UNIVERSIDADE DE SÃO PAULO

INSTITUTO DE PSICOLOGIA

ÁLVARO ARTURO CLAVIJO-ALVAREZ

**THE ROLE OF ASPECTS OF THE ENVIRONMENT
UNCORRELATED WITH THE CONSEQUENCE IN THE
ESTABLISHMENT OF STIMULUS CONTROL**

**(O papel dos aspectos não correlacionados com a consequência no
estabelecimento do controle de estímulos)**

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establishment of stimulus control

**(O papel do aspetos não correlacionados com a consequência no
estabelecimento do controle de estímulos)¹**

Tese apresentada ao Instituto de
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AUTORIZO A DIVULGAÇÃO TOTAL OU PARCIAL DE ESTE TRABALHO, POR QUALQUER MEIO CONVENCIONAL OU ELETRÔNICO, PARA FINS DE ESTUDO E PESQUISA, DESDE QUE CITADA A FONTE.

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Dedico este trabalho a Luana Isabela Clavijo Vasquez, minha adorada filha

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RESUMO

Clavjio,-Alvarez, A. A. (2014). O papel do aspetos não correlacionados com a consequência no estabelecimento do controle de estímulos. Tese de Doutorado, Instituto de Psicologia, Universidade de São Paulo, São Paulo.

Pelo menos uma parte do ambiente no qual uma resposta produz uma consequência ganha controle sobre a resposta. Geralmente, a parte que ganha o controle correlaciona com a consequência. Partes não correlacionadas podem dificultar ou facilitar a aquisição do controle por as partes correlacionadas e até mesmo ganhar controle por si mesmas. Esta tese trata sobre o papel que partes do ambiente não correlacionadas com a consequência têm no estabelecimento de controle de estímulos. O capítulo 1 é uma revisão sobre o estabelecimento de controle com ênfase nas propriedades do ambiente. O Capítulo 2 descreve dois experimentos que avaliaram controle por porções do ambiente não correlacionadas com a consequência. Experimentos anteriores com uma tarefa de reconhecimento sugeriram controle por partes de estímulos com forma humana não correlacionadas com a consequência. Os resultados do Experimento 2 mostraram com uma tarefa operante que o teste de reconhecimento mede controle por aspectos do ambiente não correlacionadas com a consequência e que o controle de porções não correlacionadas podem dificultar ou até impedir o controle pelas partes correlacionadas. O Capítulo 3 descreve três experimentos que avaliaram a influência da forma dos estímulos no controle por estímulos não correlacionadas. Os resultados mostraram que porções não correlacionadas de estímulos em formato humano tinham uma chance maior de controlar o responder do que estímulos com os mesmos componentes em formato não-humano. O capítulo 4 descreve três experimentos que avaliaram controle por porções do ambiente não correlacionadas com a consequência com cruces formadas por quadrados que tinham contato uns aos outros ou que tinham uma pequena distância entre eles. Os resultados mostraram que partes dos estímulos formados por quadrados desconectados ganhou controle sobre a responder, mas não ganharam controle quando as cruces estavam formadas por estímulos unidos.

Palavras chaves: controle de estímulo, correlação com reforço, estímulo visuais, atenção visual

ABSTRACT

Clavijo, A. (2014). The role of aspects of the environment uncorrelated with the consequence in the establishment of stimulus control in visual discrimination tasks. Doctoral Dissertation, Instituto de Psicologia, Universidade de São Paulo.

At least part of the environment in which a response produces a consequence always gains control over the response. As a rule, the portion that gains control correlates with the consequence. Uncorrelated portions may hinder or facilitate the acquisition of control by the correlated ones and even gain control by themselves. The present dissertation deals with the role that portions of the environment uncorrelated with the consequence play on the establishment of stimulus control. Chapter 1 is a review on the establishment of control with emphases on the properties of the environment. Chapter 2 describes two experiments that evaluated control by portions of the environment uncorrelated with the consequence. Previous experiments with a recognition task suggested control over responding by portions of human-like stimuli uncorrelated with the consequence. Results from Experiment 2 demonstrated with an operant task that the recognition task measures control by aspects of the environment uncorrelated with the consequence and that control by uncorrelated portions of the stimuli may hinder or prevent control by the correlated portions. Chapter 3 describes three experiments that evaluated the influence of the stimuli's shape on the acquisition of control by uncorrelated features. Results showed that uncorrelated portions of stimuli in human format had a greater chance of gaining control over responding than stimuli with the same components in nonhuman format. Chapter 4 describe two experiments that evaluated control by portions of the environment uncorrelated with the consequence with crosses formed by squares that touched each other or that had a small distance between them. Results showed that portions of the stimuli formed by disconnected squares gained control over responding, but they did not gain control when the crosses were formed by united stimuli.

Key words: Stimulus control, reinforcement correlation, visual stimuli, visual attention.

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PRESENTATION

A portion of the environment in which a response produces a consequence always acquires control of the response. The consequence is a key factor in the establishment of that control. Without the consequence, there is no operant responding let alone stimulus control of an operant response. During the acquisition process, factors other than the consequence may affect how a portion of the environment gains control over the response. When the response produces the consequence for the first time, no stimulus controls it. In the presence of simple stimuli like a single illuminated key in an operant chamber or a geometrical shape on a computer screen, the portions of the environment correlated with the consequence gain control as a rule. However, in the presence of more complex stimuli, like the ones in most natural situations, the portions of the environment that correlate with the consequence does not necessarily acquire control of the response.

In relation to the target response, characteristics of the environment may facilitate, hinder, or even prevent the acquisition of control by portions of the environment that correlate with the consequence. There is no reason for assuming that the initial environment is neutral. As organisms are always interacting with their environment, different forms of stimulus control must exist. For a stimulus gaining control over the response, sensory contact with the stimulus is necessary. Organisms have sensory contact with portions of their external environment permanently. The probability of the initial sensory contact with each one of the different parts of the environment in which a response produces a consequence does not have to be equal, which implies that responding is already under some form of control by some stimuli in the initial environment; namely, the environment before the establishment of an operant response.

In many situations, the portions of the environment that correlate with the consequence are part of complex, compound stimuli. The aim of this research was to evaluate

the role that the uncorrelated portions of stimuli with a component that correlates with the consequence plays on the establishment of control by the correlated components. Five chapters compose the thesis. Each chapter has a format as close as possible to a paper to facilitate its posterior submission to research journals. However, they are not in a strict APA format in order to facilitate the reading of the thesis. The major sections have sequential numbers that identify them. Chapter 1 is a conceptual review on operant stimulus control and the variables that regulate it with emphases on the role of the initial environment during the establishment of stimulus control. Chapters 2, 3, and 4 are experimental reports. Chapter 5 is a brief integrative summary of the conclusions that derive from the experiments that this text presents.

In all the experiments, a computer presented participants with stimuli that had a component that correlated with the consequence while the other components did not correlate in simultaneous discrimination tasks. Chapter 2 describes two experiments that evaluated control by features of the stimuli uncorrelated with the consequence with operant procedures. A previous study with a recognition task with human-like stimuli showed evidence of control by components of the stimuli uncorrelated with the consequence. The purpose of the two experiments was evaluating if operant procedures showed control as well. Chapter 3 describes three experiments that evaluated if the shape of the stimuli affects the establishment of control by portions uncorrelated with the consequence. Uncorrelated portions gained control over responding with stimuli in human format. The stimuli in the experiments that Chapter 3 includes had the same components in human and no human format. Chapter 4 describes three experiments that evaluated control by features of stimuli uncorrelated with the consequence with geometrical shapes. The stimuli were squares that formed crosses. The same crosses touched each other by the corners or had a space between them to evaluate if the proximity of the components of the stimuli affected the establishment of control by the

uncorrelated and correlated components. Chapter 5 listed the five main conclusions that derived from the experiments as a whole.

CHAPTER 1

Properties of the Environment that may Affect The Establishment Of Stimulus Control: A
Conceptual Revision

Introduction

Different variables account for the acquisition, maintenance, and extinction of stimulus control; acquisition is the focus in this text. Furthermore, and paraphrasing Sidman (1969), the emphases will be on “the stimulus side of the controlling stimulus relation” (p. 745). When a portion of the environment in which a response is reinforced correlates with the consequence, that portion gains control over the response (Terrace, 1966). In the lab, the correlated portion is usually against a constant, uniform background to control for the influence of the uncorrelated ones. However, uncorrelated parts may play a role in the establishment of stimulus control. Given that the correlated along with the uncorrelated parts constitute the entire setting in which reinforcement takes place, it is worth to study how and why they affect how environmental segments gain control over human and nonhuman responding. To discuss the role of the environment during the first stages of the establishment of control by a stimulus – the initial environment–, this text begins with a review of the notion of stimulus control. Then, it continues with an evaluation of some variables that regulate its establishment. Finally, it examines the notions of attending and observing because their role in the acquisition of stimulus control.

1.1 The notion of stimulus control

According to Skinner (1972),

An adequate formulation of the interaction between an organism and its environment must always specify three things (1) the occasion upon which a response occurs, (2) the response itself and (3) the reinforcing consequences. The inter relationships among them are the "contingencies of reinforcement." (p. 423).

Skinner (1953) illustrated a three-terms reinforcement contingency with a situation in

which a researcher reinforces a pigeon's neck stretching only when a signal light is on and never when it is off. Eventually, the neck stretching will occur mostly when the light is on and hardly when it is off. In this situation, "the *stimulus* (the light) is the occasion upon which a *response* (stretching the neck) is followed by reinforcement (with food)" (Skinner, 1953, p. 108). In Skinner's illustration, the environment controls the response by providing a consequence, food, and by setting the occasion for the consequence to occur, the light.

The occasion for the response is an antecedent condition, and according to Moxley (1998) in relation to antecedent conditions, Skinner moved from the notion of a discriminative stimulus in his first works (e.g. Skinner, 1933, 1938) to that of setting in his latests (e.g. Skinner, 1973, 1988). A setting, which includes what Skinner called a discriminative stimulus in his first papers, "suggests a wider range of component members than a discriminative stimulus does" (Moxley, 1998, p. 81). Although Skinner referred in his earlier papers to the antecedent condition as a discriminative stimulus, in later papers, he emphasized the control over a response rather than its discriminability. Skinner (1987) argued (as cited in Moxly, 1988),

The term discrimination which I took from contemporary work on animal behavior, was not quite right. I did not really care whether a rat could tell the difference between light-on and light-off. The control acquired by a stimulus was the issue. I began to speak of a stimulus as "the occasion" for a response or even of responding "in" a stimulus as short for "in the presence of," but neither expression quite represents the way in which a stimulus gains control of an operant. (p. 201).

Researchers did not use the term stimulus control before 1940. It is necessary to discuss the concepts of discrimination and generalization briefly to examine what the concept of stimulus control describes. During the first decades of the twenty-century, discrimination and generalization were important concepts in the "contemporary work on animal behavior"

to which Skinner alluded in the preceding paragraph. Generalization referred to responding to non-reinforced stimuli similar to the one reinforced and discrimination to responding to the reinforced stimulus (Catania, 1992). According to Honig and Urcuioli (1981), researchers used the concept as “constructs for the explanation of other behavior” (p. 406). Authors assumed that discrimination and generalization were underlying processes that they inferred from their experiments (see Brown, 1965; Terrace, 1966). Pavlov’s (1927) irradiation theory was an example on one of such theories. He assumed that the associative strength acquired after training to a stimulus irradiated to other stimuli in proportion to their degree of similarity.

According to Terrace (1966), the concept of stimulus control replaced those of discrimination and generalization for two reasons. First, because it describes the empirical functions that researchers observe rather than the processes that authors such as Spence (1937) and Hull (1950) assumed existed when they used the concepts of discrimination and generalization. Second, stimulus control emphasizes stimulus-response relations rather than inferred processes. Terrace (1966) disagreed with the theories that explained generalization by maintaining that response strength spreads around a stimulus correlated with reinforcement.

According to Dinsmoor (1995a), the terms generalization and discrimination do not describe different process, but two opposite points in a continuum. On the subject, Guttman and Kalish (1956) had wrote,

The generalization gradient should be proportional to the reciprocal of the DL –

Differential Limen–. It is a way to say that the organism generalizes to the extent that it cannot discriminate or that generalization is the inverse of discrimination (p. 79).

Guttman and Kalish’s (1956) point, known as the Inverse Theory, asserts that generalization results from little or no discrimination (see Honig & Urcuoli, 1981). Along the same line that

Guttman and Kalish (1956), Dinsmoor (1995a) argued that the slope of a generalization gradient is an index of the level of stimulus control that a training procedure has attained rather than the expression of an underlying spreading mechanism.

A high level of generalization simply indicates a low level of discrimination and not that responding strength has extended to other, similar stimuli. To illustrate his point, Dinsmoor (1995a) noted that the gradient of generalization for a surgically deafened pigeon to different tones would be as broad as possible. Response rates to the different tones would be similar because the pigeon's incapacity to distinguish between them and not because response strength has spread to other tones (later in this text there is an additional discussion on the issue of the strengthening of responding in the context of the establishment stimulus control). On the other hand, a broad gradient of generalization also may indicate control by stimuli different to those that a researcher intended to be the controlling one rather than any underlying mechanism (see Sidman, 1969).

Additionally, as Dinsmoor (1995a) mentioned, when food is systematically delivered in the presence of a stimulus and not in its absence, "the gradient of generalization about that stimulus becomes narrower, rather than broader, as the training continues" (p. 59). Results of an experiment by Hearst and Koresko (1968, quoted by Dinsmoor, 1995a) exemplify Dinsmoor's arguments. They reinforced pigeons in a variable-interval schedule only when they projected a white line on the response key. They presented the line for periods of 30 s interspersed with 10 s periods in which the key was dark and responding produced no grain. They plotted average gradients of generalization for their birds after 2, 4, 7, and 14 days of training and found that generalization decreased while stimulus control increased as the training progressed. The second day, for instance, they found some small amount of responding in the presence of each test stimulus what contrasted with the peak on the stimulus in which they had reinforced their pigeons pecking the 14th day. The increase in

stimulus control was evident, so, according to Dinsmoor (1995a), differential responding results in discrimination or stimulus control.

Changes in behavior that results from changes in stimuli demonstrate stimulus control. According to Sidman (2008):

An event can be called a stimulus only if changes in it lead to changes in a response; an event can be called a response only if it produces a measurable consequence and if it changes when some aspect of the environment changes; a consequence can be called reinforcing only if it produces a subsequent change in the preceding response.

Taken together, then, the three elements define a unit of behavior. (p. 128)

As Jenkins (1965) asserted, stimulus control implies a “difference in behavior attributable to experimental stimuli. Responding in the presence of a stimulus is not, in itself, evidence of stimulus control. Control is a synonym for covariation” (p. 365). On the subject, McIlvane, Kledaras, Callahan, and Dube (2002) argued that stimulus control refers to a probabilistic situation in which a response is more, or less, likely in the presence of a stimulus; it does not have to occur, or not occur, always. Given that the notion of control by a stimulus describes variations in responding as a result of changes in the antecedent stimulus, reflex, classically conditioned, and operant responses are under the control of their respective antecedent stimuli (Dinsmoor, 1995; Mackintosh, 1971; Terrace, 1966).

