

THE STIMULUS IN BEHAVIOR THEORY: EVENT OR FUNCTION?

EL ESTÍMULO EN TEORÍA DE LA CONDUCTA: ¿EVENTO O FUNCIÓN?

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ABSTRACT

The concept of stimulus is examined as one of the basic units for the analysis of behavior. Sensing is shown to be a set of differentiated reactive systems which are ineffective as compared to skeletal-muscle based response systems. A distinction is made among stimulus object, stimulus and stimulus function. It is argued that stimuli are not parts of stimulus objects but rather the responses to changes in stimulus objects. Psychology is interested in stimulus functions and not in stimuli as biological response functions. Elicitation, inhibition and reinforcement are shown not to be stimulus functions. A tentative classification of stimulus functions is proposed.

Key words: stimulus object, stimulus function, elicitation, inhibition, reinforcement.

RESUMEN

Se examina el concepto de estímulo como unidad básica de análisis de la conducta. Se muestra que el sensar constituye un conjunto de sistemas reactivos diferenciados que son inefectivos cuando se les compara con los sistemas de respuesta músculo-esqueléticos. Se establece una distinción entre objeto de estímulo, estímulo y función de estímulo. Se argumenta que los estímulos no son partes de los objetos de estímulo. La psicología está interesada en las funciones de estímulo y no en los

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estímulos como funciones biológicas de respuesta. Se muestra que la educación, la inhibición y el reforzamiento no son funciones de estímulo. Se propone una clasificación tentativa de funciones de estímulo.

Palabras clave: objeto de estímulo, función de estímulo, educación, inhibición, reforzamiento.

Modern behavior theory is grounded on two basic analytic units: the stimulus and the response. The theory assumes that these conceptual units correspond to the two only ways of breaking down the continuum of flux, represented by the events in the environment and the behavior of organisms. For behavior theory, occurrences in the world take place as stimuli and responses. However, both concepts have been ill-defined with respect to how technical terms should be defined in behavior theory. The concepts of stimulus and response have been loosely based on intuition and common sense practices, and they have been considered as static or changing physical properties in the external and internal environments.

The attempt to classify stimuli has been a persistent effort in psychological theory (Graham, 1951; Allport, 1955; Heider, 1959; Lawrence, 1965; Schoenfeld and Cumming, 1965). With the exception of Kantor (1924) and partly of Skinner (1938), stimuli have been identified mostly with objects and physical properties in the environment. Identification of stimuli with objects and physical properties does, however, pose conceptual difficulties for the understanding of the diversity of psychological functions that are involved in behavioral interactions. Stimuli imply objects, things and events, but they do not directly denote them. The etymology of the term 'stimulus' indicates that it carries the implication 'to goad' to action, that is, the implication of a force or impulse impinging on the organism and forcing it to act in a particular direction. Stimuli, in this context, represent the actions of objects through the organism. The clear assumption is that although objects and events are not incorporated by the organism, stimuli actually do "go in" into the organism.

On the Nature of Sensing

The concept of stimulus is historically bound to the concepts of sensation and "sensing", that is, "receiving" stimuli through physical energy coming from the external and internal environments. Since the Cartesian formulation of Man divided into two substances, one dealing with cognition and the other with action, psychology has assumed that actions correspond only to movements and that knowing in its first stages has to do with "receiving". Behavior is action and knowing through stimuli is some sort of receptive

episode: sensing, feeling or perceiving. This conception of the divided organism describes sensing, feeling and perceiving as no-actions, that is, as stuff, different from behavior.

Before examining the concept of stimulus as a psychological function, I will attempt to show that sensing, feeling and perceiving are not different from the general behavior of the organism. To do so, I will resort to some arguments initially provided by J. R. Kantor (1924) regarding the nature and characteristics of stimuli and responses.

Sensing and moving (Aristotle, 1978 - Spanish translation) are evolved differentiations of a general property of the living cell: irritability (Loeb, 1918; Weiss, 1924). This differentiation is correlated in phylogeny with the emergence of neural tissue and its progressive development in the form of a specialized coordination of a biological reactional system. From this viewpoint, sensing is a reactive differentiated function of organisms, and feeling and perceiving, as sense-based functions, involve always some reactive pattern of responding. Modern neurophysiology supports this view of the senses as differentiated reactive systems to the extent that all sensory systems involve both the so-called afferent and the efferent pathways (Sokolov, 1963). A revisiting of Pavlov's (1927) concept of 'analyzer' would show that sensory systems were thought of as nervous activity and not as mere receptive functions. Bykov's (1958, Spanish translation) and Adam's (1967) research on interoceptive conditioning confirms this interpretation.

