiments, however, the necessary converging operations have not been undertaken to justify delimitation of the effect to the perceptual system.

Suppose an experiment similar to one by Hyman and Hake (9), in which subjects are required to identify the form of stimuli presented tachistoscopically. In one condition subjects are told prior to the stimulus exposure that the form will be one of two particular alternatives. In another condition they are told that the form will be one of four. When the duration of exposure required for identification of the form is shorter with just two stimuli, a possible conclusion is that subjects adopt a more accurate perceptual set with the smaller number of stimuli.

There is, however, an alternative explanation which requires no assumptions about the accuracy of the perceptual process, namely, that the amount of error in the response system decreases with a decrease in number of response categories. One necessary converging operation, then, is to run another experiment in which four stimuli are presented, but only two response categories are allowed. If the accuracy of identification in this case is identical to the two stimulus-two response case, then we must assume that the effect is due entirely to a characteristic

of the response system. To complete the set of converging operations, it would be necessary also to present two stimuli but to allow four response categories. If the responses, however, are direct descriptions of the stimuli, this last operation would be meaningless to carry out.

Actually, there is still another set of converging operations necessary if two responses are used with four stimuli. If the nature of the responses and stimuli are such that the subject can observe one of two aspects of the stimulus, then this operation is parallel to that of using two stimuli and two responses. For example, suppose that the four stimuli were red square, blue square, red circle, blue circle; and the two responses were red, blue. For all practical purposes, there are just two stimuli, not four, and this operation would not allow us to determine where the effect exists. If the responses were abstract, such as letters of the alphabet, and were not assigned to the stimuli by just color or form, the operation would be converging. One system for handling this problem is to use the two responses with all possible pairs of the four stimuli to determine the extent to which meaningful grouping of the stimuli affects discrimination.

Sensory scales. One area of perceptual research where these principles of converging operations are most difficult to apply, and have been applied least, is that of sensory magnitude scales. Psychological scales have been produced for pitch, loudness, weight, brightness, length, and many other perceptual attributes. In most cases it is assumed that the resultant scale tells us about a property of the perceptual system, but we believe that very few of the experiments have included the necessary converging operations to ensure that the final function truly describes a perceptual process.

To illustrate, let us suppose an experiment similar to one reported by Reese *et al.* (12). We provide a large circular, vertical display on which appears a single line radiating from the center. This line is set to various angular positions, and subjects are asked to estimate the angle, using as responses the whole numbers from 0 to 360. When we have obtained many estimates, and averaged them for given physical settings, we plot the estimated angle against the presented angle. At first glance it would appear that we could call such a function a psychological scale of inclination having interval properties. We have no converging operations, however, to indicate that the subjects actually used the numerical response system in such a way as to reflect the perceived magnitudes of angles. People have had considerable experience with such estimates, particularly with clocks, and in the course of this experience they have learned to identify certain perceptions with certain numbers. The fact that later they can do so in an experiment does not alter the fact that they are using the numbers simply as learned identifying responses. Since the subjects have had experience with the 0 to 12 scale but not with the 0 to 360 scale, it might be argued that the new number system would actually reflect properties of the perceptual system. However, as we pointed out above, one operation which is a transform of another does not satisfy the requirements of converging operations.

There is an operation which would appear to satisfy the requirements of convergence for the property under consideration—an interval property of the perceptual system. This operation would be to have the subjects set series of three radiating lines in such a way that two equal angular intervals are provided. In this case a number system is

not used, and thus the chance that the numbers are used simply as identifying labels would seem to be minimized. Subjects are so accustomed to using numbers in this situation, however, that they may very well verbalize the numbers to themselves, and thus once again we have a transform rather than a converging operation.

Actually, in situations where so much learning of objectively assignable numbers to stimulus attributes has occurred, it is doubtful that we can ever sufficiently satisfy the requirements of converging operations to be sure that we are measuring a metric property of the perceptual system, rather than of the objective stimulus system. It would be necessary to get subjects who have had no previous experience in assigning numbers to the continuum under consideration.

Gibson and Bergman (8) have clearly recognized the nature of this problem in their experiments on estimation of distance. Consistent underestimations of distance can be corrected by one or two correction trials (the correction generalizing to all distances used in the experiment), and the authors feel that the correction has simply changed the subjects' conceptual scale of yards. In other words, they are assuming that the change was not in the perceptual system, but rather in the response system. Given a situation like this, we can make statements about the conceptual scale of numbers which the subject has, and its relation to physically measured distance, but we cannot know anything about the metric properties of the perceptual system.

There are other types of psychological dimension that make the problems more obscure because there is no commonly accepted number system which the usual subject has been trained to use. Of these, the one dimension that has received the greatest attention is loudness. Presumably, subjects have had little or no training in using a number scale to describe the loudness of a tone or noise. So when a subject is asked to assign numbers to the loudnesses of various tones, he should be able to respond only on the basis of the perceived magnitudes. This position has been taken by several psychologists, particularly Stevens (13). However, when subjects are required to use a set of responses which constitute a numerical scale, we have no assurance that they in fact use the response continuum in such a way as to reflect the ratio or interval properties of the perceived loudness correctly. The question is not whether they can use the *number* scale correctly, when using it as an abstract scale, but rather whether they use it in such a way as to reflect a metric property of the perceptual system.