In defining stimulus control, Terrace (1966) stated:

Stimulus control refers to the extent to which the value of an antecedent stimulus determines the probability of occurrence of a conditioned response. It is measured as a change in the response probability that results from a change in stimulus value. The greater the change in response probability, the greater the degree of stimulus control with respect to the continuum being studied (p. 271).

The term is operational in character (see Honig & Urcuioli, 1981) and as Makintosh (1971) pointed out “has come to be used as a convenient shorthand expression describing (...) an observed relationship between changes in external stimuli and changes in recorded behavior” (p. 481).

As Honing and Urcuioli (1981) pointed out, Terrace’s definition of stimulus control describes better classical than operant conditioning. However, also as Honing and Urcuioli (1981) pointed out, it is easy to reformulate the definition in operant terms by, for instance, replacing conditioned response by instrumental response and response probability by response rate. Translating Terrace’s definition from classical to operant conditioning is easy because as noted before in both cases there is control by antecedent stimuli (see Dinsmoor, 1995a; Terrace, 1966; and Skinner, 1938). As Terrace (1966) argued, between a stimulus and a response might exist a lot of different functional relationships, but “only the eliciting and discriminative function... are suggested by the concept of stimulus control” (p. 272).

According to Honig and Urcuioli (1981), the notion of stimulus control has some noteworthy implications. First, it involves a comparison between two or more different conditions that may be just the presentation and removal of a stimulus in a discrete-trial procedure or a complex generalization task with multiple stimulus values. Second, given that it always implies “a correlation between a set of stimulus values and a set of response values” (p. 408), it is inappropriate to assume that a stimulus controls a response; in reality, some stimulus values control some response values. Hence, stimulus control is always a matter of degree that does not follow an all-or-none principle. It is possible to restrict observations to only how one of those stimulus values affects a response, but it is important not to forget that other not-measured values exist. Third, it does not have explanatory properties because it is descriptive in nature. As noted above, a generalization gradient, for instance, is a measure and not the result of stimulus control.

A generalization gradient is one of the many possible measures of stimulus control (Blough, 1966; Dinsmoor, 1995a; Honig and Urcuioli, 1981). As Mackintosh (1971) wrote:

That a particular stimulus has acquire control over a subject's behavior is tantamount to saying that this stimulus has been established as a signal for reinforcement, or a signal that a certain class of responses will be reinforced ... Evidence that a stimulus has been successfully established as a signal for reinforcement may be provided in a variety of ways (...) The slope of generalization gradient (...) is only one of several measures of stimulus control. It is not even necessarily the best or more sensitive measure. (p. 482)

Other measures include responding rate to the S+ and the S- and rate of responding in the absence of the S+. In the first case, responding should be higher to the S+ and minimum or inexistent to the S-. In the second case, responding should decreases or disappears until the S+ is available again. Although behavior analysts have always acknowledged that their unit of analysis includes at least three terms, during the first years of Behavior Analysis's history, the emphasis was on the last term, the consequence (Dinsmoor, 1995a; Sidman, 2008). Dinsmoor (1995a) stated:

In the Analysis of Behavior, a great deal of emphasis has been placed on the control of responding by stimuli that follow the response (e.g., reinforcing stimuli), but comparatively little attention has been given to control by stimuli that precede the response (e.g., discriminative stimuli). Control by stimuli that are already present before the response occurs plays a much more significant role in everyday life than it is currently accorded in our research or even in our textbooks. (p. 51)

According to Dinsmoor (1995a), earlier behavior analysts favored the role of the consequence over that of the antecedent because of Skinner's influential distinction between respondent and operant behavior. Dinsmoor asserted:

Although contemporary evidence suggests that Pavlovian conditioning is broad in its application and complex in its functional relations (e.g., Rescorla, 1988), this was not commonly recognized in the early years of Skinner's work. Perhaps it was to contrast his views with the prevailing stereotype of Pavlovian conditioning and to insulate himself against the charge of adopting an overly atomistic approach that Skinner rejected the label of a stimulus-response psychologist. (p. 52)

However, as Dinsmoor (1995a) noted, in his paper on the two types of conditioning, Skinner acknowledged the antecedent stimuli's ubiquity when he said that after the initial conditioning of an operant response, "discriminative stimuli are practically inevitable after conditioning" (1972, p. 491).

Given that nonhuman and human animals are always interacting with their environment, they are also always responding to a variety of stimuli. Hence, there are always stimuli controlling the organisms' responding. According to Ray (1969), Skinner recognized in his initial account of the operant the existence of antecedents to each response, but he thought that they were too difficult to identify and that the consequence of a response was more useful for a functional analysis of behavior. Nevertheless, some researchers always recognized the ubiquity of the antecedent stimuli. For instance, Blough (1966) said, "stimulus must control some behavior in order to acquire further control over behavior" (p. 347); according to him, for example, a future visual discriminative stimulus must control at least responses involving sensory contact with the stimulus. Without such contact, control of other responses is impossible.

1.2 Key issues in the establishment of stimulus control

Differential reinforcement and the strengthening of responding to the antecedent stimuli have been key issues in relation to stimulus control acquisition. Terrace (1966) published the first comprehensive review on the establishment of stimulus control. In his now classical paper, he discussed the role of differential reinforcement in depth. On the other hand, Terrace (1966) in a lesser extent and Dinsmoor (1985) in a more extensive review examined the scope of the strengthening account in the establishment of stimulus control. The text in this section presents the central points that Terrace (1966) and Dinsmoor (1985) advanced after a brief discussion on the role the consequence and the contingency on the establishment of stimulus control.

1.2.1 The consequence and the contingency arrangement in stimulus control acquisition

It is the consequence what in the three terms contingency defines an operant response; without a consequence there is no operant responding let alone stimulus control of an operant response (Catania, 1973; Skinner, 1938, 1953, 1969). It is more likely that an antecedent stimulus acquires control of a response if its correlation with the reinforcer is positive or negative. A stimulus positively correlated with it becomes the S⁺; a stimulus negatively correlated, the S⁻, and the closer the correlation to 1.0 or to -1.0, the greater the control (see, for instance, Farthing, 1973; Mackintosh, 1974, 1975; Rescorla & Wagner, 1972; Rescorla & Solomon, 1967). Antecedent stimuli with a correlation of 0.0 with the consequence should not gain control over a reinforced response. Although, some findings indicate that, under certain circumstances, stimuli uncorrelated – a correlation of 0.0 – with the consequence may acquire control of some responding (Andrade-Mescouto, 2011; Sidman, 1969). Some authors have called the correlated stimuli relevant and the uncorrelated, irrelevant. The correlation

between antecedent and consequent stimuli is what defines the relevance of the stimuli (see, for instance, Dopson, Esber & Pearce, 2010; Hammer, 1955; Zeaman & Denegre, 1967).

Operant contingencies affect how a portion of the environment gains control over the reinforced response. A contingency is synonymous with a reinforcement schedule in the sense that “it states the conditions under which reinforcement will occur” (Zeiler, 1974, p. 4). By stating how a response will produce a consequence, the contingency determines up to a point what portion of the environment becomes the controlling stimulus. An experiment by Nevin (1968) illustrates this issue. In Phase 1, he reinforced the pigeons’ pecking of a white key with or without a vertical line in an interval schedule. In Phase 2, he kept reinforcing the pecking to the white key in the same interval schedule without the line. In this phase, he extinguished the key pecking of some pigeons and reinforced the not responding to the key with the vertical line of others. In Phase 3, he measured responding to four line orientation degrees in a generalization test. He found that pigeons trained with extinction responded more to other orientations than to the vertical line – a negative generalization gradient – while pigeons trained with high frequencies for not responding tended to respond equally to all the lines orientations – a flat generalization gradient. Line orientation became the aspect of the stimulus controlling the not responding for the pigeons trained in extinction. The different generalization gradients indicate that different aspects of the environment became involved in the controlling stimulus relations.

The consequence type can affect the way in which a stimulus gains control of responding. For instance, Dobrzecka, Szwejkowska, and Konorski (1966) reinforced the responses of two groups of dogs with food to a metronome in front of them but not to a buzzer behind them. They reinforced two responses in the dogs of the first group: Raising their right leg in the presence of the metronome and their left leg in the presence of the buzzer. They also reinforced two responses in the dogs of the second group: raising their

right leg in the presence of the buzzer (go) and not raising it (not-go) in the presence of the metronome. Dobrzecka et al. (1966) changed the position of the stimuli to determine what aspect of the stimuli – position or quality – had gained control over the dog's responding, so they put the buzzer in front and the metronome behind the dogs. They found that most of the dogs they had trained on the right-left task responded based on stimulus location rather than on stimulus quality; they raised their right leg to whatever stimulus, buzzer or metronome, in front of them. On the other hand, the dogs they had trained to raise the right leg to the buzzer and not to the metronome responded only to the buzzer regardless of its position; they raised their right leg to the buzzer whether it was in front or behind them. The important point here is that all else equal, a small change in response topography seemed to have ended in a different controlling relation.

Experiments like those aforementioned exemplify how factors like the contingency and consequence itself contribute in determining what portions of the environment will gain control over a reinforced response. In the lab, even when a researcher has not explicitly specified an antecedent stimulus, portions of the environment gain control of the reinforced response. On the other hand, even if the researchers have defined an antecedent stimulus, the defined portion does not become the controlling one or the only one that exerts control over the response.

1.2.2 Differential reinforcement and the establishment of stimulus control

Although authors agree on the consequence's role in the acquisition of control by antecedent stimuli, there has been controversy on the origin of that control in at least two issues: differential reinforcement and the strengthening of a response. Terrace (1966) in a classical text highlighted the importance of differential reinforcement and stated that it was essential for the establishment of stimulus control. His argument relied mostly on a study by Peterson (1962). After rearing four ducklings in an environment illuminated only by a

sodium vapor lamp of 589 nm and two others in white light, Peterson trained the ducks to peck a key illuminated with a light of 589 nm and afterwards obtained generalization gradients with other wavelengths. He found that the two birds raised with white light showed typical steeped generalization gradients while the four birds raised with sodium vapor, flat gradients. Based upon Peterson's (1962) results, Terrace (1966) concluded, "a necessary condition for obtaining a generalization gradient of wavelength whose slope is greater than zero is prior exposure to white light. White light presumably allowed differential reinforcement with respect to different wavelengths to occur prior to the generalization test" (p. 279). Hence there should not be stimulus control without differential reinforcement.

Although differential reinforcement has a key role in the establishment of stimulus control, it does not seem as essential as Terrace (1966) had prior assumed. Malott (1968), Mountjoy and Malott (1968), Rudolph, Honig and Gerry (1969), and Tracy (1970) attempted to replicate Peterson's (1962) experiment unsuccessfully. They all reared ducklings in monochromatic and white light and compared their generalization gradients to other wavelengths and found no difference between them. Based on data of his own replication, Terrace (1975) concluded:

Since the monochromatic reared subjects did not experience the stimulus that occasioned the highest frequency of responding before the generalization test ... results demonstrate that ducklings possess an innate basis for ordering stimuli of different wavelengths. It appears as if differential reinforcement with respect to but two wavelengths is sufficient to activate whatever mechanism is responsible for the ordinal arrangements of a larger set of wavelengths. (p. 85)

As Honig and Urcuioli (1981) pointed out, the sensory order in the generalization gradients that different researchers have found in the experiments on early rearing suggest that it "is primarily dependent on physical maturation rather than differential experience" (p.

415). The individuals of a species can respond only to a range of values within each possible stimulating dimension as a result of the evolutionary process of the species. One implication of this conclusion is that the sensory capacities of an organism determine along with other variables the values from the environment that will become the stimuli that control the response. In the section on the role of the environment in the acquisition of stimulus control, this issue will be discussed with more detail again. As Domjan (2002) argued, the organism's sensory world determines the range of stimuli that can control its behavior. For an organism does not exist events outside the range of what the organism can detect with its senses. For instance, there are no visual stimuli for a blind person. As Mackintosh (1977) noted, the susceptibility of different species to different stimuli evidence how the characteristics of an organism determine stimulus control. For instance, visual stimuli control birds' responding quicker than rat's responding. The important point here is that some environmental properties have a better chance of affecting responding in some animals than in others.

1.2.3 The strengthening of responding to the antecedent stimuli

According to Dinsmoor (1983, 1985), the ideas of Skinner and Spence on the establishment of stimulus control dominated the area for more than 50 years. Both Skinner (1933, 1934, 1938) and Spence (1936, 1937) explained the establishment of a discriminated response in a similar way: By the accumulation of small differences of response strength in the presence of the positive and negative stimuli. They assumed that by reinforcing a response in the presence of the S⁺, strength response to the S⁺ would increase. They also assumed that by not reinforcing the response in the presence of the S⁻, strength response to the S⁻ would decrease. At the beginning of a discrimination procedure, there should be no response strength in the presence of S⁺. After reinforcing the first response in the presence of the S⁺, strength should increase a little. Each subsequent instance of reinforcement would

increase the strength a little more until reaching some asymptotic level. Similarly, by not reinforcing the first response in the presence of the S-, strength should decrease a little, and each subsequent instance of extinction would decrease the strength a little more until reaching the lowest strength possible.

According to Dinsmoor (1985), some empirical data posed problems to the strength account. Dinsmoor (1985) argued that it did not explain the central issue during the establishment of stimulus control: “The transfer between the two stimuli of the effects of their respective schedules” at the beginning of a discrimination training procedure (p. 365). On the subject, Dinsmoor (1985) wrote, “The traditional account deals only with what happens in the presence of each stimulus independently, not with the change in the interaction between them” (p. 366). At the beginning of a discrimination procedure, there are increases in responding to the S- along with increases in responding to the S+ so that, as Ferster (1951) noted, performance in the presence of both, negative and positive stimuli, is practically indistinguishable. Skinner (1933, 1935, 1938) argued that the response strength to the S+ also increased the response strength to the S-. Similarly, decrements of response strength to the S- diminished response strength to the S+. Skinner (1933) said, “The reinforcement of S1 – R affects the strength of S2 – R also, and there is a converging sharing of extinction” (p. 303).

According to Skinner (1933, 1935, 1938), the strength transfer between the S+ and S- resulted of the response induction phenomena – or generalization. In later texts, Skinner (1953) stated that the term induction simply “describes the fact that the control acquired by a stimulus is shared with other stimuli with common properties” (p. 134), but in his earlier papers, Skinner’s emphasis was on the spreading of reinforcement’s effects to other stimuli than the S+ and S- (Skinner, 1933, 1938). As Skinner (1933, 1935, 1938) assumed that response strength increases to each stimulus were independent from each other, induction had also to be independent. There would be induction from S+ to S- when accumulated responses

to the S+ were also available to the S- and from S- to S+ when responses emitted under S- subtracted from those available to the S+. For a discrimination to take place, induction breakdown was necessary. Discrimination was “the mere widening of the difference in strength in two fields” Skinner (1938, p. 229) said, and “the breakdown of the induction from S^d (S+) to S^a (S-) does not affect the reciprocal induction from S^a to S^d” (p. 228).