Sensing involves varied responses according to the functional reactive differentiation of each sensory system. The so-called receptors, and their innervation correlated with neural tissue, are in fact highly specialized response systems. The distinct sensory systems such as vision, audition, smell, taste, temperature, mechanics, posture, proprioception, and visceroreception are complex reactional systems responding to changing conditions in the external and internal environments. They involve responses which are coordinated by neural tissue, the only response system that is not directly reactive to changes external to the organism. Each of these sensing reactional systems are monoreactive, e.g., the visual system always responds photically to any kind of stimulation, the auditory system always responds acoustically to any kind of stimulation, etc.

Kantor (1924) distinguished between response systems in terms of various dimensions. Two of them are particularly relevant to our analysis: a) effective and non-effective reaction systems, and b) apparent and inapparent reaction systems.

Effective responses are those that have an effect on the stimulus object, and involve skeletal movements and manipulation. Ineffective responses may involve also skeletally mediated movements but these may be only expressive,

without affecting the stimulus objects. Nonetheless, non-effective responses primarily involve most of sensory reaction systems and smooth muscle mediated movements. These responses do not affect the stimulus object but may affect in many occasions the organisms itself, as in "emotional" states, need-related sensations and proprioception. Apparent reaction systems are those clearly manifested to the outside observer, while those that are not observable to the non-reacting observer are non-apparent reaction systems. This distinction is important because many of the non-effective reaction systems are also non-apparent to the outside observer and sometimes to the organism itself, as does happen with interoceptive responses.

Stimulus Object, Stimulus and Stimulus Function

Skinner (1938) originally defined a stimulus as "a part, or modification of a part, of the environment correlated with the occurrence of a response" (p. 234). He stated that a stimulus could be understood as:

"a part of the energies or substances directly affecting the organism. It is elliptical, but often convenient, to speak of their sources -as, for example, when a bell is called an auditory stimulus or a book a visual one. The practice is dangerous, since the stimulation arising from such a source is highly variable, but it is frequently successful because of the generic nature of stimuli. In the case of a proprioceptive stimulus it is necessary to appeal to the activity of the organism responsible for the stimulation, and it is implied that a given movement (e.g., flexing a limb) always produces the same stimulation within generic limits" (p. 235).

Along the same argument, Schoenfeld and Cumming (1963) wrote:

"... The definition of stimulus is a perfectly general one, but, by way of a shorthand convenience rather than logical necessity, we most often use the term for those classes of independent variables which affect sense organs and produce correlated behavior changes" (p. 221).

These statements show the two common features of most definitions of stimuli: (i) definition in terms of parts of objects as energy sources, and (ii) identification of the stimulus by its effect on the organism in "producing" a response. These two criteria were essential in the generic definition of the concepts of stimuli and response as dependent covariations or correlations.

Nevertheless, some problems arise with the identification of stimuli with parts of objects assumed to correlate with the "production" of a response.

Objects and things are continuous parts of the physical and chemical environment and as discrete occurrences, they are usually actions, reactions or interactions of those objects. For Schoenfeld and Cumming (1963) the distinction among stimulus and stimulus object "only directs to consider stimulus complexity..." (p. 222). However, the distinction goes beyond the mere pointing out of complexity of the stimulus. As Kantor (1924) stressed:

"A stimulus is entirely a functional affair. It refers to the operation of some object or thing or set of things which elicits a response from the reacting person...The stimulative function is a reciprocal phase of the response function...Stimulative functions therefore must be differentiated from the things or objects possessing these functions, for the same object may have several or many stimulus functions for the same person. Moreover, the same object may stimulate other individuals in still other ways...Psychological processes consist of making natural phenomena (objects, persons, customs, etc.) into stimulus objects which can then function to elicit responses" (pp. 47-48).

Following this argument, three aspects must be distinguished: (i) stimulus objects, (ii) their actions, reactions and interactions as stimuli affecting the organism, and (iii) the functions developed by stimulus objects as result of the reciprocal relation with the reacting organism.