Suppose we have done an experiment in which direct numerical estimates of the loudnesses of tones, or of the relative loudnesses of two different tones, are made. From these estimates we can construct a functional relation which we can tentatively call a psychological scale of loudness. Having no assurance that the number scale was used to reflect the metric properties of the perceptual system—the numbers could have been used as simple identifying responses, or perhaps as ordered responses—we need to carry out one or more operations which converge to allow us to delimit a property of the perceptual system. We could ask our subjects to produce tones which sound half, or a quarter, as loud as other tones which the experimenter provides. Such an operation does not converge with the former, however, since the number system whose use is in doubt is the same in both instances.

A considerably better converging operation is one that does not require the use of numbers at all. If a fractionation or direct estimation has been car-

ried out, and if the resultant function is truly a loudness scale with the properties of a ratio scale, then we should be able to determine a set of equal interval points on our scale. Now if we ask our subject to set a series of tones at intensities which provide a series of equal intervals of loudnesses, these equal intervals should check with those obtained from the fractionation experiments. In the one instance in which such a comparison has been made, Garner (7) showed that the results of the two experiments do not check; the two experimental operations did not converge to a single concept about the metric properties of the perceptual system. Garner also showed that if it is assumed only that the fractionation experiments provided equal ratios—not necessarily with the stated magnitude—the two experiments can converge to a single loudness scale. This scale is quite different from that obtained with numerical estimates, however, and its properties and uses are different from those assumed for "scales" obtained from direct estimates.

The major point of this section is not to prove that psychological magnitude scales are impossible to construct but simply to point out that before we can ascribe a property to the perceptual system as refined as that of a ratio scale, certain minimal converging operations are required—operations that in practice have rarely been carried out. Furthermore, it is not sufficient to carry out the same experiment twice, or to carry out a slightly modified experiment which provides only transform operations. The operations must truly be converging for the pertinent assumed property of the perceptual system. Until these operations are carried out, we can have only functional relations, not magnitude scales.[2]

[2] It should be pointed out that there are other scaling techniques for which the ascribed properties of the perceptual system are not at variance with the converging operations carried out. The discriminative scaling techniques, particularly as developed by Thurstone, satisfy these requirements as long as no attempt is made to assume that the resultant scales reflect magnitude of perceptions rather than discriminability of perceptions.

CONCLUSION

Our emphasis on the use of carefully planned operations in order to isolate properties of perceptual behavior should not be taken to mean that operationism properly used tends to minimize the importance of perception. We believe simply that its proper use rigorously defines those properties which validly can be assigned to perception.

This argument holds for all aspects of behavior which can be described as perceptual. For example, the comparison usually made betwen the rich, although unreliable, data provided by introspection and the sterile, although rigorous, data provided by operationism is invalid for two reasons: first, because the basic position taken by many operationists does not indicate the real possibilities inherent in this position; second, and more important, because the data produced by introspection can have no meaning independent of the operations used to produce them.

For example, two aspects of the introspective method have been claimed to have special advantages. First, it is claimed that a much more detailed description of experience can be reported by a subject using unrestricted responses. This problem is not unique with introspection. Operationism does not require that responses be restricted in any way; it only points out that with unrestricted response sets, it is difficult or impossible to separate properties of the response system from those of the perceptual system.

A second claimed advantage of introspection is that subjects can be instructed to confine their attention to

facts of subjective experience, i.e., the stimulus error can be avoided. There is nothing about operationism which excludes this possibility, either. The effects of the subject's set produced by instruction and training are important experimental problems in perception. We insist, though, that if these effects are in the perceptual system, then operations can be devised to demonstrate this fact. These operations must demonstrate that the effect of instructions is not merely to change the kinds of responses that subjects use, nor simply to decrease the correlation between stimuli and responses by causing subjects to respond to factors other than stimuli. That is to say, the methods of introspection are operations, and as such cannot lead to valid concepts that are independent of these operations. Introspection and the data produced by it do not lie outside the scope of operationism as here conceived.

We also feel that there is no need to minimize experimental questions about "awareness." For humans, at least, awareness is undoubtedly one aspect of perception. We insist, however, that the awareness of a subject can be no more than a property of his perceptual system, and that it can be specified only in terms of a set of converging operations.

In summary, we believe that our position is truly one of operationism. We believe that a concept has no meaning beyond that obtained from the operations on which it is based. This statement does not mean that any set of operations can lead to a concept. Nor does it mean that the complexity and usefulness of concepts derived from operations are necessarily limited in any way. In practice they are limited only by the ingenuity of the individual experimenter to devise appropriate converging operations.

SUMMARY

Perception is conceived as a process intervening between stimuli and responses. As such it can be viewed as a concept whose properties may be delimited by converging operations. Converging operations are any set of experimental operations which eliminate alternative hypotheses and which can lead to a concept which is not uniquely identified with any one of the original operations, but is defined by the results of all operations performed. Thus converging operations can lead to concepts of processes which are not directly observable. For example, converging operations can be used to describe properties of the perceptual process which are distinct from those of the response system directly observed.

Illustrations from current experimental problems in perception indicate how some response characteristics may be isolated from perceptual properties, and vice versa. Some of these properties have been ascribed to perception without supporting converging operations by researchers dissatisfied by the sterility of operationism as it is commonly, but mistakenly, conceived.

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