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# CONTEXT WHERE LEARNING TAKES PLACE

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## ABSTRACT

This compilation is to provide a brief and general review of the main functions of context in learning. Although the role of context in learning has been studied by learning theorists for decades, only in the last 20 years has an attempt for a systematic account of such a role been developed. In the manuscript, definition of contex and its component stimuli were done comprehensively. Then from the functional perspective, how an organism perceives the context was elaborated. Three main functions of the context (e.g. As a CS, as a modulator, and as an occasion setter) were identified and detailed.

**Key Words:** Contex in learning, CS-US association, Context-US associations, occasion setters, facilitation and inhibition.

## Öğrenmede Bağlam

## ÖZET

Sunulan metin ile öğrenmede bağlamın rolüne ilişkin kısa ve genel bir gözden geçirmenin yapılması amaçlanmıştır. Öğrenmede bağlama ilişkin etkiler uzun zamandan beri çalışılmakla beraber, bağlamın öğrenmede oynadığı role ilişki sistematik açıklama çabaları ancak son 20 yıldır geliştirilmektedir. Metinde, bağlam ve bağlama ilişkin uyarıcılar incelikli ve kapsamlı olarak tartışılmıştır. Daha sonra da işlevsel bakış açısından, organizma için bağlamın nasıl algılandığı ve organizma için ne ifade ettiği incelenmiştir. Yine işlevsel bir yaklaşımla, bağlama ilişkin üç ana işlev (bir CS olarak bağlam, bir modülatör olarak bağlam ve ve bir durum kurucu olarak bağlam) tartışılmıştır.

**Anahtar Kelimeler:** Bağlam ve öğrenme, CS-US bağıntısı, Bağlam-US bağıntıları, durum kurucular, hızlandırma ve ketleme.

## Introduction

The role of context in learning has been studied by learning theorists for decades, but only in the last 20 years has an attempt for a systematic account of such a role been developed.

Before presenting how learning theorists have dealt with context, we have to consider a preliminary definition of context. A very informal definition would say that the context of an organism is the organism's situation in a specific space and time. That includes physical, psychological, and social aspects. The important thing is how the behavior of the organism is affected by such context.

The systematic study of the behavior of the organisms started at the end of the 19th century and the beginning of the 20th century. Even though there are many antecedents in philosophy, biology, and other disciplines, the organized and adequate collection of information about behavior has been the perview of psychology. As in every science, psychology started by trying to understand small sets of events but since, has been broadening its field to include many

related areas, as well as finding applications to many other problems. Some of the first problems faced by psychologists were:

-How does an organism learn from its surroundings?

-How does it recognize a dangerous situation, or find nutrients and a safe place?

All those question are very important, but psychology theorists during 19th century could not solve them satisfactorily because of pre-existing ideas that attributed the causes of such phenomena to magical events of final purpose. Perhaps because of the close proximity between medieval philosophy and the social scientists, the first scientific approach to the study of learning came from the natural sciences. Ivan Pavlov (1849-1936), a Russian physiologist, while studying the digestive glands, established the first experimental paradigm for learning. He called the result "psychic secretion" (Gray, 1979). The first studies by Pavlov developed a methodology based on precision and a strict definition of the responses measured in the studies. Pavlov used salivation as the response, and drops of saliva as the unit of measurement. A methodological mistake in the variables control, however, afforded Pavlov the opportunity to find the so-called "conditional reflexes"

In the normal procedure used in the study of the digestive glands, the investigators put food in the mouth of the animal, and observed its effect on the production of saliva and other gastric juices. While developing these experiments, Pavlov accidentally discovered that when his assistants appeared in front of the animal, it started to salivate. More detailed observations showed that even the presence of the white dressing gown by itself, or the sound of steps alone, could provoke salivation in the animal. In this way, Pavlov found a general explanation for the so-called "psychic secretions". Such psychic secretions were controlled by Pavlov by mean of his famous "silence tower" (Todes, 2000), but still being without a precise explanation, he decided to study the conditions under which they appeared. Because he found that different stimuli could provoke such responses, he chose some that could be studied in a parametric way, that would be possible to identify.