Stimulus objects represent complex potential sets of actions as stimuli, but only those qualify as such, to which the organism is reactive. Stimuli take place only as responses to the changes in stimulus objects. These changes may take place directly in the stimulus objects, or they may be an arise from changes in the response systems of the organism which produce discrete contacts with continuous properties of the objects. Stimuli, as distinct from stimulus objects, are not detachable from sensory reactions. These sensory reactions may be identified in biological terms (Bartley, 1951), according to overt reactions (Blough, 1966), or as verbal reports (Graham, 1952). Sensory reactions are related to the psychophysical problem of determining absolute and difference thresholds, although the latter may also be correlated with some specific stimulus functions derived from learning.

In brief, stimulus objects and stimuli are to be distinguished, since only stimuli may identified in terms of threshold sensory reactions, regardless of the measurement criterion employed, whether it is physiological, movement-correlated, or verbal. Since responses cannot be separated from stimuli, it is

incorrect to state that responses are elicited by stimuli as physical and chemical properties of objects. Acting, reacting and interacting objects affect the reactive systems of organisms, and the changes in reactivity are identified as stimuli. In physical and chemical terms it is unnecessary to divide reality of the world in the form of stimuli, just as it does not make good sense to talk about particles, forces, waves, etc., as stimuli for physical bodies, atoms or particles. Stimuli always presuppose a reacting organism. Stimulus is a term that can be only used in reference to biological responses and it is synonymous with a biological response function.

Nevertheless, it is fundamental to distinguish among biological and psychological stimulus functions. Biological functions directly depend on the physical and chemical properties and parameters of the stimulus-object affecting the organism. The relations described by the static and dynamic laws of the reflex (Skinner, 1938) are examples of biological response and stimulus functions. They involve relatively invariant relations of biological reactions with the physical and chemical characteristics of stimulus objects. In contrast, psychological response and stimulus functions develop in the ontogeny as results of individual interactions with the environment -including other individuals. Kantor (1924) advanced six characteristics of psychological behavior as different from other kinds of behavior (physical, chemical or biological behaviors): a) variability, b) differentiation, c) modifiability, d) integration, e) delay, and f) inhibition.

Stimuli in psychology should be conceived as stimulus functions. A definition based only in the physical and chemical features of stimulus objects would apply to the potential involvement of determined biological response systems. The functions of stimuli develop as the result of functions acquired by biological responses when interacting with stimulus objects. A stimulus function, as synonymous with psychological 'stimulus,' could be characterized in terms of the functional properties of stimulus objects once the organism has biologically responded to them. Therefore, the stimulus function could be conceived as the result of the interaction of certain stimulus object properties and the response systems of the organism. It should not be equated with an energetic change in the environment impinging on the organism. Stimuli, as psychological functions, are response-derived properties of the interaction of the biological response systems with acting stimulus objects (not necessarily present at the time). Stimulus functions are properties of the interaction of the organism and the stimulus objects and settings, but they are not properties of the stimulus events themselves. Therefore, stimulus functions are better described by the language of perception than by language related to sensations.

Ryle (1949) has emphasized that the language of perception implies the language of sensation but that, in addition, it involves always an observer or

perceiver doing something connected to a situation. Wittgenstein (1980) relates the language of observing and perceiving with "noticing an aspect", that is, acting differentially in regard to one or various objects in a situation. Perceiving, as corresponding to stimulus functions, refers to expressions of achievement such as "I distinguished the chord" or "I saw very clearly that figure", or to expressions of "seeing as" that emphasize special manners of relating with objects and circumstances: "I see this flower as a rose", etc.

To summarize, stimulus functions are based on sensory and other elicited responses but do not constitute complex sensations. Stimulus functions, equivalent to perceiving, always entail diverse activities as moving, orienting, and talking that involve differential interactions with stimulus objects and their settings (Ribes, 1990). Stimulus functions emerge from learning and should not be identified with particular properties of stimulus objects and their settings defined in physical or chemical terms. Kantor (1924) stated clearly this issue by saying that "to a very considerable extent psychological phenomena consist of the transformation of objects into stimuli..." (p.48).