A key supposition for the strength account was that the strength of a response increased to all the stimuli that were present when the response produced a reinforcer. On the other hand, strength decreased to all the stimuli that were present when the response did not produce a reinforcer. However, Hull (quoted by Dinsmoor 1985) had noted that the S+ and S- are only a part of the total experimental situation in which most of the stimuli are present when reinforcement follows and does not follow a response. Then as Dinsmoor (1985) argued:

If it was assumed that reinforcement increased the tendency to respond to all of the stimuli present at the time and nonreinforcement decreased the tendency to respond to all of the stimuli, the effects of S+ and S- would be greatly diluted by the control exerted by these "incidental" or "static" stimuli (p. 366).

Restating what happens at the beginning of a discrimination procedure, when the response produces the first reinforcer, response strength should increase to the S+ but also to all the other stimuli present in the situation. Similarly, when the response does not produce a reinforcer in the presence of the S-, response strength to S- should decrease but also to all the other stimuli present. As a consequence, control by the incidental stimuli should weaken the control by the stimuli correlated with reinforcement. Hull (1950), and implicitly Skinner (1933, 1938) and Spence (1936, 1937), assumed that the effects of no reinforcement should balance the effects of reinforcement in such a way that they cancelled each other. This balancing would imply that incidental stimuli should not gain control over any responding.

Besides not explaining the transfer between S+ and S-, the strength account has had difficulties explaining other phenomena as well. Although, the strength account can explain some phenomena related to compound stimulus, it does not seem fit to explain others. When a response produce reinforcement in the presence of a stimulus composed by two separable components, the responding rate to each isolated component is less than to the compound: Addition occurs (see Weiss 1969, 1971, 1972). In this case, the strength account explains the increases and decreases in responding easily by assuming that the individual strength acquired by a response adds to the individual strength of the other when they are together. When they are in isolation, the strength diminishes by subtraction of the individual strength. So far, the strength account seems to work well. However, in blocking experiments, another procedure involving stimulus compounding, the strength account by itself is insufficient.

In a blocking procedure (see Kamin, 1969), researchers reinforce a response in the presence of a stimulus A. Once responding to A stabilizes, researchers present a second stimulus B along with A. According to the strength account, response strength to B should increase so that there should be responding to each isolated stimulus. However, human and nonhumans subjects typically respond only to A. They might not respond to B because all the possible response strength went to A, but this entails the inclusion of new assumptions alien to the original strength account. For example, Kamin (1969) argued that on compound trials, subjects already expect the consequence. He also argued that only unexpected stimuli reinforce a response. The expectancy of the reinforcer is a new assumption. Subjects might not respond to B because they might have reached the asymptotic level, but it does not change the fact that there should B increases in the strength to B. On the other hand, after extinguishing the responding to A, subjects begin to respond to B, which cannot be explained by the strength account.

As if the issues above were not enough, Dinsmoor (1983, 1985) argued that research on interdimensional training posed “an insurmountable obstacle to interpretation in terms of the traditional strengthening and weakening formulation” (p. 367). As Honig and Urcuioli (1981) pointed out, interdimensional training procedures emerged in the context of inhibitory stimulus control research. Researchers knew that a decremental gradient would emerge with a maximum height at S+ by varying in a generalization test aspects of a stimulus previously correlated with reinforcement. However, they wonder if generalization gradients around the S- would show corresponding incremental gradients with a minimum height at S- (for instance Hearst, 1968; Honig, 1961; Terrace, 1966). Although, the testing method to evaluate inhibitory stimulus control is the same method that researchers use to evaluate excitatory stimulus control –the generalization gradient–, the training procedure differs.

It is sufficient the reinforcing of responses in the presence of the positive stimulus to evaluate excitatory stimulus control. To assess control by the positive stimulus, researchers present subjects with different values on any one of the dimensions of the stimulus. In contrast, to evaluate control by the negative stimulus, it is necessary the reinforcing of responding to some stimulus other than the negative stimulus. As Honig and Urcuioli (1981) pointed out, the symmetrical operation of extinguishing responding to a value other than the positive stimulus is not necessary to evaluate control by the positive stimulus. According to Honing and Urcuioli (1981), there are at least three procedures for generating this baseline level. First, one can reinforce responses to a range of values in the test dimension. Second, one can reinforce responses to a stimulus orthogonal to the test dimension, inter-dimensional discrimination training. Third, one can reinforce responses to another value on the same dimension, intra-dimensional discrimination training. The first and third procedures that Honing and Urcuioli (1981) mentioned entail measurements on the same dimension, but in

the second procedure, orthogonal discrimination training, the measurement of control by the negative stimulus is in a different dimension.

Inter-dimensional or orthogonal discrimination training is a procedure in which researchers can reinforce negative gradients without reinforcing responding to stimuli lying on the test dimension (Switalski, Lyons, & Thomas, 1966). In general, subjects learn first to discriminate between a S+ and S- from different stimulus dimensions. Then, the researcher obtains generalization gradients around S- by varying the not shared S- characteristic with the S+. As the non-shared characteristics must be orthogonal to the one defining the S+ dimension, any influence of the S+ upon responding should be equal across test values. Honig, Boneau, and Bernstein (1963 quoted by Dinsmoor, 1995) performed an experiment that illustrates the procedure. They trained one group of pigeons to discriminate between a black vertical line against a white background as S+ and the white background as S-. They also trained a second group of pigeons to discriminate between the white background with the vertical line as S- and the white background as S+. Then, they gave a generalization test to both groups. The pigeons from the first group produced a decremental gradient with a maximum high at the vertical line. The pigeons from the second group produced an incremental gradient with a minimum high at the vertical line. The pigeons from the first group had not produce any consequence by responding to values on the same dimension than the S-.

As Dinsmoor (1985) argued, the strengthening account work well with stimulus values on the same dimension, but it does not work with stimulus values in dimensions other than the stimulus in which presence a response produces a reinforcer. According to the strengthening account, for instance, there should the same level of responding to all values in the generalization test in the above experiment by Honig, Boneau, and Bernstein (1963). According to Dinsmoor (1985),

Although the training schedule may have affected the level of responding in the presence of the one stimulus, and consequently the absolute level of the rest of the gradient, there is no way in which it could have had a direct strengthening and weakening effect on the subject's response to any of the other stimuli in the test series. Differential reinforcement has not been applied to any two points along the test dimension and cannot account in any immediate sense for the difference in rates (p. 368).

Theories alternatives to the strengthening account emerged. Most of them focused on the concept of attention, but from a cognitive point of view. According to most of these theories, human and nonhuman have limitations in the amount of information that they can handle. As a consequence, they allocate their resources in such a way that they attend only to the portion of the environment that controls their responding (see, for instance, Mackintosh, 1973, 1975). In this text, the emphasis is on attending as a controlling stimulus relation rather than a psychological process that cognitive theories advocate. Attending and observing are the subjects of the next section.

1.3 Attending, observing, and the establishment of stimulus control

As an alternative to the strength account and theories based on hypothetical constructs, Dinsmoor (1985) proposed the observing response and attention as a nervous process, so he stated,

The conformity of behavior to the consequences encountered in the presence of each of two or more alternative stimuli (stimulus control) depends on how much contact the organism has with those stimuli. By contact I mean the impingement of the stimulus energy on the receptors cells of the relevant sensory apparatus, which typically requires or is modulated by auxiliary behavior that is known as observing behavior. Second...we are

obliged to consider analogous process occurring further along in the sequence of events, presumably in the neural tissue, and commonly known as attention (p. 365).

According to Dinsmoor (1983, 1985, 1995), organisms observe and/or attend to irrelevant stimuli while they learn to respond to the relevant stimuli, and it is because that learning process that responding in the presence of the S+ and S- is similar at the beginning of a differential reinforcement procedure. Once, they learn to observe the proper stimuli, they respond to the positive stimulus and do not respond to the S-. The first part of this section is on the notion of attention. The second part is on the concept of an observing response.

1.3.1 Attending as a controlling stimulus relation

According to the Webster (2001), attention is “the act or state of applying the mind to something,” it is also “a condition of readiness for such attention involving especially a narrowing or focusing of consciousness and receptivity” (from internet). Cognitive and more traditional psychologists define attention as a process or cognitive operation that regulates the allocation of psychological resources so that organisms respond only to a portion of the environment (see, for instance, Chun, Golomb, & Turk-Brown, 2011). From the perspective of the Experimental Analysis of Behavior, attention is synonymous with stimulus control as defined in the first section of this text (Ray, 1969). According to Skinner (1953), “the control exerted by a discriminative stimulus is traditionally dealt under the heading of attention” (p. 122). As Hutssel and Jacobs (2013) pointed out, Skinner’s notion of attention did not refer to a form or class of behavior but to “the empirical demonstrable co-variation between a class of discriminative stimuli and a class of operant responses that produce consequences uniquely correlated with that discriminative stimulus class” (p. 1). However, not all behavior analysts share this view. For instance, Nevin, Davidson, and Shaham (2005) following Dinsmoor (1985) argued that attention refers to covert, unmeasured responses.

A key point in Skinner’s approach to attention is what he called the direction of action.

The traditional notion of attention puts the control in the subject, so, for instance, one could argue that human and nonhuman animals respond to stimuli because they attend to them. In contrast, Skinner (1953) put the control in the stimulus, so organisms respond to the stimuli that control their behavior. For example, if a person who is listening to a symphony detects that an instrument is out of tune, one can say that the person was attending to the instrument. Alternatively, one can say that the instrument was controlling the person's responding. In the first case, the attending would explain why the person realized that the instrument was out of tune. In the second case, the instrument was controlling some of the subject's responding. As attending, according to Skinner (1953), involves a controlling stimulus relation, the attending is not in the subject, but in the controlling stimulus relation itself.

Different aspects of a discriminative stimulus may control responding. As stated by Ray and Sidman (1970), "all stimuli are [complex] in the sense that they have more than one dimension or aspect to which a subject might attend" (p. 199). If, as Skinner (1953) argued, attention refers to variations in responding that result from independent variations or eliminations of aspects of the stimulus, the aspects changing responding are the controlling ones. Experiments by Lashley (1938), Reynolds (1961), Wilkie and Mason (1976), and Zeiler (1974) illustrate how different aspects of the antecedent stimulus may gain control over the subject's responding. Those experiments show that when a researcher reinforces a response in the presence of a stimulus, not all the aspects of the stimulus gain control over the reinforced response.

Lashley (1938) evaluated which aspects of the stimulus control a response. He reinforced the jumping of a rat toward a square and punished it toward a diamond. Once the rat had learned the task and responded to each stimulus consistently, he presented the rats only with the forms' halves and found an inconsistent jumping toward the upper halves that contrasted with the consistent jumping to the lower halves. Lashley concluded that the rat had attended only to the lower halves. In control terms that the lower halves were the stimulus's

aspects controlling the jumping of the rat.

To understanding how different aspects of a discriminative stimulus control a response, Zeiler (1974) presented 16 normal children and 6 institutionalized adult women with intellectual disabilities with sets of three bars of different lengths and reinforced them by always choosing the middle-size one. The middle bar during training was always of the same size, 36 mm, while the other bars varied in size. Afterward, to test the controlling factor, he exposed them without reinforcement to sets in which the middle-size bar was of a different size from the one he used in training. If size relation were the controlling factor, subjects in the test condition would have chosen the middle-size bar. On the other hand, if size length were the controlling factor, participants would have chosen the bar with the closest size to 36 mm. In the test trials, eight normal children choose the middle size bar; one participant responded to a discoloration of the block on which Zeiler presented the bars; and, the remaining subjects choose the smallest stimulus (closest in size to 36 mm). There was no difference between normal and children with intellectual disabilities and between boys and girls.

Zeiler (1974) concluded that two aspects of the stimulus controlled the response of the subjects in his experiment. One aspect, size length, controlled the responding of some of them and the other aspect, relation between stimuli, controlled the responding of the others. Zeiler (1974) pointed out that he was unable to identify characteristics in the subjects that accounted for the stimulus's aspect that controlled their responses on the basis of the number of errors, trials, or learning speed. Zeiler's experiment demonstrates that a similar performance by different subjects in the same discrimination task does not indicate control by the same stimulus. Although he wondered about why some aspect controlled the responding of some subjects and the aspect controlled the responding of the others, he acknowledged that he had no answer and suggested more research on the subject.

Attempting to extend Lashley's (1938) findings on the controlling stimulus's aspects in a situation, Reynolds (1961) reinforced according to a VI 3-min schedule the key pecking of two pigeons of a key when he illuminated it by a white triangle on a red background and not when he illuminated it by a white circle on a green background. When the pecking stabilized, he presented the stimulus's color and form aspects separately in the absence of reinforcement and measured the pecking to each component. He found virtually no responding to the white circle or green color. He also found that one pigeon responded almost exclusively to the white triangle but not the red color and that the other pigeon responded almost exclusively to the red color but not the white triangle. Based on his results, Reynolds concluded, "a pigeon may attend to only one of several aspects of a discriminative stimulus" and "every part of the environment that is present when a reinforced response occurs may not subsequently be an occasion for the emission of that response" (p. 208).

Wilkie and Masson (1976) challenged the first of Reynolds's conclusions. There is general agreement on the second. Wilkie and Mason (1976) trained ten pigeons as Reynolds did, but controlled more variables. They reinforced in a VI-60 seconds schedule the key pecking of Birds 1, 2, and 3 to a white triangle on a red background but not to a white circle on a green background. On the other hand, they reinforced Birds 4, 5, and 6 by responding to the circle on a green background but not to the triangle on a red background. Birds 7, 8, 9, and 10 served as controls and underwent the same procedure that the other pigeons but only with colors. Subsequently, Wilkie and Masson (1976) evaluated responding to each component without reinforcement, trained all the pigeons with the same procedure again with reinforcement, and tested them with reinforcement (the resistance-to-reinforcement procedure, see Hearst, 1972).

In their first test, Wilkie and Mason (1976) presented as Reynolds each component alone but, unlike Reynolds, found that all their pigeons had responded exclusively to color

and not to shape. In their second test, they reinforced responding to the two forms from Phase 1; they did not present the colors. If form had not controlled any responding in Phase 1, response rates should be similar to the negative and positive forms. However, response rates were higher to the form that had been a part of the positive compound. For instance, the response rates of pigeons reinforced in Phase 1 in the presence of the white triangle but not the white circle were higher to the triangle than to the circle. Willkie and Mason (1976) concluded that in the absence of further measurements, a researcher could have assumed as Reynolds (1961) that form had not controlled any responding; however, their data showed otherwise.

Shapes in the experiment by Wilkie and Mason (1976) did not gain control over the pigeons' key pecking but gained control of some other responding. In colloquial terms, the pigeons had attended to the aspects that did not control the target response. In a similar way, aspects of the environment uncorrelated with the consequence and present during the establishment of control by a stimulus may gain control of some responding. Again, in colloquial terms, human and non-humans subjects may attend to them. Tomanari (personal communication, April, 2009) devised a procedure that allows indirect evaluation of control by aspects of the environment uncorrelated with a consequence. His procedure has two phases. Phase 1 is a simultaneous discrimination procedure in which a researcher presents images with one aspect that correlates with the consequence and with aspects that do not correlate. Phase 2 is a recognition task in which, in the absence of reinforcement, the researcher presents the aspects of the images uncorrelated with the consequence without the correlated aspects mixed with a new set of similar images and asks the participants to identify the ones presented in Phase 1. If a participant recognizes a number of images above chance, the researcher must conclude that the uncorrelated aspects of the images controlled some responding.