Stimuli that elicited responses such as salivation were called "unconditional", and stimuli that did not have this capacity, but could acquire it, were called "conditional". The only characteristic important to the Conditional Stimulus (CS) was thought to be its neutrality to produce the Unconditional Response (UR). It was observed that the CS elicited orientation responses originally, but after repeated presentations of the CS, such orientation responses disappeared. Many Unconditional Stimuli (US) and CSs were studied, but now all the CSs were specific, localized and presented only in very few dimensions.

The nature of the CS has been extensively discussed in the learning literature. The CSs are considered as punctual, specific, and novel stimuli. In this sense,

permanent stimuli would not be good CSs. In the recent years, however, some authors have considered sets of stimuli such as the context in which learning takes place. This idea is not new. In 1902, Pavlov said, in discussing the variety of stimuli that could be a CS: "Even conditions altogether collateral to the stimulus, such as the room and furniture of the room in which the animal is placed, the vessel containing the food, the presence of the attendant who ordinarily feeds the animal, the sound of his approach, produce an effect" (pg. 84). If Pavlov later used only very specific stimuli for his studies, it was for the purpose of control, to measure the stimuli, and to evaluate how changes in the intensity and quality of the stimuli would produce changes in the magnitude and topography of the response (Todes, 2000).

Other authors also accepted that contextual stimuli could elicit a Conditional Response (CR) when associated with an US (Domjan, 2005), as we will see in the next section.

There is a common characteristic to all the authors who considered context as susceptible of being used as a stimulus to control behavior. All of them accepted the principle of contiguity as necessary and sufficient for the conditioning to take place; this is perhaps one of the main obstacles for the development of research using context as a control stimulus. Another possible obstacle is the notion of "selective attention", which implies that an organism will pay attention only to those stimuli that exercise control over the appearance of the US. According to this concept, change is necessary, and because context is relatively permanent, it would not be a good predictor and the organism would not learn anything about it.

Thus, during many years context was considered innocuous and irrelevant in conditioning; then, experimental evidence changed this idea. In an article published in the *Journal of the Experimental Analysis of Behavior*, Eckermman, Lanson, and Cumming (1968), reported changes in the response in a matching-to-sample procedure, caused by the cleaning of the experimental cages. Such changes were explained in various terms. Other authors also reported similar effects.

The next sections will present in some detail what different authors have considered as context, how an organism perceives a context, and how context acquires the capacity to control the behavior of the organisms in some experimental situations.

## Definitions of Context

A stimulus is very often defined in terms of, or compared to, the environment. Because of that, we should define context first, and based on that definition, then define stimulus. It is possible, however, to go the other way around; an inductive approach is always helpful in these situations. It is easier for us to

show what is understood by stimulus and then to present different definitions of context. In both cases we will follow an historical perspective.

*What is a stimulus ?*

There have been different uses of the concept of stimulus in psychology. A first idea is to consider a stimulus as having a role in motivation (Gibson, 1960). This idea is not accepted by authors such as Skinner (1938), who distinguishes between drive and stimulus, separating the function of the stimulus from motivational factors.

Second, a stimulus seems to be defined in many situations in terms of its relation to a response. This idea is derived from the reflexology tradition. For example, Pavlov (1927) considered stimuli and responses to be extremely related in a causal fashion. It is interesting to note that Skinner presented a similar idea in his *The Behavior of the Organisms*, in which he wrote: "The environment enters into a description of behavior when it can be shown that a given part of behavior may be induced at will by a modification of the part of the forces affecting the organism. Such a part of the environment is traditionally called a stimulus and the correlated part of the behavior a response. Neither term may be defined as to its essential properties without the other" (1938). Later on, however, he argued against this practice: "We frequently define the stimulus by the very doubtful property of its ability to elicit the response in question, rather than by any independent property of the stimulus itself" (1959, pg. 355). Estes (1959), agrees with this idea, saying that "...by stimulus and all variants of the term I refer to environmental conditions describable in physical terms without reference to the behavior of the organism". That supposes a psychophysical definition of stimulus; in other words, a stimulus can be defined in terms of its physical properties. Psychology of learning, however, has not been using stimulus in this sense. For most of the theorists, the functional possibilities of the stimulus seems more important than a strict set of limits about what actually is a stimulus. As Staddon and Ettinger (1989) say, "...the word stimulus implies the existence of a response" (pg. 155). As restrictive as this idea is, it represents the notion that the importance of a stimulus resides in its capacity to control behavior.