On Some Versions of Pseudo-Stimulus Functions

Behavior theory has traditionally classified stimulus functions into three main classes: a) eliciting stimuli, b) discriminative stimuli, and, c) reinforcing stimuli. Some additional categories have, however, been proposed such as emotional stimuli (Skinner, 1938), instructional stimuli (Goldiamond, 1966), and contingency-specifying or evocative stimuli (Blakely and Schlinger, 1987).

The criterion for establishing this classification have been twofold. First, the functions of stimuli have been based on observational criteria, that is, in terms of the possibility of identifying a functional stimulus antecedent to, or following the response, and in the case of the antecedent stimulus if it is presented prior or jointly to the effects of the consequent stimulus (this is the distinction between eliciting and conditional stimuli and discriminative stimulus). Second, the functions of stimuli have been restricted to accounting for changes in the frequency or magnitude of responding, including latency. In the case of verbal behavior (Skinner, 1957) probability of responding was conceived in terms of accuracy rather than of frequency, in order to maintain the evocative (eliciting) or discriminative properties of stimuli regarding speech and reading.

In my analysis of stimulus functions I exclude, from the outset three commonly attributed stimulus functions that do not have sound conceptual grounding. These are the so-called eliciting, inhibitory and reinforcing functions of stimuli.

Eliciting cannot be considered a stimulus function. Eliciting is concerned with the effects of stimulus objects on biological response systems. Therefore,

eliciting defines stimuli, but not stimulus functions. The elicitation of responses is an automatic effect of some properties of stimulus objects, making distal or proximal contact with the organism's response systems. Elicitation is described by the static and dynamic laws of the reflex, including orienting, adaptation and defense reflexes (Sokolov, 1963). Nonetheless, part of the responses involved in an elicited reaction (or reflex) may, and normally do, develop new response functions (see Watson's analysis of embryological responses in 'Behaviorism' in 1924). A form of behavior may be related to with diverse stimulus functions, but elicitation as an invariant, automatic relation between stimulus objects and particular responses does not qualify as a stimulus function. Eliciting relations are part of biology, not of psychology.

Distinguishing any inhibitory functions of stimuli seem to be unnecessary. Inhibition is a term borrowed, as many others, from neurophysiology. 'Inhibition' implies an active force to not respond. In the case of contemporary neurophysiology, inhibition has to do with the chemical medium interfering or facilitating the transmission of electrical impulses. Inhibition can not be identified with some mysterious impulse preventing an impulse or electrical response in the neurons. By the same token, inhibitory functions of stimuli regarding behavior can be interpreted in only two ways: 1) as a stimulus object, correlated with non reinforcement, that has lost its functions with respect to a particular set of responses, or 2) as a stimulus object that has developed some functions regarding a set of responses overweighing other stimulus functions of the same or a different stimulus object (antagonistic or competitive stimulus functions).

I will limit myself to quote Pavlov and Skinner on this issue, since both advanced the same arguments regarding inhibitory functions of stimuli.

Skinner (1938), without being aware of his agreement with Pavlov (1973, Spanish translation), argued against considering inhibition a stimulus function. Pavlov, in his lecture on 'An attempt of physiological interpretation of the symptomatology of hysteria' commented as follows in a footnote:

"In spite of the amount of data we have gathered in the field of the physiology of the nervous system in general, and for the theory of the conditioned reflexes in particular, the issue of the relations among excitation and inhibition remain, until now, without solution. Is it a same and unique process that exchanges itself when conditions lend themselves for doing so, or is it, in certain circumstances, a strongly animated and solded couple of a revolving movement that allows to see, partly or completely, one or the other of its components?" (pp. 384-385).

Skinner (1938) discussed the problem of postulating inhibitory functions of stimuli as follows:

"The use of the concept of inhibition in accounting for the effect of the discriminative stimulus not correlated with reinforcement is partly due to the narrowness of the traditional conception of a stimulus. The term has the unfortunate connotation of a goad or spur to action. In its traditional use it refers to a force which drives the organism, a meaning which has been congenial to writers who wish to prove that the occurrence of a bit of behavior under a given set of external circumstances is inexorable. By extension the same active function of the stimulus has been made to apply to inactivity through the notion of inhibition as a suppressing force. While the present system presupposes the lawfulness of behavior and recognizes the role of the environment, it does not necessarily appeal to the environment as a driving force" (p 234).