A team² composed of graduate and undergraduate students working under Professor Tomanari's supervision conducted some pilot experiments with his procedure. The team created a set of human-like images based on the South-Park cartoon television series. The positive and negative stimuli were the images' pants, and the uncorrelated aspects were the set of images without the pants. The team found that participants took a larger number of trials to reach criterion than with other procedures that members of the team had used before (for instance, Endenman, 2009). The team also found that most participants recognized the images uncorrelated with the consequence, which implies that aspects of the environment uncorrelated with the consequence had gained control of some responding during the differential reinforcement procedure. Andrade-Mescouto (2011), who used the procedure in her master thesis, reported similar findings (her experiment is discussed elsewhere in this document).

In colloquial terms, data with the recognition test mentioned above suggest attending of the participants to aspects of the stimuli uncorrelated with the consequence. Hence, in non-colloquial terms, these data indicate a controlling stimulus relation between the uncorrelated aspects with the participants responding. Wilkie and Mason (1976) argued that researchers "should be cautious in making attentional interpretations of other instances of nondifferential responding during an aspect of a redundant compound stimulus" (p. 211). From the absence of responding to an aspect of an antecedent stimulus, a researcher should not conclude that there is no attending or a controlling relation. As Wilkie and Mason stated:

One potential problem in the behavioral analysis of attention is that the appropriate response or response topography may not be chosen for observation and/or that different test procedures may be differentially sensitive to differences in responding. The consequence of an inappropriate choice, of course, would be to conclude falsely

² I was a team member and participated in the entire process.

that attention is absent. (p. 207)

Wilkie and Mason's (1976) advice is relevant for events or aspects of the environment uncorrelated with the consequence. Most theories on the establishment of stimulus control assume that features of stimuli uncorrelated with the consequence would not gain control of any responding. According to the theories based on the strengthening of a response to the stimuli antecedent discussed previously, there should be no control by uncorrelated features of the stimuli in which presence a response produces a consequence. Virtually all of the theories based on attention make the same assertion. According to theories based on attention, the aspects of the environment that will gain control of responding are those to which organisms attend (see Mackintosh, 1975). The experiment by Wilkie and Mason (1976), Zeiler (1974), and Andrade-Mescouto (2011) illustrate situations in which there is control of some responding by aspects of the stimuli that did not gain control over the reinforced response. The unmeasured responses of those experiments must involve at least some sensory contact akin to what Wyckoff (1952, 1969) called observing responses.

1.3.2 The observing response

The observing response, as Wyckoff (1952, 1969) defined it, is a topic strongly related to the concept of attention. As a matter of fact, Wyckoff (1952) argued that authors in the area of discrimination learning had referred to a "set or predisposition to learn differential responses" (431) with terms such as attending, orienting, or perceiving. Wyckoff (1952, 1969) replaced them with the notion of the observing response that he defined as exposure to the discriminative stimuli, which implies, as Dinsmoor (1995) clarified, sensorial contact with them. Wyckoff (1952) stressed the importance of distinguishing between observing and effective responses, which are those that directly produce the consequence. The distinction

matters because a discriminative stimulus controls a response only if in its presence an organism produces both observing and effective responses.

As Tomanari (2010) argued, following Wyckoff (1959, 1969) and Dinsmoor (1985, 1995a, 1995b), a discriminated operant involves two interlocked contingencies. A contingency is, “in the operant case, the conditions under which a response produces a consequence” and, “in a more specific sense, the conditional probabilities that relate some events to others” (Catania, 1992, p. 368). The events, of course, are stimuli and responses. According to Tomanari (2010), the first contingency establishes that for contacting the discriminate stimuli organism must observe them. The second contingency establishes that to obtain the consequence, organisms must emit the effective response (see Figure 1). Hence, in any situation in which a stimulus has gained control of a response, the stimulus always controls two responses: observing and effective. It is worth to point out that organisms may produce the observing response in the absence of the effective response. Therefore, verifying that an observing response is more likely in the presence than in the absence of the stimulus demonstrates stimulus control.

Figure 1. Graphic description of the observing contingency ($R_o - S^{r/d}$) interlocked to the contingency associated with the final consequence ($S^d - R_p - S^R$). In the figure, R_o = Observing response, $S^{r/d}$ = Discriminative stimulus for the main operant response and reinforcing consequence for the observing response, R_p = main operant response, S^R = main reinforcing consequence (figure from Tomanari, 2010, p. 302).

Although, virtually all the research on observing have focused on visual contact with the stimuli, the notion of observing applies to any sensorial modality. For instance, if a rat produces food by pressing a bar in the presence of a sound x but not of a sound y, optimal performance would indicate that the rat observed x; otherwise, its responding would result in suboptimal, random reinforcement. As Skinner (1953) pointed out, in most situations, the best and only way to evaluate sensory contact with a stimulus is by identifying the controlling stimulus. Skinner (1953) said, “When we listen to a phonograph recording of a symphony while attending particularly to the clarinets, it is apparently not possible to demonstrate any special orientation of the ear” (p. 123). There is no technology available for measuring directly most observing responses. As Skinner (1953) claimed, if by some mean a researcher verifies that a stimulus controls some responding, that stimulus controls observing responses necessarily. Given that producing effective responses without observing results in suboptimal performance, a suboptimal performance indicates little or no observing. Wyckoff (1969) argued, “the effectiveness of discriminative stimuli is revealed by the degree to which they control performance”(p. 237) and “changes in the probability of observing behavior may have a profound effect on discrimination learning in a wide variety of experimental situations” (p. 253). A discriminated performance without observing is impossible (Dinsmoor, 1983; Wyckoff, 1952, 1959, 1969).

As according to Wyckoff (1952, 1969), organisms learn to observe in a similar way as they learn to make the effective response, he assumed that just as increases in the effective response result from reinforcement, some form of reinforcement had to increase observing responses, so he stated,

The problem at hand is to show how exposure to discriminative stimuli may have a reinforcing effect under the condition of differential reinforcement, while the same

stimuli do not have this effect under the condition of non-differential reinforcement.

(Wyckoff, 1959, p. 434)

Wyckoff (1959) proposed two possible forms of reinforcement for an observing response. First, the consequence for the effective response might reinforce the observing response as well given the short time interval between them. Second, the discriminative stimuli may provide conditioned, secondary reinforcement for the observing response. In any case, according to Wyckoff (1952), the probability of an observing response changes as a function of reinforcement. Researchers sided mostly with the secondary reinforcement hypothesis that found expression in later theories as the delay reduction hypothesis or theories based on the informative properties of the discriminative stimuli (Fantino, 1977; Fantino & Case, 1983). Perhaps, most of the research on observing has been about the reinforcing properties of the discriminative stimuli (see for instance, Dinsmoor, 1983; Fantino, & Case, 1983; Lieberman, 1972; Preston, 1985; Tomanari, 2008).

During the acquisition of control by a stimulus, other variables besides the consequence play a role. While responding to produce a consequence, organisms may contact three different populations of stimuli that Wickoff (1952) denoted as S_1 , S_2 , and S_3 . The correlations between stimuli and consequences determine which portions of the environment belong to each category, the closer to 1.0 or 0.0, the greater their positive or negative value. S_1 or S^+ describes the stimuli with a positive correlation with the consequence ($P(\text{consequence/response}) \geq 0.5 \wedge P(\text{consequence/response}) \leq 1.0$); S_2 or S^- , the stimuli with a negative correlation ($P(\text{consequence/response}) \leq 0.5 \wedge P(\text{consequence/response}) \geq 0.0$); and S_3 , the stimuli with a random correlation ($P(\text{consequence/response}) = 0.5$). Strictly speaking, Wyckoff's observing responses refer to sensorial contact with the positive and negative discriminative stimuli – S_1 and S_2 – once that they have gained control over the response and acquired reinforcing properties.

Tomanari (2009) pointed out that there is no name for sensory responding to environmental, non-discriminative events. Tomanari's concern applies of course to responses that in the future could become observing responses. Wyckoff (1959) denoted an observing response as R_o and its probability of occurrence as P_o , but there is no a specific name for R_o before becoming under stimulus control. Hence, hereinafter, a potential observing response, R_{op} , will be the name to designate it and P_{op} will denote its probability. It is worth to remember that a R_{op} may not ever become an actual R_o ; other way to say the same is that a R_{op} is an intended R_o . If P_{op} initial value is low, R_{op} will take much more time in gaining control over the response than if P_{op} initial value is high. If P_{op} initial value is too low, R_{op} may not ever gain any control at all. Although the consequence is essential for the establishment of stimulus control, the consequence cannot affect P_{op} initial value, so other factors than the consequence must account for P_{op} initial value.

Wyckoff (1952) mentioned experimental situations in which P_{op} initial value was 1.0, which implies that he acknowledged P_{op} role in the establishment of R_o . However, in most cases, especially outside the lab, P_{op} initial value might be less than 1.0 and close to 0.0. Consequently, it is worth asking about the factors determining P_{op} initial value. Although the consequence will establish R_o , the consequence can hardly affect P_{op} initial value. The factors determining P_{op} initial value must be in the environment. Cowan (1968) suggested two characteristics of the environment as factors determining P_{op} initial value. On one hand, instructions may put humans in contact with the relevant stimuli. On the other hand, the number of irrelevant stimuli in the situation may affect the probability of contact with the relevant stimuli. P_{op} value will be inversely proportional to the number of irrelevant stimuli in the situation. Cowan (1968) assumed equal probability for the sensory contact with each irrelevant stimulus in the situation. However, equal probability is hardly the case.

P_{op} value must depend on the initial environmental conditions. There is no reason for assuming that the stimuli in the environment previous to the establishment of control are neutral. As Mackintosh (1971) said, “no one would deny that some stimuli appear to be more effective for some subjects than others” (p. 483). He also added, the “most important cause of differences in stimulus control is not any difference in the opportunity for differential reinforcement, but a difference in the extent to which such control is masked by the presence of other stimulus” (p. 483). If a researcher provides reinforcement to a subject by responding in the presence of a stimulus A, but another stimulus B is also present, it might happen that attempts to evaluate A do not result in differential responding if B is also present, but in the absence of B, the researcher may observe the responding to A. According to Mackintosh, in such a situation, B would have masked A.

Other factors associated to the stimulus affect how a stimulus gains control over responding. According to Mackintosh, the salience of a stimulus, which he characterized as stimulus intensity, determines the masking. Salient or intense stimuli mask the lesser salient. Dinsmoor (1995b) deemed stimulus salience and disparity as key parameters in discrimination training because their role in a variety of behavioral paradigms that include overshadowing, blocking, fading, and concept formation. Dinsmoor (1995b) defined stimulus salience as the “magnitude of the difference between the discriminative stimulus and the background stimulation” (p. 254) and stimulus disparity as “the magnitude of the difference in physical units between the positive and the negative stimulus” (p. 254). Both stimulus salience and disparity illustrate how, everything else equal, the stimuli in which presence a response produces a reinforcer can affect stimulus control. Besides salience and disparity, other stimuli factors may influence the establishment of stimulus control. Experiments as those by Reynolds (1961), Wilkie and Mason (1976), Zeiler (1974), or Andrade-Mescouto

(2011) indicate that some aspects of the initial environment have a greater probability of gaining control of responding than others.

1.4 Final considerations

Operant stimulus control depends on the interaction between three terms: response, consequence, and antecedent stimuli. When a researcher verifies that the response is more or less likely to some portions of the environment than to others, the researcher may conclude that those portions have gained control over the response. The response becomes a discriminated operant response in relation to the stimuli previously correlated with the consequence. A discriminated response is a function of the consequence and the observing response. In the absence of reinforcement, there is no responding. In the absence of observing, there may be responding, but the responding will be suboptimal.

As the discriminated response values change as a function of reinforcement and observing, the observing in turn changes as well as a function of reinforcement but also of some unknown variables. Researchers (see Dinsmoor, 1983, 1985; Tomanari, 2009, 2010) have assumed (see the previous discussion on the subject), following Wyckoff (1952, 1959, 1969), that observing is a function of the reinforcing value of the discriminative stimulus; however, they infer the reinforcing value from their subjects' behavior. If, for instance, their subjects' observing behavior's rate increases when they produce the S+ or the S-, they presume that the stimulus has a reinforcing function. If, on the contrary, the observing decreases, they presume that the discriminative stimulus has a punishing function. One cannot manipulate the reinforcing or punishing value of the discriminative stimuli

directly³. A researcher can manipulate factors such as final reinforcement rate, delay to reinforcement, or correlations between the discriminative stimulus and the final consequence.

At the beginning of a differential reinforcement procedure, there is no control by any portion of the environment over the response that will produce a consequence. A differential reinforcement procedure consists of positive, negative, and random correlations between portions of the environment with the reinforcer. If human and non-human subjects learn to observe the portions of the environment correlated with the consequence, their performance will be optimal and will obtain all or most of the available reinforcers. Otherwise, their performance will be suboptimal and will obtain only the fraction that random responding allows. Hence, suboptimal performance suggests the absence of observing. The need of observing responses for an optimal performance demonstrates that the consequence is not the only relevant variable for the stimulus gaining control over responding. Particularly, at the beginning of discrimination training, the initial sensory contact of the subjects will depend mostly on the characteristics of the environment. The environmental arrangement may facilitate or hinder the sensory contact with the features of the stimuli correlated positively and negatively with the consequence. The concept of salience illustrates such initial, environmental influence. A more salient stimulus is just a portion of the environment that has a greater chance of controlling sensory responses than others.

Besides salience, other aspects of the environmental arrangement may affect the way in which portions of the environment gain control over responding. The findings of Andrade-Mescouto (2011) with the procedure by Tomanari (unpublished data) imply that characteristics of portions of the environment uncorrelated with the consequence may hinder or even prevent that the correlated portions acquire control of the reinforced response. On the

³ Since the discriminative stimulus is a conditioned reinforcement, its reinforcing value depends on external factors such as the frequency of pairings or any other correlation with the main consequence.

other hand, Andrade-Mescouto's data suggest that portions of the environment uncorrelated with the consequence gain control of some responding, which is contrary to what most theories on the establishment of stimulus control predicts. Andrade-Mescouto used a recognition task to evaluate control by aspects of the stimuli uncorrelated with the consequence. Although recognition demonstrates control by the stimuli, it is not necessarily equivalent to the control that more traditional procedures from Behavior Analysis perspective reveal. It is necessary evaluating if in more traditional tests, stimuli uncorrelated with the consequence as those used by Andrade-Mescouto gain control of responding. It is important to evaluate as well if that control is so powerful as to hinder control by correlated aspects. Finding that aspects uncorrelated with the consequence gain control of some responding would demonstrate that the arrangement of the environment is a key factor in the establishment of stimulus control.

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CHAPTER 2

Response Control by Aspects of Human-Like Stimuli Uncorrelated With the Consequence

(Controle por aspetos de estímulos com forma humana não correlacionados com a
consequência)

Introduction

Usually, a Differential Reinforcement Procedure (DRP) results in control of a discriminated operant response by the stimuli that correlate positively (S+) and negatively with the consequence (S-). Responding mostly to the positive stimulus and fairly to the negative stimulus demonstrates that the correlated stimuli have gained control over the response and have acquired discriminative functions. In contrast, responding similarly to them implies that they have not gained control over the response (Dinsmoor, 1995a, 1995b; Terrace, 1966; Sidman, 2008; Skinner, 1938, 1953). Given that in a DRP reinforcement and extinction occur in the presence of uncorrelated events alternatively, uncorrelated events should not gain control of any responding. However, some evidence suggests that uncorrelated events gain control over some responding eventually.