Let us accept that we can define stimulus in relation to the response; we still have to be specific about the characteristics of the stimulus that control behavior, and this is not clear in such an approach. Perhaps the most important discussion about this aspect is the distinction between punctuate and molar stimuli. Again, psychophysics would claim that a stimulus is punctuate by definition, because it would activate only a set of receptors. If it activates different sets of receptors, it is more than a stimulus. Following this idea, we should expect a claim that there is also a temporal limit for a stimulus. In order to be a stimulus, it should be momentary. From a functional point of view, such

restrictions would not apply. A stimulus can be punctuate or not, and it can be temporal or relatively permanent, or even permanent. The important aspect of the stimulus is that it provides information to the organisms about the environment (Gibson, 1960). In 1956, Melton complained about a restrictive definition of stimulus: "There is the assumption in much of theory and experimentation, especially on the simpler forms of learning in the rat and in human conditioning, that the stimulus is a simple punctiform affair, something that can be dealt with as though it occurred without context, as though it were the stimulation of a single receptor" (p. 281). This complaint is partially justified as we will see later. We could argue, however, that not all authors ignored completely the context in the control of behavior.

*What is Context?*

We have seen that the traditional definition of stimulus restricts the possibilities of considering context as functional in learning. Many authors after Pavlov, however, recognized a possible role for context in learning. For example, Thorndike (1911) used the term "situation" to describe what we usually call "stimuli". The first term is more general and because of that, less specifiable and controllable. Later on (1913), he said that a reflex, or an instinct, implies the ability to be sensible to certain situations.

For Tolman (1932), context was central to his theories. He thought that animals make internal representations of the environmental stimuli in order to solve a problem such as the radial maze. For him, context was a series of stimuli and the relation between these stimuli. Additionally, Tolman presented various interesting ideas that are used currently. He attributed two possible roles to the context; one, as a direct elicitor of behavior, and two, as a provider of "support" for the behaviors that the CS would normally elicit. This last role may be interpreted as what is called "modulation of behavior" (Rescorla, 1988).

Hull (1943) considered that in a conditioning situation, the CS includes a wide and complex set of elements. He said: "It is obvious that in addition to the stimulus, many additional or incidental stimuli become conditioned to the response. These include other stimuli which consistently impinge on the organism's sensorium during the repeated reinforcements; we will call them incidental stimuli" (1952, pg. 65). The concept of incidental stimuli is situational; it refers to elements temporally and spatially related to the CS. Context is clearly related to the presentations of the reinforcements, but it is also related to the non-presentation of them; therefore, is context what Hull called "incidental stimuli"?

B.F. Skinner in his article "Are theories of learning necessary?" (1950) said, in trying to explain spontaneous recovery, that the stimulation present during the time the animal is being reinforced becomes conditioned, and the animal, once again being under the same conditions, presents responses related to the

previous reinforcer. For Skinner, as for Hull, temporal and spatial contiguity was important for context in order to control behavior. Harry Helson (1959), a social psychologist, restricted this possibility, saying that contextual stimuli could acquire control properties when they are salient to other stimuli, either being larger or more intense, or because they are presented more frequently than other stimuli.

Looking at these authors' ideas, we can identify some problems about the use of context in conditioning situations as an independent variable. First, most of the theorists seem to consider that context would have a minor role in learning (except perhaps for Tolman), and that this role would be dependent of its relation to the CS. Second, in order for context to acquire control properties, it has to be salient. In other words, context has to have the same characteristics as a punctuate stimulus. Thus, is the only difference between context and stimuli its relatively bigger size?

## Perception of Context

Organisms react to their environments. Psychology can be seen, in a very simple way, as the study of the characteristics of the environment to which the organisms react, and as the study of the characteristics of such reactions. In the same way, psychology of learning would be the study of how characteristics of the environment evoke a response that was not previously evoked (Balsam, 1988). If we want to know why a response occurs, we have to know what is the stimulus and what are its characteristics that led to such a response. Typically, two procedures have been used to study this problem: Generalization and discrimination.