The concept of reinforcement as a stimulus function has many difficulties. Reinforcement is usually understood in two senses: first, as a stimulus that increases the frequency of responses preceding reinforcement, and secondly, as a stimulus that selects certain responses among a large sample of potential or actual responses in a situation. It is difficult to separate both accounts of reinforcement, since the selection of a response only can be measured in terms of the increase in frequency of that response relative to other responses. At the same time, the increase of response frequency implies that a specific response has been "selected" to the extent that it is being differentially followed by the reinforcing stimulus. In both senses in which reinforcement is described and accounted for, the stimulus follows the response being strengthened or selected, and although the response class concept was formulated to avoid the criticism about the retroactive nature of reinforcement, the effect always has to be related to a particular property or morphology of behavior. The problem has to do with the sample of behavior to which the effect of the reinforcing stimulus is related.

One logical solution to this problem is to postulate that since the reinforcing stimulus affects all the members of a response class, the effect of the stimulus is proactive on future responses. Obviously this is a fragile solution, since the forward account does not explain why and when the responses affected by the stimulus will occur. When responses take place long after the occurrence of the last reinforcing stimulus, discriminative stimuli and reinforcement history are usually advocated to account for the time-mediated

effect. But how are the discriminative properties of previously neutral stimuli to be explained? The argument seems to be the same. A retroactive effect of the reinforcing stimulus on the stimuli being present when a response is reinforced is assumed. An alternative argument would consist of explaining the "tendency" to respond more frequently in terms of deprivation or similar states. However, deprivation states do not seem to relate well to the definition of a stimulus, even when it is possible to pin-point to response-produced stimuli correlated with deprivation. In any case, if deprivation states account for the increase in responding, then the concept regarding the results of reinforcement is unnecessary.

The logical weakness of the reinforcing stimulus function is inherent in its application to the operant response-reinforcer relation. In the case of respondent conditioning the reinforcer or unconditional stimulus (UCS) precedes the unconditional response (UCR). Conditioning is conceived as an anticipatory responding in presence of a signal of the reinforcer. There are no backward effects. In contrast, in operant conditioning the terminal or consummatory response is neglected, and the reinforcer is related only to the response which produces or precedes its occurrence. In the later case, which deals with the superstition experiment, the response being "reinforced" is a complex pattern taking place between reinforcers, and this pattern includes eating. In the former case, which deals with the traditional operant response preparation, experimental observations do not take into account responses such as drinking or eating, except when they are "adjunctive" behaviors. If, as I have suggested (Ribes, 1995), the consummatory or terminal response is examined in the so-called operant contingency, it is evident that the operant response is a component of the response function including and based in the consummatory or terminal response. No retroactive effect emerges in the situation since the reinforcing stimulus always precedes the terminal response. It is well to remember that even Skinner described his first operant conditioning experiments with reference to the alimentary reflex, the eating response being the last component of the operant reflex.

From the viewpoint here presented the reinforcing stimulus plays two roles. One is that of a stimulus function signaling the consummatory or terminal response. For instance, in the case of food reinforcement, properties such as the odor, the sound of food delivery, etc., are functional regarding the manipulatory responses involved in ingesting. A second role has to do with the biological functions involved in digestion, which become the stimulus setting that facilitates or interferes with the development of different stimulus functions in the situation. Stimulus setting is the grounds or context in which stimulus functions develop. Settings do not correspond to categories describing occurrences, but rather fit into the logic of dispositional categories and

statements. Settings deal with the description of tendencies, propensity and inclinations. Reinforcement, as consuming an object or as receiving an answer after presenting a question, has to do with the changes of stimuli setting and not with specific stimulus functions. Changing settings means to end a deprivation state, solve a problem, find a route, and the like.

Some Tentative Stimulus Functions

How is it possible to identify the various kind of stimulus functions that may develop in behavioral interactions? A study by Farmer and Schoenfeld (1966) showed the variety of stimulus functions that the very same stimulus may develop in relation to various samples of a response pattern. They introduced a neutral non-contingent stimulus in various temporal placements of a fixed-interval schedule of reinforcement. The study showed that, depending on the temporal placement regarding the reinforcing stimulus, the neutral stimulus could be simultaneously related to increases in the preceding responding rate, suppression of response during the stimulus presence, and the development of a scallop pattern in subsequent responding. These functions have been separately identified as conditioned reinforcement, suppression or inhibition, and discriminative control.