Demonstrating control by a portion of the environment in which presence a response produces a consequence does not preclude control by other portions. For instance, research with compound stimuli has showed that portions of the environment that do not seem to control any responding do control it. Reynolds (1961) reinforced in a go/no go procedure the key pecking of two pigeons to a white triangle on a red background (S+) but not to a white circle on a green background (S-). Then, he evaluated responding to each component separately and found that both pigeons responded little to the white circle-green color compound and that one pigeon responded to the white circle while the other responded to the red color. Otherwise stated, while one aspect of the compound controlled the response of one pigeon, the other aspect controlled the response of the other. Based on these findings, Reynolds (1961) concluded that only one aspect of the stimulus had entered into the controlling stimulus relation that the DRP had established.

Other researchers have obtained findings similar to those by Reynolds (1961), but they have also found control by features that did not control the target response when they

tested the responding to each separate component (e.g., Farthing & Hearst, 1970; Kendal & Mills, 1979; Ploog, 2011; Wilkie & Mason, 1976). Farthing and Hearst (1970), for instance, reinforced pigeon's key pecking to a vertical line on a blue background (VB) but not to a horizontal line on a green background (HG) and measured, as Reynolds (1961), responding in extinction to each element separately – V, B, H, and G – and also to the combinations – VB, VG, HB, HG. The pigeons responded mostly to VB, next most to B, and least to HB, which implies that V and H had also gained control of some responding.

Wilkie and Mason (1976) also found control by aspects of a compound discriminative stimulus that in the test with single components did not control the reinforced response. First, they reinforced three pigeons as Reynolds (1961) did and other three pigeons on the contrary relations – by key pecking to a white circle on a green background but not a white triangle on a red background. Then, they evaluated responding to each component alone – Reynolds's attention test – and found that pigeons responded to color but not to form. Finally, they presented the white triangle and circle alternatively and reinforced key pecking to both of them – the resistance-to-reinforcement procedure (Hearst, 1972). If the forms of the negative and positive compounds had not gained control of any responding during acquisition, pigeons should have responded to them equally, but the rate of pecking to the positive form was higher than to the negative one.

As features of compound discriminative stimuli that at first sight do not seem to control any responding do control it, uncorrelated features may also control some responding. Andrade-Mescouto (2011), for instance, found that aspects of stimuli uncorrelated with the consequence control some responding with a procedure envisaged by Tomanari (unpublished data; see also Tomanari, 2010). Tomanari's procedure has two phases. Phase 1 is a simultaneous discrimination task in which one aspect of the stimulus correlates with the reinforcer while the others do not. Phase 2 is a recognition test in which researchers present

the uncorrelated features mixed with a new set of similar stimuli. If a participant recognizes uncorrelated aspects above chance, one may conclude that the uncorrelated aspects had gained control of some of responding.

Andrade-Mescouto (2011) studied how instructions affected eye movements in a simultaneous discrimination task. Her experiment had three conditions and phases. In Phase 1, she presented participants with a set of eight human-like images based on the South-Park cartoon television series. Participants obtained points by clicking images wearing red pants. In Condition 1, she instructed participants just to click the images on the screen – minimal instructions. In Condition 2, she instructed them to click images wearing red pants – right-instructions. In Condition 3, she instructed them to click images wearing green pants – wrong-instructions. In Phase 2, she presented the same Phase 1 images, but now wearing glasses sometimes and sometimes not, and participants produced points by clicking the images wearing glasses. She did not add new instructions. In Phase 3, she applied the recognition test. While Andrade-Mescouto did not report data about eye movements on aspects uncorrelated with the consequence, her results on the recognition test suggest that features uncorrelated with the consequence gained control over some responding: Participants from all conditions, but one, demonstrated recognition.

When the stimuli in which presence a response produces a consequence have aspects correlated and uncorrelated with reinforcement, different factors may hinder or event prevent that the correlated features gain control over the target response. Research in visual scanning, for instance, shows that the amount of uncorrelated events is inversely related to the number of trials or time for a response becoming under control by the correlated features (see Cowan, 1968). Signal detection theory makes similar assertions (see Green & Sweets, 1966); identifying the relevant signal is inversely proportional to the noise. However, one thing is

that the mere presence of uncorrelated events affects the establishment of control by the correlated stimuli and another thing is that those events acquire control by themselves.

Reynolds (1961) had concluded that not all the aspects of the stimulus in which presence a response produces a consequence gain control over the response. He also assumed that there is no attending to the not controlling aspects of the stimulus or that those aspects do not enter into the controlling stimulus relation (see Skinner, 1953 for a discussion between attention as stimulus control). In contrast, Farthing and Hearst (1970) and Wilkie and Mason (1976) found that aspects of a stimulus correlated with the consequence that do not control the reinforced response do become a part of the controlling stimulus relation. Andrade-Mescouto (2011) results with the recognition test entail some form of stimulus control, but it remains to be seen if it is equivalent to the control that Farthing and Hearst and Wilkie and Mason found. A high score in the recognition test does not imply that the recognized stimulus will control a response in an operant task as the ones that Farthing and Hearst and Wilkie and Mason used.

This study evaluated if aspects of stimuli uncorrelated with the consequence do become a part of a controlling stimulus relation. As Ray (1969) argued, “to identify a controlling stimulus relation it is necessary to distinguish between: a) a response that is controlled by a stimulus, and b) a response that simply occurs in the presence of a stimulus... A controlling relation between a stimulus and a response is measured by independent stimulus variation” (p. 539; see also Skinner, 1953). As differentially responding in a discrimination task demonstrates control by the positive and negative stimuli, differentially responding to features of stimuli uncorrelated with the consequence in relation to new stimuli would demonstrate that the previously uncorrelated aspects had gained control of some responding. If control in recognition tests and standard operant procedures is different, it might be because control by uncorrelated aspects is more basic than control by correlated

ones (see Herrnstein 1990 for a discussion on recognition and levels of stimulus control) and recognition tests would not be measuring the same that standard operant methods.

2.1 Experiment

In Experiment 2.1, a computer presented participants with a set of images similar to the ones that Andrade-Mescouto (2011) used. As Andrade-Mescouto had done, the images had a small part correlated with the consequence and the other parts uncorrelated. Subsequently, the computer presented a new set of images that alternated with the old set. All the images lacked the part previously correlated with the consequence to evaluate if aspects of the stimuli uncorrelated with the consequence had gained some control. Comparing responses to the new images with responses to the old ones was possible because the initial instructions specified that the computer would deliver points even when they were not visible on the screen. Responding mostly and above chance to either new or old images during the test would indicate that aspects of the stimuli uncorrelated with the consequence during the discrimination task had gained control over some responding. Participants could respond above chance during the test phases – Phases 2 and 4 – only by having become under control by the uncorrelated portions of the images during the training phases – Phases 1 and 3. A similar number of responses to the old and new images during the tests would indicate no such control.

Several response patterns are possible in the test phases. Responding within the chance range would indicate that portions of the stimuli uncorrelated with the consequence did not gain control over responding. Choosing old images would indicate that the old images had gained control and acquired a positive (S+) function and the new images a negative function (S-). A participant responding with this pattern would be behaving as if the old

images produced points. Choosing new images above chance level would indicate that the new images had gained control and acquired a positive (S+) function and the old images a negative function (S-). As the images did not correlate with the consequence, there is no particular reason for the images acquiring a particular function. Participants could also respond above or within chance levels to new or old images in one or both test phases – Phases 2 and 4. Responding above chance only in one of the test phases would be meaningful depending on the performance of the participants during the discrimination task. Learning the Phase 3 but not the Phase 1 discrimination and responding above chance level in Phase 2 but not Phase 4 would indicate that the gaining control by the relevant aspects of the stimuli during Phase 3 precluded control by the irrelevant stimuli. Learning the discrimination task in Phases 1 and 3 showing evidence of control in the two test phases would indicate that control by the relevant aspects of the stimuli does not preclude control by the irrelevant ones. Other patterns may indicate control of responding by irrelevant aspects other than those from the stimuli in the experimental situation.

2.1.1 Method

2.1.1.1 Participants

Two male, CE and NA, (age 51 and 25) and one female, JO, (age 28) students from different graduate programs of the University of Sao Paulo volunteered to participate in this study. They did not receive money or any other benefit for their participation in the experiment.

2.1.1.2 Instruments and setting

Each participant worked alone in a single session in an office-size room, 2.5m x 5m, located in the Fred Keller lab of the Institute of Psychology at the University of Sao Paulo. Four desks with computers on them occupied the room dividing it in two sections. The section in which the participants worked had a desk and a chair. An HP Pavilion computer (Windows 7), which had a 22" color monitor Samsung SyncMaster T220m, presented the images and recorded the participants' responses with a custom program in Visual Basic 2010. Participants sat at approximately 60 centimeters from the monitor and responded by clicking the images on the screen with the left mouse button. The keyboard was not available to the participants.

Depending on the experimental condition, the computer presented by pairs four sets of four colored images each similar to those from the animated cartoon series South-Park. Figure 2 depicts examples of the images that the computer presented to the participants (all the images are in the Appendix). Figure 2 A depicts two trials during the discriminative training between images wearing red and green pants. Figure 2 B depicts a trial between old and new images (see the procedure for explanation). Each image was about 210 x 290 pixels and appeared against a white background. The pants were the portions of the images that correlated with the consequence. The correlated portion was about five percent of the total area of the image. Images 1 to 4 and 9 to 12 had versions wearing green, red, and black pants. Images 5 to 8 and 13 to 16 had only versions wearing black pants. In Phase 1, the computer presented the images 1 to 4 wearing green and red pants. In Phase 2, the computer presented the images 1 to 8 wearing black pants. In Phase 3, the computer presented the images 9 to 12 wearing red and green pants. In Phase 4, the computer presented the images 9 to 16 wearing black pants. Table 1 depicts the images that the computer presented in each phase along with the stimuli that correlated positively and negatively with the consequence.

Figure 2. Examples of images used in the Experiment 2.1. A) In each trial of Phases 1 and 3, images appeared in pairs dressing green and red pants. The figure depicts two trials with the same images. B) In each trial of Phase 2 and 4, images appeared in pairs dressing black pants. The figure depicts one trial with an old, Phase 1 image and a new, Phase 2 image.

2.1.1.3 Procedure

The Experiment 2.1 had four phases (see Table 1). In Phase 1, the computer presented images 1 to 4 wearing green or red pants, and the participants' task was to discriminate between the colors of the pants. Clicking the images wearing green pants produced points in a continuous reinforcement schedule. In Phase 2, the computer presented the set of old images (1 to 4) and a new set (5 to 8), all of them wearing black pants. In Phase 2, the computer did not produce any consequence on the screen for the participants' responses. The participant's task in Phase 2 was just to click the images they thought would produce points. Phase 3 was similar to Phase 1 but with a new set of images (9 to 12), and participants produced points by clicking images wearing red pants. Phase 4 was identical to Phase 2 but with two different sets of old (9 to 12) and new (13 to 16) images (see all the images that the computer presented in the Appendix 1).

Table 1

Stimuli used in each one of the four experimental phases in Experiment 2.1.

Phase	1(Training)		2(Test)		3(Training)		4(Test)
Consequence	S+	S-	No conseq		S+	S-	No conseq
Pants' Color	Green	Red	Black		Red	Green	Black
Stimuli	1-4		1-4	5-8	9-12		9-12 13-16

Each participant worked alone in a single session that could take place in any day from Monday to Friday between 2:00 PM and 5:00 PM. On arrival, each participant sat in front of the computer, received a consent form, read it, and signed it. Once the participants had signed the consent form, the experimenter fed the program with the participant's age and gender and initiated the session; the program automatically recorded date and time. On the

center of the screen, the computer presented the instructions, and the experimenter asked the participant to read them. The instructions in Portuguese read like these:

“In this experiment, which has several phases, your task is to earn points always. There is only a way to keep earning points; you must identify that way. When you earn one point, a +1 will appear on the screen. Sometimes you will not see the points on the screen; however, you will keep earning points, so you must keep responding. If you have any question, call the experimenter. Otherwise, click the button below to begin. In case you need any assistance during the experiment, please call the experimenter who will be always nearby”.

When participants were about to click the start-experiment button, the experimenter asked them the following question: “What is your task?” If the participant responded that the task was to keep earning points always and that sometimes points would not be visible, the experimenter instructed the participant to click the start-experiment button. Otherwise, the experimenter asked the participant to read the instructions again in a loud voice. Then, the experimenter asked the participant about the task again. The previous steps were to be repeated as many times as necessary. After a participant had clicked the start-experiment button, the computer presented the first pair of images of Phase 1 on the center of the screen.

In each trial, the computer presented pair of images simultaneously on the screen. The rules to present the images differed accordingly to the phase. In Phases 1 and 3, to warrant that the pant's colors were the only aspect correlated with the consequence while the other aspects did not correlate, the computer chose a pair of images at random. The computer generated all the combinations of non-repeated pairs of images. Given that there were four images in Phases 1 and 3, the computer created six combinations. For instance, for Phase 1, the computer generated the pairs 1-2, 1-3, 1-4, 2-3, 2-4, and 3-4. The computer also generated another list with the same pairs, but in the opposite position (2-1, 3-1, 4-1, 3-2, 4-2, 3-4). In

each trial, the computer selected a pair at random from any of the two lists without replacement. If the computer selected, for example, the pair 1-2, it presented the image 1 on the left side of the screen and the 2 on the right. If, on the contrary, the computer selected the pair 2-1, it presented the image 2 on the left and the 1 on the right. A block consisted of the six pairs of images. Once the computer had selected a pair from any list, such as 1-2 or 2-1, the pair was not available any more until the next block. In this way, each image appeared the same number of times wearing green and red pants and in an unpredictable position. The position of the color of the pants, right or left, was at random ($p = 0.5$). With this procedure, only by identifying the pants' color as the relevant stimuli, participants could keep earning points consecutively.

In Phases 2 and 4, the computer generated two lists again, but with the numbers that indicated the sets with old and new images. For instance, in Phase 2, the computer generated the list for the old set 1, 2, 3, and 4 and the list for the new set 5, 6, 7, and 8. In each trial, the computer selected one image from each set without replacement, so in Phases 2 and 4 each block consisted of four trials. For example, if the computer selected the numbers 1 and 5, it presented the images 1 and 5 on the screen. Once the computer had selected a pair of images, the computer did not present the same pair until the next block. After a participant had clicked an image, the computer removed the pair of images and produced the consequence in the center of the screen for 1 sec. The positive consequence was a number one after a plus sign (+1) and the negative, a zero (0). The Inter Trial Interval (ITI) was of 1 sec. In Phases 1 and 3, participants went to the next Condition after responding right in two consecutive blocks – 12 trials – or 450 trials, what happened first. Phases 2 and 4 had 20 trials. After the last trial of Phase 4, the program opened a text box with the following message in Portuguese:

“The experiment has ended, thank you very much for your collaboration. Please call

the experimenter.”