### *Generalization and Discrimination Studies*

When we say that an animal discriminates between two stimuli, we are saying that in some way these stimuli control its behavior differentially. From the generalization point of view, we would say that an animal is generalizing when it presents the same response to two different stimuli. Balsam (1988) suggests that there are three main reasons why stimuli may be treated equivalently. First, the stimuli may be equivalent in a functional way, because they are physically similar. Second, although being different in their physical characteristics, two stimuli may be encoded similarly. Third, two different stimuli may similarly affect a decision rule and produce identical responses. In all discrimination situations, context is present for both stimuli. Thus, an animal can see context as a common characteristic of $S^+$ and $S^-$ and respond similarly to both. In such a case, context would be seen as part of the CS. Additionally context could also be seen as an independent CS. Under these circumstances, the response would be different, particularly when compared to punctuate stimuli, such as in operant conditioning or in other procedures such as autoshaping. The response is usually very specific, and is not possible with a diffuse stimulus. Because of

that, it is difficult to measure generalization between a punctuate stimulus and context.

A stimulus in discrimination training sets the occasion for a response (Thomas, 1985); this may also be the case for context. Because contextual cues are common to all the described situations, we can argue that discrimination will depend at some point on contextual permanency. For example, Perkins and Weyant (1958) found that rats trained in a runway presented generalization decrement in discrimination training when aspects of the context were changed (e.g., the floor of the runway). In this case, as previously noted, the effect of the control by context is measured in an indirect way.

An important question about the role of context in discrimination training, and in general, of stimulus control, is whether context has a function equivalent to a CS. Even though we will later on discuss some research that tests this point, we will now present some phenomena that could help answer this question. In masking, for example, the control exerted by a component of the discriminative stimulus on the conditional response is obscured or masked by the presence of another component stimulus during test phase. Very frequently, the component that masks the discriminative component is a contextual stimulus.

A remaining question about the role of context in discrimination concerns the characteristics of the compound stimulus that can acquire control over behavior. Stimuli are multidimensional; they are not presented as unique elements, but as compounds. Thus, stimulus control by the compound may depend on properties of the stimuli (e.g., overshadowing), training contingencies (e.g., masking, blocking, etc.), the species that we are studying, and previous experiences of the animal. Cues that are more salient gain more control over the response. A stimulus, and in this case, a context, may be more salient because of a low salience of the punctuate CS, or because the elements related to the $CS^+$ are more discriminable than elements of the $CS^-$ (Balsam, 1988). Another aspect relevant to stimulus control is the relationship between the stimuli; for example, when we increase the duration of the CS, control by contextual cues increases.

Spence (1936) and Hull (1939) suggested that the predictiveness value of a cue determined its importance in stimulus control. Even when there is not a CS-, because contextual cues are reinforced with the $CS^+$, a comparison is established with extra experimental conditions that would act as $CS^-$ (Balsam, 1982, 1984, 1985).

Finally, in discrimination conditions context can also compete with the CS for control over behavior (Hearst, 1988). Two examples were previously presented -masking and blocking-. This idea leads to the so-called *inverse hypothesis* that states that the control acquired by contextual stimuli is inversely proportional to the control acquired by specific cues (Gibbon et al., 1981). There are at least three additional hypotheses that explain the competency of context for control

over behavior. They center on competence for associative value (Rescorla and Wagner, 1972), attention (Mackintosh, 1975), or processing resources (Wagner, 1981).

## The role of Context in Learning

We have already seen some of the conditions under which context acquires control over behavior in discrimination training. In the following pages we will see in a more schematic way some of the most important roles identified for context in learning.

Balsam (1985) has identified different functions of context in learning that we will summarize in three classes of functions: Context as a CS, context as a modulator, and context as a response selector.

*Context as a CS: Context-US Associations*

The presentation of an US alone is considered to have a non-associative impact on behavior. The most typical phenomenon related to the presentation of the US is habituation. Habituation is a decrease in the response caused by repeated presentations of the US. Non-associative explanations assert that repeated exposure to the US, would alter the UR, leading to the alteration of the CR, not because of a change in the association CS-US, but because of a change in the UR.