Since stimulus functions depend on responding, it is not possible to identify them regardless of their specific effects on behavior's adjustment to a situation. Generally, frequency of responding has been used as the basic measure to explore the stimulus functions related to discrimination and reinforcement. However, stimulus effects related to frequency of responding are artifacts of certain conditions of operant research. Often, the frequency of responding is irrelevant to the analysis of human or animal behavior in natural settings. I shall examine some tentative stimulus functions irrespectively of the particular measure of behavior assumed to be relevant to response functions.

Here, stimulus functions will be proposed in terms of special kinds of interactions involved between the stimulus objects, the behavior of the individual (organism) and the stimulus setting conditions. Six stimulus functions may be identified: 1) signaling function, 2) preparing function, 3) discriminating function, 4) prompting function, 5) instructing function, and 6) substituting function.

The signaling function involves the relation between stimuli objects and events. The conditional and the discriminative stimuli are examples of a signaling function. In both cases, the stimulus holds a contingency relation with the reinforcer: if the antecedent stimulus is present then the reinforcer may occur, but if the antecedent stimulus is not present then the reinforcer will not occur. There is a continuous gradient of probability in which this contingency

relation between the antecedent stimulus and the reinforcer may vary. The discriminative and the conditional stimulus both are characterized as functional stimuli to the extent that the occurrence of the reinforcer is contingent to their presence or occurrence. From this view, the conditional stimulus is not attributed a strong "eliciting" function and the discriminative stimulus is not considered as an occasion for reinforcement. The occasion for reinforcement is the operant response. The discriminative stimulus signals a relation regarding the reinforcer presentation. The operant response sets the occasion for the reinforcer presentation, but not the circumstance under which it may or not occur. Both conditional and discriminative stimuli are functional because of their contingent relation with a reinforcer.

The preparing function has to do with priming a particular response or response pattern previously related with the stimulus as a signal. The preparing function facilitates or accelerates the adjustment of a particular behavior in a situation based on a prior relation between the preparing stimulus and the response. The preparing stimulus always antecede the signaling stimulus, and the use of primes in multiple schedules of reinforcement or the use of models are examples of this stimulus function.

The discriminative function involves a differentiation between two signaling functions, and it is not exclusive of stimuli antecedent to the response but may also be developed as an outcome of response-produced stimuli. Operant differential discrimination procedure and differential and conditioned inhibition procedures in classical conditioning are examples of this stimulus function. It involves a comparative signaling function in which if S1 then S', if S2 then So is dependent on a differential response to both contingencies. This may be achieved through a different response requirement or through response-produced stimuli that may be differentially correlated with each contingency, e.g., providing specific feedback additional to reinforcement as in describing a performance, etc.

The prompting stimulus function consists of a relation between a stimulus that shares part or all the components of the stimuli produced by a response and the "provocation" of that response. The prompting function requires that the response to be prompted has occurred in the past with some probability. The prompting stimulus is presented always after the signaling stimulus in order to assure the occurrence of a response relevant to the signaling contingency. The use of texts, some sort of instructions and models, illustrate the prompting stimulus function.

The instructing stimulus function consists of restricting the antecedent stimuli, the response requirements and the setting stimuli (the so-called motivational events) that participate in a contingency. Goldiamond (1966) has referred to instructional stimuli as verbal stimuli shaping the discriminated

response in a contingency relation. The instructing stimuli are normally verbal, but they may consist of nonverbal stimuli as in the case of second-order matching-to-sample in which the second-order stimuli restrict the possible responses given a stimulus contingency arrangement.

Finally, the substitutional stimulus function consists of response-produced stimuli, usually conventional stimuli (symbols), that replace any of the other stimulus functions. Substitutional stimuli may stand for a particular object, but their function as stimuli is to replace their function in a given situation. In this sense, substitutional stimuli transform contingencies in particular situations by replacing the stimulus functions of present stimuli in terms of non-present stimuli.

This classification of stimulus functions may help to avoid the confounding of objects with stimulus functions. It also helps to distinguish some stimulus functions that are assumed to be biological from phenomena connected with dispositional categories.

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