Before participants left the room, the experimenter asked them about what they had to do to obtain points; they had to explain as if they were instructing someone else how to obtain points. Once they had finishing the explaining, the experimenter debriefed them.

In each Phase, the computer recorded the number of right and wrong responses as well latencies. In Phases 1 and 3, the color of the pants defined a right response. In Phases 2 and 4, the computer counted responses to old and new images. Choosing above chance ($p = 0.05$) mostly old or new images would indicate that the participant had attended to the old images. Not attending to the images in Phases 1 and 3 entails responding at random in Phases 2 and 4.

2.1.2 Results and discussion

As the Experiment 2.1 evaluated if aspects of the stimuli uncorrelated with the consequence gained control over responding during discrimination training, the number of old or new images that participants selected in Phases 2 and 4 were the relevant data. The participant's performance in Phases 2 and 4 indicated if aspects of the stimuli uncorrelated with the consequence in Phases 1 and 3 had gained control of responding. Trials to criterion in Phases 1 and 3 were useful for examining if aspects of the stimuli uncorrelated with the consequence hindered the acquisition of control by the correlated features. The participant's performance in Phases 1 and 3 also helped to interpret their performance in Phases 2 and 4. As Figure 3 depicts, only one participant, NA, learned the discrimination after 222 trials in Phase 1. The participant reported that the colors of the pants were the stimuli that reliably predicted points. The other two participants did not reach criterion and completed the maximum of 450 trials that the program allowed. In Phase 2, there was evidence of control by aspects of the stimuli uncorrelated with the consequence for NA and CE. Participant NA

responded 16 times to images from Phase 1 –old images– and four times to new images. CE responded 16 times to new images and four to old images. NA and CE performance indicates that aspects of the stimuli uncorrelated with the consequence gained control of some responding during Phase 1 ($\chi^2 = 7.2, p = 0.001$). There was not evidence of control by uncorrelated aspects for Participant JO in Phase 1 who responded in Phase 2 eleven times to old images and nine times to new images. In Phase 4, there was no evidence of control by images uncorrelated with the consequence for any participant during Phase 3.

Figure 3. Trials to criterion in Phases 1 and 3 and responses to old and new images in Phases 2 and 4 for each participant. Figures on the left -black bars- depict trials to criterion in Phases 1 and 3 and on the right, the number of responses to old images in Phases 2 and 4. The light gray bar section of the bars depicts responses to Old Images (OI) and the darker gray section,

to New Images (NI). Dashed lines indicate the values above or below chance level (χ^2 , $p=0.05$).

The average response latency was another data of interest because short versus long latencies suggest less or more interaction with the stimuli. In Phase 1, the mean latency of responding for participants NA, CE, and JO was respectively 0.65, 0.43, and 0.46 ms while it was 0.14, 0.36, and 0.49 ms in Phase 3. The latencies of NA and CE were longer in Phase 1 than in Phase 3, especially for NA. JO's latencies were similar in Phases 1 and 3. As NA was the only participant that learned the discrimination, NA's latencies suggest a longer interaction with the stimuli in Phase 1 than in Phase 3. Given that the mean latencies for NA were also higher in Phase 1 than those of CE and JO, NA might have interacted more with the stimuli in Phase 1 than CE and JO. The fast responding of NA in Phase 4 combined with his having learned the discrimination in Phase 1 implies that only the colors of the pants gained control of his responding in Phase 4. NA might not have attended to the aspects uncorrelated with the consequence at all. It is worth to point out that while participant NA assumed that to obtain points had to click old images, CE assumed that had to click new images.

At debriefing, the three participants reported that they tried to find relations between characteristics of the images to obtaining points before trying other strategies. According to JO report, different characteristics of the images seem to have controlled her observing responses in different moments. CE reported that he tried to establish relations between faces and points. CE also reported that the task was boring and that in Phases 3 and 4 he just wanted to end the experiment. In contrast, JO found the task demanding and interesting and asked to continue with the experiment or to participate in other similar experiments. NA also found the experiment demanding and interesting and preferred to send a complete report by email. NA said that he responded to old images in Phase 2 because he assumed that familiar

images produced points. CE argued that as he had not found any relation between images and points in Phase 1, the new images in Phase 2 should produce points.

Data from Phase 2 imply that some responding of participants NA and CE became under control by aspects of the stimuli that did not correlate with the consequence in Phase 1. Aspects correlated with the consequence controlled the effective response only for NA. Data do not indicate that either correlated or uncorrelated aspects of the stimuli had controlled JO's responding. Data from Phase 4 indicate that uncorrelated aspects of the stimuli did not gain control in Phase 3 for any participant. The fact that data from Phase 4 for all participants and 3 for JO do not demonstrate control by the uncorrelated aspects in Phases 1 and 3 do not rule out the existence of some control. In Experiment 2, the procedure evaluated if aspects of the stimuli uncorrelated with the consequence acquire control of some responding during the establishment of stimulus control by reinforcing responding in the test phases.

Experiment 2.2

Data from Experiment 2.1 demonstrated control of responding by aspects of stimuli uncorrelated with the consequence for two participants in Phase 1. However, the uncorrelated aspects might have controlled the responding of the other participant in Phase 1 and of all the participants in Phase 3. As in Experiment 2.1, in the test phases of this experiment, all images lacked the part that had correlated with the consequence in the discrimination phases — they wore black pants. In the test phases to evaluate control by aspects uncorrelated with the consequence, the participants' task was to discriminate between sets of images. It was necessary to add a new phase that served as a baseline. The computer presented in this additional phase two new sets of images. Arbitrarily, one set was the positive stimulus and the other, the negative. The set from Phases 1 and 4 were the positive stimuli in Phases 2 and 5

respectively and a new sets of images, the negative. If images uncorrelated with the consequence had gained control during Phases 1 and/or 4, participants should have reached criterion in fewer trials in Phases 2 and/or 5 than in Phase 3. If the uncorrelated images had not gained control, participants should have showed one of two patterns. They could have reached criterion in about the same number of trials in Phases 2, 3, and 5 or they might have reached criterion in fewer trials in Phases 3 and 5 than in Phase 2. The second pattern should have resulted from learning by successive exposition to a similar task.

2.2.1 Method

2.2.1.1 Participants

Five graduate students from the experimental psychology program of the University of Sao Paulo, three men, RA, MI, and HE and two women, LA and AL ($M_{age} = 28$, age range = 25-33), volunteered to participate in this experiment after an invitation by one of the experimenters. They did not receive money or any other benefit for their participation.

2.2.1.2 Instruments, setting, and procedure

Instruments and settings were similar to those in Experiment 2.1. The images for this experiment were different. They had been used in previous studies (see Appendix). Unlike Experiment 2.1, responses in the test phases produced consequences (see Table 2). A point (+1) appeared on the screen if participants clicked images wearing green pants in Phase 1 and red pants in Phase 4; in Phases 2 and 5, if participants clicked old images; in Phase 3, if participants clicked images 9 to 12. As the computer provided points in all phases, instructions differed from those in Experiment 2.1 and in Portuguese read like this:

“In this experiment, which has several phases, your task is to earn points always.

There is only a way to keep earning points; you must identify that way. When you earn one point, a +1 will appear on the screen. If you have any question, call the experimenter. Otherwise, click the button below to begin. In case you need any assistance during the experiment, please call the experimenter who will be always nearby ”.

Phases ended if participants obtained 12 consecutively points or completed 450 trials without reaching criterion. As in Experiment 2.1, no instruction indicated the beginning of a new phase.

Table 2

Images and contingencies used in each one of the five experimental phases in Experiment 2.2.

Phase	1(Training)		2(Test)		3(Baseline)		4(Training)		5(Test)	
Consequence	S+	S-	S+	S-	S+	S-	S+	S-	S+	S-
Pants' Color	Green	Red	Black		Black		Red	Green	Black	
Stimuli	1-4		1-4	5-8	9-12	13-16	17-20		17-20	21-24

2.2.2 Results and discussion

Trials to criterion in each phase were the relevant data in this experiment (see Figure 4). The participant's performance in the discrimination – Phases 1 and 4 – and categorization tasks – Phases 2, 3, and 5 – indicate the different ways in which the irrelevant aspects of the stimuli affected the establishment of control by the relevant ones. One of those ways was the acquisition of control by the irrelevant aspects. Four patterns were possible in Phases 1 and 4. First, participants could have learned both discriminations. This pattern would indicate that the relevant aspects of the stimuli gained control over responding; particularly, if the participants show reversal. Second, participants could have learned only the Phase 4

discrimination. This pattern would indicate that the relevant aspects did not gain control in Phase 1, but that they did gain control in Phase 4. Third, participants could have learned only the Phase 1 discrimination. This atypical pattern would suggest some form of restricted or incomplete stimulus control. Fourth, participants could not have learned any discrimination in Phases 1 and 4. This pattern would indicate that the relevant aspects of the stimuli did not gain control over responding. The relevant aspects of the stimuli became the controlling stimuli in Phases 1 and 4 only for AL. For RA and LA, the colors of the pants acquired control of responding only in Phase 4. The relevant aspects of the stimuli did not control the responding of MI and HE in Phases 1 and 4. Clearly, aspects of the stimuli uncorrelated with the consequence in the present experiment hindered or prevented the acquisition of control by the correlated aspects.

The comparison between Phases 2, 3 and 5 would reveal control by aspects of the stimuli uncorrelated with the consequence during Phases 1 and 4. The participant's task in Phase 3 –baseline– was to discriminate between two sets of new images; arbitrarily, one set was the positive stimulus and the other, the negative. In Phases 2 and 5, the set of images from Phases 1 and/or 4 were the positive stimuli and sets of new images, the negative. Reaching criterion in fewer trials in Phases 2 and/or 5 than in Phase 3 would demonstrate control by the images from Phases 1 and/or 4. On the contrary, a similar number of trials to reach criterion in Phases 2, 3, and 5 would indicate no such control. A decreasing number of trials to reach criterion from Phase 2 to 5 would also show no control by the images from Phases 1 and/or 4. All participants required fewer trials to reach criterion in Phase 2 than 3, which implies that aspects of the images uncorrelated with the consequence acquired control of some responding during Phase 1. It is worth pointing out that if the participants have had only categorization tasks, they should have required fewer trials to reach criterion from phase to phase. Participants had a categorization task in Phase 2 so that their performance in Phase

3 should be better in Phase 3 than 2. Fewer trials to criterion in Phase 2 than 3 would demonstrate control by aspects of the stimuli uncorrelated with the consequence.

RA, MI, and HE required fewer trials to reach criterion in Phase 5 than 3, which implies that aspects of images uncorrelated with the consequence during Phase 4 also acquired control of their responding. LA and AL took more trials to reach criterion in Phase 5 than 3, which implies that something hindered the acquisition of control by the set of old images in Phase 5. For LA and AL, the control that the relevant features of the stimuli gained in Phase 4 might have hindered the control by the relevant stimuli in Phase 5. MI and HE data show that when the aspects of the stimuli correlated with the consequence do not gain control over the target response, the uncorrelated aspects do. LA and AL performance in Phase 5 indicates that once aspects of the stimuli correlated with the consequence gain control of the response, uncorrelated aspects do not gain control.

Unlike Experiment 2.1, results show that images uncorrelated with the consequence gained control of observing responses during Phase 1 for all participants. In Phase 4, the images gained control of the observing responses of three participants, RA, MI, and HE. MI and HE did not learn the discriminations in Phases 2 and 4. RA learned the discrimination in Phase 4. Images uncorrelated with the consequence did not gain control of observing responses for participants LA and AI in Phase 4, which indicates that the control by the relevant stimuli had prevented control by uncorrelated features. However, not always control gained by uncorrelated features prevents control by uncorrelated aspects as the data for RA indicates. RA took fewer trials than LA to reach criterion in Phase 4, which entails a lesser exposure to the stimuli; even so, irrelevant aspects gained control of LA responding. All participants required fewer trials to reach criterion in test phases than in discrimination phases, which demonstrates that the simple discrimination in Phases 1 and 4 was more difficult for them than the categorization task in Phases 2, 3, and 5.

Figure 4. Trials to criterion for the five phases of Experiment 2.2. Phases 1 and 4 were, on the left, correspond to training. Phases 2, 3 and 5, on the right, correspond to tests. The black segment of the bar and the numbers within the bars indicate correct responses.

2.3 General discussion

Andrade-Mescouto (2011) had found that most participants in her experiment recognized the uncorrelated portions of images like the ones in Experiments 2.1 and 2.2. Recognition entails control of responding by the recognized stimuli. The purpose of these experiments was evaluating if aspects of the stimuli uncorrelated with the consequence also showed stimulus control of responding with a more traditional operant procedure. The stimuli in these experiments as in the one by Andrade-Mescouto included a small portion that correlated with the consequence while the other portions did not correlate. Data from Experiments 2.1 and 2.2 demonstrate control of responding by features of stimuli uncorrelated with the consequence during a simultaneous discrimination task. At least, another conclusion derives from the data. The aspects of the stimuli uncorrelated with the consequence in these experiments prevented the acquisition of control by the correlated aspects.

These data are not the first in showing control by stimuli uncorrelated with the consequence. Sidman (1969) reported control by stimuli uncorrelated with the consequence in an experiment with brain-damaged subjects. Sidman, Stoddard, and Mohr (1968) had observed that some patients with brain lesions were affected by the delays in matching to sample procedures. Specifically, they had observed that the longer the delay, the lesser control had the sample. Based on the data by Sidman, Stoddard, and Mohr (1968), Sidman (1969) presented a group of brain-damage patients with eight ellipses that varied in size in a delayed matching to sample task. He presented the stimuli in a square matrix of nine translucent windows. The sample always appeared in the central cell. Once a participant pressed it, the central panel became dark, and the other panels illuminated showing the choices after the delay that Sidman had scheduled. As the independent variable, Sidman manipulated several delays. To evaluate the dependent variable – stimulus control–, Sidman

constructed generalization gradients from the participant's responses to the choices. As the value of the delays increased, the participants choose wrong choices more frequently so that he constructed the generalization gradient with the differences in size between wrong choices and sample.

Sidman (1969) found that control by the samples diminished with increasing delays. He also found that for longer delays other stimuli replaced the control that the sample had when the delays were short. Some of his participants' responding, for example, became under control by absolute ellipse size. When the delays were long, some participants choose large ellipses. As the sample varied in size at random from trial to trial, the participants produced the consequence when the sample was also large but not when it was small. Therefore, the participants sometimes obtained the reinforcer by responding to large samples, but sometimes they did not. Consequently, there was a random correlation between the stimulus that controlled the participant's responding and reinforcement. From this random correlation emerged an unexpected source of control. As Sidman (1969) said, "although control by the samples was consistent with the reinforcement contingencies, the development of control by the choice display was not predictable on behavioral or logical grounds" (p. 756).

Most theories on the establishment of stimulus control predict no control by stimulus features uncorrelated with the consequence. Data from the experiments in this paper contradict those predictions. One way to group those theories is by classifying them in accounts based on strengthening, attending, or observing. Next, there will be a general description of each one of these theories and their relation with the data from Experiments 2.1 and 2.2. A complete revision is not necessary and is far beyond the scope of this paper. The purpose of presenting the theories is to illustrate the key point from the performed experiments: the initial environmental arrangement influences which portions of the environment will gain control over responding. According to traditional strengthening

theories (see Dinsmoor, 1985 for a detailed revision), reinforcement should increase the tendency to respond to all the stimuli present in the situation, and extinction should decrease it. The joint action of reinforcement and extinction should nullify the influence of features of the stimuli uncorrelated with the consequence. Thus, stimuli uncorrelated with the consequence should not gain control over responding.