The US is presented in a context and it can be assumed that an association between context and US could be formed. Thus, habituation to the US could be altered by changing the contextual conditions of the presentation of the US (Randich and Ross, 1985). The assumption that US and context can be associated in US exposure has some implications and possible predictions, one being that massed presentation of the US would have a stronger impact on context-conditioning. This is proved by Williams et al. (1991), who showed that short intertrial intervals between USs promote contextual conditioning. Another prediction is that context-US pre-exposure would have a negative effect on the formation of associations between other CSs and the US. Tomie (1981) showed that US pre-exposure retarded the acquisition of autoshaping response in pigeons. His explanation was in terms of blocking of the CS-US association by the context-US association (see Kamin, 1969).

Context-US associations have been observed using aversive USs. Fanselow (1990) demonstrated that rats can learn context-aversive US associations in just one trial. This effect can be attenuated by reducing the presence of the subject in the experimental chamber to about half a minute in this situation. The phenomenon was particularly effective when the animal was pre-exposed to the chamber 24 hours before the presentation of the US, and if a tone was used as part of the context.

Balsam (1985) presented food to doves in a specific context. Then, he measured the general activity level of the animals and compared them in a generalization test. He found that contextual cues acquire control over behavior, even without differential reinforcement of the context.

The use of general activity level is a common measure of context-US associations. For example, Rescorla et al. (1985) compared the activity level of two groups that were differentially presented with US (food) or without it. Behavior was observed in the five-minute period before the US presentations for the experimental group started. The results showed that the group that was presented with food showed a higher general level of activity, demonstrating that the animals could discriminate between the two contexts.

Previously, we saw that context-US associations may have a negative effect on CS-US associations, but they usually have a weaker impact in the facilitation of the exhibition of that conditioning. For example, when a fixed-value CS was tested in contexts of different value, the performance was similar; however, a stimulus conditioned in contexts having different strength exhibited differential levels of performance when it was tested in a fixed-value context (Rescorla et al., 1985). That suggests that context-US associations affect the learning process, but not the performance process.

As we saw, context-US associations may compete with CS-US associations. Context may also be compared to the CS in learning situations. Gibbon and Balsam (1981) propose that animals can compare a ratio of delay of reinforcement with a context, to a ratio of delay of reinforcement with specific cues. For example, in reinforcement schedules, subject would compare a ratio of reinforcement in the presence of the CS with the general ratio of reinforcement in the experimental situation. In classical conditioning, the comparison occurs between the expectancy of the US when the CS is present and the expectancy of the US in the general situation, or context (Miller and Matzel, 1988; Miller and Schachtman, 1985).

Konorski (1967) suggests that additionally, context-US associations could evoke a motivational condition that facilitates the formation of CS-US associations.

*Context as a Modulator: Context-CS Associations and Occasion Setting*

If context acquires similar properties to a CS in some situations, it should be possible to observe not only context-US associations, but also, context-CS associations. The most typical phenomena of CS-CS associations are second-order conditioning and sensory preconditioning. Rescorla et al. (1985) have demonstrated second-order conditioning in autoshaping using context as CS1 and a specific cue as CS2. Helnstetter and Fanselow (1989) demonstrated that rats form context -US associations based on aversive USs in a higher

conditioning situation. Additionally, Archer et al. (1985) not only proved higher order conditioning in a taste aversion learning using context as CS1, but they also demonstrated sensory preconditioning in the same paradigm. It is important to say that in all these experiments, context is defined as the set of cues present in the experimental situation, but the animals lived in a context that was not evaluated. In other words, context in those cases had a temporal limitation, and presumably represented certain degree of novelty for the subjects. Research using more permanent contexts would be of great interest, particularly in context-CS associations.

A final problem derived from the formation of context-CS associations is that they could lead to a difficulty in the formation of the CS-US association. Wagner (1978) suggests that this happens because the CS loses salience and that affects the CS-US relationship. A different kind of explanation would say that, for example, in a CS pre-exposure condition, the animal learns a non-relationship between context and CS, and the US (Baker and Mackintosh, 1977).