Data from Experiment 2.1 are relevant to the predictions of the strengthening account. In Experiment 2.1, participants did not produce points in the test phases. Instructions in the test phases specified that they had to click the images that they supposed would produce points, but participants would not see the points on the screen. Only one of the participants (JO) behaved as the strengthening account predicts. In the test phases, there was not evidence of control by the stimuli uncorrelated with the consequence in Phase 1 for JO. In contrast, NA and CE performance contradicts the strengthening account predictions. NA responded as if the uncorrelated aspects had become positive stimuli for him. One could argue that NA responding in Phase 2 resulted from some correlation between his responding in Phase 1 with the consequence. Although the correlation between the images in the absence of the pants was at random, one can argue that there was a correlation after all. Nevertheless, CE responding contradicts such a view. CE responded as if the uncorrelated aspects had become negative stimuli. According to the strengthening account, CE could not have responded to new stimuli because CE never obtained any consequence in their presence, strengthening was impossible.

Most theories based on attention do not predict control by irrelevant aspects either; although some theories allow the possibility of control by features of the stimuli uncorrelated with the consequence. Theories based on attention take as a fundamental premise that cognitive resources are limited. Human and nonhuman animals cannot respond to all the sources of stimulation in their environment so that they respond to portions of the

environment selectively. As Mackintosh (1965) put it, “ the most obvious implication of the concept of attention is that animals should not learn equally about all the stimuli impinging on their receptors” (p. 125). Associative strength is a key issue in most attention theories (for instance Perkins, 1953; Sutherland & Mackintosh, 1971). Theories based on attention mean by strength the predictive or signaling power of the discriminative stimuli in relation to the reinforcer (Mackintosh, 1975). The better the stimulus predict the reinforcer; the stronger is its strength. Stimuli uncorrelated with the consequence, by definition, lack predictive power so that human and nonhuman animals should not attend to them. They should not either learn about them. In general, data from Experiment 2.2 show that all participants attended and learned something from stimuli uncorrelated with the consequence in Phase 1.

Selective attention theories assert that organisms attend to a set of stimuli in each trial and that the set is available for association with the outcome of the trial (Sutherland & Mackintosh, 1971). According to Mackintosh (1975), all selective attention theories share some assumptions. The first of those assumptions is that the experience with the stimulus can change the probability of attending to it. An extension of this assumption is “that the probability of attending to relevant stimuli typically increases, while the probability of attending to irrelevant stimuli typically decreases” (Mackintosh, 1975, p. 278). This assumption implies that variations in a stimulus correlated with reinforcement result in more attention to the stimulus. In contrast, variations in stimuli uncorrelated with reinforcement result in less attention to the stimulus. The second assumption is “that the probability of attending to one set of stimulus is inversely related to the probability of attending to others” (Mackintosh, 1975, p. 278). Thomas (1970) called this second assumption the inverse hypothesis. Data from Phase 1 in Experiments 2.1 and 2.2 do not support the inverse theory predictions. According to the inverse theory, participants should have attended to particular sets of stimuli in each trial. If in a trial they obtained a consequence, strength –as predictive

power—, to the set of stimuli to which participants had attended should increase. Nevertheless, if the set were uncorrelated with the consequence, in other trials that same set would predict the absence of the consequence so that strength should decrease. Consequently, organisms should not attend in future trials to sets of stimuli that had not predictive power.

Mackintosh (1975) advanced a theory that allows the attending to irrelevant stimuli during discrimination learning. His theory highlighted the role of the stimulus during acquisition. According to Mackintosh (1975), most attention theories had assumed that a general parameter of learning regulates the acquisition process. This parameter would depend mostly on the characteristics of the organism. Mackintosh proposed the addition of another parameter that would depend mostly on the properties of the stimulus. This new parameter would account, for example, for the differential learning to a stimulus of higher than lesser intensity. It would also explain why stimuli from a particular modality are more effective for the conditioning of a response than others. According to Mackintosh (1975), Pavlov (1927) had observed that the conditioned response was stronger when Pavlov used more intense conditioned stimulus. Pavlov had also observed that in relation to a conditioned response, not all the modalities of stimuli were equally effective. For example, a salivation response was stronger to tactile and auditory stimuli than to other modalities such as visual or thermal. In instrumental learning, Foree and Lolordo (1973, quoted by Mackintosh, 1975) reported that lights gain control over food related responses faster and stronger than tones. The stimulus parameter proposed by Mackintosh would account for Pavlov's and Foree and Lolordo's observations.

According to Mackintosh (1975), stimulus properties such as its intensity or type affect the conditioning process in such a way that an organism might attend to irrelevant stimuli if, for instance, the irrelevant stimuli are more intense than the relevant ones. Applying Mackintosh arguments to data from Experiments 2.1 and 2.2, one can argue that

aspects of the stimuli uncorrelated with the consequence were so salient that the participants attended to them rather than to the relevant stimuli. In the present text, however, the notion of attention differs from the one that Mackintosh (1975) holds. In the present text, attention refers to a controlling stimulus relation. As Skinner (1953) said,

The control exerted by a discriminative stimulus is traditionally dealt with under the heading of attention. This concept reverses the direction of action by suggesting, not that a stimulus controls the behavior of an observer, but that the observer attends to the stimulus and thereby controls it. (p. 122)

Parts of Mackintosh's (1975) arguments are compatible with the notion of attention as controlling stimulus relation. For instance, Mackintosh acknowledged that parameters like intensity influence the way in which a stimulus gains control over responding. Nevertheless, Mackintosh put the control in the organism because organisms *attend* to the stimuli. In the present text, following Skinner (1953), the attending is synonymous of stimulus control (see Ray, 1969; Vyazovska, Teng, & Wasserman, 2014)

In the experimental situation, some stimuli have a better chance of gaining control over a response than others. As argued above, organisms do not enter into the experimental situation in a vacuum. Organisms are behaving things that are responding to something all the time, which implies that the responding that they bring to the experimental situation is already under the control of some stimuli. When a researcher begins the process of reinforcing a response in the presence of a stimulus, the researcher expects that the stimulus gain control over the response. However, the contingencies established by the researcher will be effective only if they break the control exerted by stimuli unknown to the researcher.

As Sidman (1969) said,

The suggestion has been presented elsewhere, on independent grounds, that stimulus control other than that intended by the experimenter develops as a result of factors

which render the subject unable to respond in concordance with the scheduled contingencies. (p. 756)

In the present experiments, at least, two factors associated to the stimuli may have produced the obtained results. First, the stimuli were human shapes. Undoubtedly, human forms are powerful stimuli for human participants. As faces control most of people daily interactions, some of the participants might have been under the control of the character's faces from the beginning. Second, the relevant stimuli in these experiments were the pants of the characters. The pants in the experiment were a part of the whole. People do not interact with parts of other people, but with entire persons. To learn the discrimination, participants might have had to extract the part from the whole. In order to evaluate the role of the stimuli used in the present experiments, it is necessary to use stimuli that share similar components but that do not have human format.

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Appendix

Figure 1. Images used in Experiment 2.1. Images from Phases 1 and 3 had versions wearing green and red pants.

Figure 2. Images used in Experiment 2.2. Images used in Phases 1 and 4 had versions wearing

CHAPTER 3

Response Control by Aspects of Human-like and no Human-Like Stimuli Uncorrelated With the Consequence

Introduction

As data from Experiments 2.1 and 2.2 demonstrated, the environment in which a response produces a consequence is not and does not have to be neutral in relation to the possible responses that an organism may emit before the establishment of a new operant response. For instance, the probability of each of the different responses that a rat may emit when the first time in an operant chamber does not have to be equal; some responses may have a greater chance to occur than others. As Skinner (1969) argued, the “contingencies of reinforcement remain ineffective until a response has occurred. The rat must press the lever at least once ‘for other reasons’ before it presses ‘for food’” (p. 175). The other reasons must be in the initial environment. The characteristics of the initial environment may affect the probability of each response so that not all the stimuli have the same probability of gaining control over the response that produces the consequence (see Segal, 1972).

The observing response as Wyckoff (1952, 1969) defined it is useful for illustrating how and why some aspects of the environment have better chances of gaining control over a response than others. It is necessary the organism’s sensory exposure to the stimulus for the stimulus acquiring control of a response, (see Dinsmoor, 1983). A rat in an operant chamber for the first time and before obtaining the first reinforcer is always in contact with some portion of its environment; it cannot be otherwise unless the animal is dead. However, the frequency and duration of the initial contact with each aspect of the environment does not have to be the same. Necessarily, environmental features control the rat’s sensory responding differentially from the beginning. Sensory control by the features that correlate with the consequence must compete against control by uncorrelated features.

Regarding their correlation with a consequence, environmental features may have a positive, negative, or random correlation. In pristine laboratory conditions, aspects with a positive correlation gain control over the response becoming the S+ and S-, but that is hardly

the case in a less controlled or more complex environment. Phenomena such as restricted stimulus control (Dube & McIlvane, 1997; Litrownik, McInnis, Wetzel-Pritchard, & Filipelli, 1978) or stimulus over-selectivity (Lovaas, Koegel, & Schreibman, 1979; and Dube, 2009) exemplify how some aspects of the environment have a greater chance of controlling a response than others under certain circumstances. As Dube, Dickson, Balsamo, O'donnell, Tomanari, Farren, Wheeler, Mcilvane (2010) argued,

A number of factors may be related to restrictions in the range, breadth, or number of controlling stimuli. In normally capable humans, these factors include the number of stimuli or relevant stimulus features, increase in task difficulty, requirements for rapid responding, or some concurrent and distracting activity (p. 297).

Similar factors to those that alter the range of controlling stimuli correlated with the consequence might affect uncorrelated features so that they may prevent or hinder the acquisition of control by the correlated aspects.

Studies by Andrade-Mescouto (2011) and data from Experiments 2.1 and 2.2 suggest that the shape of events uncorrelated with the consequence make them more or less competitive with the correlated aspects. They presented their participants with a set of human-like figures that had a small part that correlated with the consequence –their pants– while all the other parts did not correlate. They found that the correlated features of the stimuli hardly gained control of the reinforced response. They also found that the uncorrelated aspects almost always gained control of some responding and that the uncorrelated aspects had a greater chance of gaining control than the correlated aspects. The human shape of the stimuli that Andrade-Mescouto (2011) used and of the stimuli in Experiments 2.1 and 2.2 might have exerted competitive control. Some features of human shapes might have a greater chance of controlling sensory responses than others; faces, for example.

The purpose of this study was evaluating if the human shape of the images that Andrade-Mescouto (2011) used and those from Experiments 2.1 and 2.2 had some effect on the gaining of control by uncorrelated aspects of the stimuli. To evaluating such control, in three experiments, the computer presented images similar to those used by Andrade-Mescouto and those from Experiments 2.1 and 2.2 in human-like as well as in scrambled format. The images in scrambled format had the same components that the original ones but in a different arrangement. Control by the scrambled images would suggest that a human shape is not a relevant factor in relation to control by uncorrelated aspects while absence of control would demonstrate that human shapes as aspects of stimuli uncorrelated with the consequence have a greater chance of gaining control than other stimuli. Establishing that certain shapes have a greater chance of controlling some initial responding than other shapes is in itself a demonstration of the role of the initial environmental arrangement in the acquisition of stimulus control.

3.1 Experiment

In Experiment 3.1, a computer presented participants with a set of images whose originals were similar to those from Experiments 2.1 and 2.2 to verify control by aspects of stimuli uncorrelated with the consequence during simultaneous discrimination learning. The original images were human-like characters similar to those from the television series South Park. The parts of each image were scrambled so that they did not look like human characters. As in Experiments 2.1 and 2.2, in some experimental phases, a small part of the images correlated with the consequence while the other parts did not. In the other phases, the computer presented sets of images that had appeared previously in previous Phases and new images, and participants obtained points by clicking old images.

3.1.1 Method

3.1.1.1 Participants

Two female, LA and VA, (both of them age 18) and two male, GA and AN, (ages 20 and 24) undergraduate students from the psychology program of the National University of Colombia volunteered to participate in this study. They did not receive money or any other benefit for their participation in the experiment.

3.1.1.2 Instruments and setting

Participants worked simultaneously in the lab for the study of human cognition located at the Department of Psychology of the National University of Colombia. The lab is a room of 3 m x 6 m that contains 12 individual workstations in which participants can work individually. In each workstation, an all-in-one desktop Dell computer with a 23 in. monitor presented the stimuli and recorded the participant's data with a costume program in Visual Basic 2010. Participants sat at approximately 60 centimeters from the monitor and responded by clicking the images on the screen with the left-mouse button. The keyboard was not available to the participants.

Depending on the experimental condition, the computer presented four sets of four colored images. The images were similar to those from Experiments 2.1 and 2.2, but they were not the same. The images in the present experiments had fewer components than those from Experiments 2.1 and 2.2. In this experiment, the computer presented all the images in a scrambled format (see Figure 5, see all the images for the experiments of chapter 3 in the Appendix). Each image was about 210 x 290 pixels. Images 1_s to 4_s and 9_s to 12_s had versions with the bottom part on green, red, and black colors. Images 5_s to 6_s and 13_s to 16_s had the bottom part on black (see Table 3).

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Figure 5. Examples of images used in the Experiment 3.1. A) A human-like image and its scrambled versions with the bottom part in red, green, and black colors. B) The images illustrate those used in Phases 1 and 4. C) The images illustrate those used in Phases 2, 3, and 5.

3.1.1.3 Procedure

The general procedure was like the one in Experiment 2.2. The experiment had 5 phases (see Table 3). In Phase 1, the computer presented images numbered 1_s to 4_s with green and red bottom parts that correlated with the consequence, and the participants' task was to discriminate between them. Clicking images with a green bottom part produced points always

while clicking images with a red bottom part never produced them. In Phase 2, the computer presented the set of old images (1_s to 4_s) and a new set (5_s to 8_s), all of them with a black bottom part. Participants produced points only by clicking old images; clicking new images never produced them. Phase 3 was like Phase 2 but with two sets of new images. Arbitrarily, clicking a set of new images (9_s to 12_s) produced points always while clicking the other set (13_s to 16_s) never produced them. Phase 4 was like Phase 1 with a new set of images (17_s to 20_s) that had green and red bottom parts. Participants produced points by always clicking images with a red bottom. Clicking images with green bottom parts never produced points.

Table 3

Images used in each one of the five experimental phases in Experiment 3.1. The subscript s indicate that the number refer to a scrambled image and not to the original image.

Phase	1(Training)		2(Test)		3(Baseline)		4(Training)		5(Test)	
Consequence	S+	S-	S+	S-	S+	S-	S+	S-	S+	S-
Pants' Color	Green	Red	Black		Black		Red	Green	Black	
Stimuli	1 _s -4 _s		1 _s -4 _s	5 _s -8 _s	9 _s -12 _s	13 _s -16 _s	17 _s -20 _s		17 _s -20 _s	21 _s -24 _s

On arrival, each participant sat in a workstation, read a consent form, and signed it. Once they had signed the consent form, the researcher fed the program with the participant's age and gender and initiated the session; the program automatically recorded date and time. On the center of the screen, the computer presented the instructions, and the experimenter asked the participant to read them. The instructions in Spanish read like these:

“In this experiment, which has several phases, your task is to earn points always.