In many situations context is a diffuse compound that does not produce very specific responses. As we said, a general activation is frequently the observed response to context. This could suggest that context may have an effect on arousal and/or that it sets the occasion for the response (Balsam, 1988). In both cases, the effect on the response is indirect, but not less important.

*As an occasion setter, two main functions have been attributed to context: facilitation and inhibition.*

In facilitation (other authors call it "occasion setting"; e.g., Schmajuk and Holland, 1998), a stimulus informs the subject that another stimulus will be followed by the presentation of the US (Rescorla, 1986, 1987, 1988). In a typical experiment of facilitation, Holland (1983) presented rats with a tone that was followed by food only when such a tone was preceded by a light. Under different conditions (no presence of light), the food was not presented. The result was that the response of the rat to the light increased. This kind of experiment shows the facilitatory stimulus as a modulator (Rescorla, 1988) more than as an excitor. We say that the facilitator is a modulator and not an excitor because it has more than one direction of effect. The nature of the facilitated response is not necessary similar to the nature of the modulator, but to the nature of the CS and/or the US.

To understand the mechanisms of action of a facilitator, it is necessary to know not only when it does work, but when it does not. Rescorla (1986) did a series of experiments and found the following results: The effect of a facilitator does not decrease with non-reinforcement when it is presented by itself, or when combined with a third stimulus. If it is presented with the CS and non-reinforced, however, its facilitatory properties decrease. Rescorla's experiments

confirm the idea that a facilitator is not an excitor, but has different functions that are related to those of an excitor.

The original paradigm for facilitation is A-/BA+, being A the CS, and B the facilitator. Studies by Holland (1983) and Ross and Holland (1981) state that in this paradigm we can observe two different functions for B. If A and B are presented simultaneously, B will have excitatory functions, but if B precedes A, B will be a facilitator. This idea is very interesting because it suggests that context, that is usually present when a CS (excitor) is presented, could not be a facilitator. Rescorla (1985) trained pigeons to be reinforced preceded by a keylight in the presence of a diffuse auditory or visual stimulus. Under such circumstances the diffuse stimulus facilitated the response to the key. This results shows that certainly context can be a good facilitator when presented simultaneously with the excitor (CS). It could be argued, however, that context preceded the CS, acquiring the properties of a facilitator.

Inhibition as a procedure is contrary to facilitation. For some authors (Rescorla, 1987, 1988) this may suggest that their mechanisms are contrary but comparable, as two sides of the same coin. For example, both facilitators and inhibitors act as modulators. They do not elicit responses by themselves, but they need excitors to have an effect on the response. Facilitators and inhibitors behave similarly when they are under conditions such as extinction or reinforcement. Witcher and Ayres (1984) found that the non-reinforcement of an inhibitor did not have an effect on its inhibitory capacities, such as was shown for facilitation.

Finally, a variation in the inhibition procedure showed a similarity between facilitation and inhibition. Holland and Lamarre (1984) did an experiment using the following procedure: BA-/A+. When B and A were presented simultaneously, B acquired excitatory properties, but when they were presented successively, B acquired properties as modulator of A. Those similarities do not prove definitely that facilitation and inhibition are equal, but they support the idea that although both may have similar mechanisms, they have contrary effects on behavior.

*Context-CR relations*

In our discussion of the properties of modulators, we said that they do not determine the form of the CR. Under some conditions, however, context may select or alter the topography of the conditioned response.

Tomie (1985) showed that the responses presented by a pigeon to the keylight in an autoshaping procedure were not altered by contextual associations when the response was well established, but they changed when context-US associations preceded CS-US associations.

The role of context in the topography of the conditioned response has not been adequately and directly evaluated. Further research is needed.

## Conclusions

This has been a very brief and general review of the main functions of context in learning. We can appreciate, however, the many ways in which organisms use context to predict their environments. Animals do not perceive a world of particles, a world of separated and just occasionally related stimuli, but a very complex and molar series of stimuli. If as scientists we have used molecular stimuli and simplified situations, it is to understand the mechanisms of behavior related to such complex characteristics of the world, and not because we ignore the fact that the world is not summarized in the laboratory.

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