There is only a way to keep earning points; you must identify that way. When you earn one point, a +1 will appear on the screen. If you have any question, call the

experimenter. Otherwise, click the button below to begin. In case you need any assistance during the experiment, please call the experimenter who will be always nearby ”.

When participants were about to click the start-experiment button, the experimenter asked them the following question: “What is your task?” If the participant responded that the task was to keep earning points always, the experimenter instructed the participant to click the start-experiment button. Otherwise, the experimenter asked the participant to read the instructions again in a loud voice. Then, the experimenter asked the participant about the task again. If necessary, the experimenter repeated the previous steps. When the participant had understood the instructions could click the start-experiment button. After a participant had clicked the starting-experiment button, the computer presented the first pair of images of Phase 1 on the center of the screen.

In all the Phases, participants went to the next Condition after responding right in two consecutive blocks – 12 trials – or 450 trials, what happened first. After the last trial of Phase 5, the program opened a text box with the following message in Spanish:

“The experiment has ended, thank you very much for your collaboration. Please call the experimenter.”

Before participants left the room, the experimenter asked them about what they thought they had to do to obtain points.

In each Phase, the computer recorded the number of correct and wrong responses as well latencies. In Phases 1 and 4, the color of the pants defined a correct response. In Phases 2 and 5, correct responses were to click images that had appeared in Phases 1 and 3 respectively. In Phase 4, all images were new; the set of images that defined correct responses was arbitrarily defined.

3.1.2 Results and discussion

The Experiment 3.1 evaluated whether aspects of scrambled human-like stimuli uncorrelated with reinforcement gained control over responding when other aspects of the stimuli correlated with the consequence. Data from Experiment 2.2 showed with human-like stimuli that features correlated with the consequence hardly gained control under these circumstances and that uncorrelated aspects of the stimuli acquired control of responding. As in Experiment 2.2, trials to criterion were the relevant data. The task in Phases 1 and 4 was a simultaneous discrimination. In Phase 4, the conditions of Phase 1 reverted. Phases 2, 3, and 5 were tests evaluating control by uncorrelated aspects in Phases 1 and 4. Phase 3 was a baseline with which to compare Phases 2 and 5. Fewer trials to reach criterion in Phases 1 and/or 4 than in Phase 3 would indicate that uncorrelated aspects had gained control over some responding in Phases 1 and/or 4. A similar number of trials to criterion in Phases 2 or 4 than in Phase 3 would show no such control.

In contrast with Experiment 2.2, all participants learned the Phase 1 simultaneous discrimination, and aspects uncorrelated with the consequence gained control over only one of the participants responding. GA and VA results in Phase 1 indicate that correlated aspects of the stimuli gained control over their responding as their performance in Phase 4 demonstrates. While in Phase 1, the green bottom part of the images produced points, the red bottom part produced them in Phase 4. The rapid acquisition in Phase 4 for both participants show that aspects of the stimuli correlated with the consequence gained control in Phase 1 and that control reverted in Phase 4 as the contingencies reverted. As Figure 6 depicts, aspects of the stimuli uncorrelated with the consequence did not gain control over GA responding, but they gained control over VA responding whose performance was similar to that of most participants in Experiment 2.2.

Figure 6. Trials to criterion for the five phases of Experiment 3.1. Phases 1 and 4, on the left, correspond to the simultaneous discrimination between colors. Phases 2, 3, and 5, on the right, correspond to tests. The dark grey segment of the bars and the numbers within them indicate responses that resulted in points. Numbers within the light grey segment indicate responses that did not result in points.

LA and AN data are odd. Both of them reached criterion in Phase 1, which means that aspects of the stimuli correlated with the consequence gained control over their responding. However, the correlated aspects did not seem to have gained the same control as for GA and VA given that in Phase 4 LA and AN had to learn the discrimination again; there was no reversion. There are two possible ways to explain these results. Both participants might have reached criterion by chance, but the probability of obtaining 12 consecutive points is very low ($P < 0.0002$). The case of AN is more dramatic given that he obtained points during 14 consecutive trials ($P < 0.000006$). It is important to point out that the program in Phases 1 and 4 evaluated criterion based on blocks what implies that the probabilities of obtaining 12 or 14 consecutive points is even lower. Furthermore, the combined probability of two participants obtaining these results is extremely low. None of them reported that the color of the bottom part was the relevant stimulus for obtaining points in Phase 1. AN reported that color was the relevant aspect in Phase 4. LA did not report color as the relevant factor neither in Phase 1 nor 4.

On the other hand, LA and AN responding might have become under a different form or level of control. To say so, a control that they could not put into words and that might be different from the one that occurs when people can describe it verbally. If the computer had presented LA and AN with one only a green square correlated with points and a red square with their absence instead of the images in this experiment, almost certainly, their responding would have been different. Probably, they would have learned the Phase 1 discrimination faster, made the reversion in Phase 4, and put the rule into words. LA and AN performance suggest that the presence under some circumstances, which are still unknown, of uncorrelated aspects may change the way in which the correlated aspects gain control.

3.2 Experiment

Data from Experiment 3.1 showed that aspects of stimuli uncorrelated with a consequence that does not have a human-like form did not gain control over most of the participant's responding. In this experiment, the computer presented in Phases 1, 2, and 3 human-like images and Phases 4 and 5 similar images but in a scrambled format. In all the phases, some aspects of the stimuli correlated with the consequence while other aspects did not. The purpose was to verify if human-like stimuli uncorrelated with a consequence have a greater chance of gaining control over responding than stimuli with the same components that do not have a human like shape. The experiment also evaluated if presenting uncorrelated human-like images before presenting them in a scrambled format affected the acquisition of control of some responding by the no human-like stimuli.

3.2.1 Method

3.2.1.1 Participants

Five postgraduate female students from the experimental psychology program of the University of Sao Paulo, LA, AL, RE, RA, and CA (ages 18, 22, 32, 26, 12), volunteered to participate in this experiment. They did not receive money or any other benefit for their participation.

3.2.1.2 Instruments, setting, and procedure

The general procedure was very similar to that of Experiment 3.1. The setting, instructions, and stimuli differed. Each participant worked alone in a single session in an

office-size room, 2.5m x 5m, located in the Fred Keller lab of the Institute of Psychology at the University of Sao Paulo. Four desks with computers on them occupied the room dividing it in two sections. The section in which the participants worked had a desk and a chair. An HP Pavilion computer (Windows 7), which had a 22" color monitor Samsung SyncMaster T220m, presented the images and recorded the participants' responses with the Visual Basic program from Experiment 3.1. Participants sat at approximately 60 centimeters from the monitor, and the keyboard was not available to them. Stimuli included some of those from Experiment 3.1, but in this experiment the computer presented them in a human-like form (see Table 4). Instructions were the same that in Experiment 3.1 but in Portuguese.

Table 4

Images used in each one of the five experimental phases in experiment 3.1. Each number indicates an image. Numbers with subscript indicate scrambled images.

Phase	1(Training)		2(Test)		3(Baseline)		4(Training)		5(Test)	
Consequence	S+	S-	S+	S-	S+	S-	S+	S-	S+	S-
Pants' Color	Green	Red	Black		Black		Red	Green	Black	
Stimuli	1-4		1-4	5-8	9-12	13-16	17 _s -20 _s		17 _s -20 _s	21 _s -24 _s

3.2.2 Results and discussion

Experiment 3.2 evaluated if human-like stimuli uncorrelated with the consequence gained control over the participant's responding in Phases 1 and 4. Results show that as in Experiment 2.2, uncorrelated aspects gained control of some responding when the stimuli have a human shape. In this experiment, as Figure 7 shows, stimulus features correlated with the consequence did not gain control over responding response for four of the five participants. The correlated aspects gained control only over LA responding. Uncorrelated

features gained control over AL, RE, RA, and CA responding in Phase 1 as their performance in Phases 2 and 3 demonstrate. Correlated aspects acquired control over all participants responding in Phase 4 just as in Phase 1 of Experiment 3.1, in which the computer presented scrambled images. Uncorrelated aspects gained control in Phase 4 for four of the five participants as well as their performance in Phase 5 shows.

Data from this experiment contrast with those of Experiment 3.1 in relation to control by scrambled images. In Experiment 3.1, the scrambled images did not gain control over most of the participants responding. In this experiment, the scrambled images controlled the responding of RE, RA, and CA. Participant's performance in Phase 5, with the exception of LA, indicates that the scrambled images acquired control in Phase 4. It seems as if presenting human-like shape in Phase 1 facilitated control by scrambled images in Phase 4. As a matter of fact, all participants reported that the scrambled images corresponded to human-like ones.

Figure 7. Trials to criterion for all the Experiment 3.2 phases. Discrimination training, Phases 1 and 4, is on the left. Test, Phases 2, 3, and 5, are on the right. The dark grey segment of the bars and the numbers within them indicate responses that resulted in points. Numbers within the light grey segment or above them indicate responses that did not result in points.

3.3 Experiment

Data from Experiment 3.2 demonstrated, first, that aspects of human-like stimuli uncorrelated with the consequence have a greater chance of gaining control over responding than scrambled images and of hindering the acquisition of control by correlated features. Furthermore, they showed that presenting human-like shapes first and scrambled images later seems to increase the odds that the scrambled images gain control. The purpose of this experiment was to confirm the role of the shape of the stimuli and evaluate the third conclusion from Experiment 3.2. In this experiment, the computer presented in Phases 1, 2 and 3, scrambled images and in Phases 4 and 5 human-like images.

3.3.1 Method

3.3.1.1 Participants

Two female, AD and VA (ages 28 and 22), and two males, SE and JA (ages 22 and 30), students from different programs of the University of Sao Paulo volunteered to participate in this study. They did not receive money or any other benefit for their participation in the experiment.

3.3.1.2 Instruments, setting, and procedure

The general procedure was identical to that of Experiment 3.2. Only the stimuli that the computer presented in each phase differed as Table 5 shows.

3.3.2 Results and discussion

Like in Experiments 3.1 and 3.2, trials to criterion in each phase were the relevant

data. As Figure 8 depicts, all participants learned all the discriminations in Phases 1 and 4. These findings contrast with those from Experiment 2.2 and Experiment 3.2 in which most participants did not learn the discrimination when the computer presented stimuli in human format. In Phase 2 in this experiment, the computer presented human-like images and all the participants learned the discrimination. As with Experiment 3.1 and Phase 1 of Experiment 3.2, most participants responding did not become under uncorrelated features control. These findings suggest that presenting scrambled images in Phase 1 facilitated the Phase 4 discrimination with human-like shapes, but did not facilitate control with uncorrelated aspects of the stimuli. JA's performance was similar to that of AN and LA in Experiment 3.1 probably for the same reasons.

Table 5

Images used in each one of the five experimental phases in Experiment 3.3. Each number indicates an image. Number with subscript

Phase	1(Training)		2(Test)		3(Baseline)		4(Training)		5(Test)	
Consequence	S+	S-	S+	S-	S+	S-	S+	S-	S+	S-
Pants' Color	Green	Red	Black		Black		Red	Green	Black	
Stimuli	1 _s -4 _s		1 _s -4 _s	5 _s -8 _s	9 _s -12 _s	13 _s -16 _s	17-20		17-20	21-24

Figure 8. Trials to criterion for all the phases of Experiment 3.3. Figure conventions are identical to images 2 and 3.

3.4 General discussion

The present experiments had two objectives. First, they evaluated if the shape of visual stimuli with components that correlate and do not correlate with the consequence influence the establishment of control by the correlated components. Second, they evaluated if the shape of the components affects the probability of the uncorrelated components of gaining control over responding. Previous experiments (Andrade-Mescouto, 2011 and

Experiments 2.1 and 2.2) had demonstrated control by features of stimuli uncorrelated with the consequence when the stimuli had a human shape. In the present experiments, a computer presented stimuli with the same components in human and a non-human shape. Altogether, the results of these experiments demonstrate that the shape of stimuli with aspects that correlate and do not correlate with a consequence have dramatic effects on the features that will gain control over responding. On one hand, when the uncorrelated aspects have human format, they may hinder the establishment of control by the correlated ones. On the other hand, aspects of stimuli uncorrelated with the consequence have a greater chance of gaining control over responding when they are in human format than when they are not.

The shapes of stimuli might prevent aspects correlated with the consequence from gaining control over responding. When human-like stimuli have components that correlate and do not correlate with the consequence, the uncorrelated components hinder the establishment of control by the correlated ones. The images that Andrade-Mescouto (2011) used and those from Experiments 2.1 and 2.2 had a small part correlated with reinforcement: The colors of the pants. In relation to the image as a whole, the pants were a small fraction. Consequently, one could argue that in the experiments by Andrade-Mescouto and Experiments 2.1 and 2.2, factors as the size and position of the correlated component might have prevented the correlated portions from gaining control over responding. However, in the present experiments, the computer presented participants with images in human format and also with scrambled images so that the images in human and non-human format had the same components. In Experiment 3.1, the images did not have a human shape, and all the participants learned the discrimination in Phases 1 and 2. In Experiment 3.2, the computer presented images in human shape in Phase 1 and the same scrambled images in Phase 4. In contrast with Experiment 3.1, only one participant learned the Phase 1 discrimination.

Nevertheless, stimuli that do not have a human shape may also affect the

establishment of control by the correlated aspects. Data from two participants seem to demonstrate that the scrambled images hampered the correlated aspects from gaining control in Phase 4. The performance of these two participants (LA and AN) is difficult to interpret. They reached criterion in Phase 1, but LA did not learn the Phase 4 discrimination, and AN took a lot more of trials in Phase 4 than Phase 1 to reach criterion. As discussed above, it is highly unlikely that they had reached criterion in Phase 1 by chance. Participant JA from Experiment 3.3 had a similar performance, but in Experiment 3.3, the computer presented in Phase 1 scrambled images and in Phase 4 the same image in human format. JA had 15 consecutive right responses ($\chi^2(1)$, $p=0.000$). LA, AN, and JO responding showed an atypical pattern. The pattern of responding of LA, AN, and JA had four characteristics. First, they learned the Phase 1 discrimination in a relatively few trials. Second, they did not learn the Phase 4 discrimination or took relatively too many trials to reach criterion. Third, aspects of the stimuli uncorrelated with the consequence did not gain control over their responding. Fourth, they were responding to stimuli in non-human format. This pattern did not appear in Andrade-Mescouto's (2011) data or in Experiments 2.1 and 2.2. Reaching criterion in Phase 1 implies that one of the components correlated with the consequence gained control over responding. The responding of a participant might have become under control by the green pants – the positive stimulus– but not under control by the negative stimulus. Another participant might have become under control by the negative but not the positive stimulus.

AN and JO had to learn the Phase 4 discrimination from the beginning. LA did not learn it at all. Restricted or incomplete control is a possible explanation for these results (see, for instance, Grow, LeBlanc, & Carr, 2010). Cipani (2012) argued that incomplete stimulus control appears in tasks involving “multiple discriminative elements within a compound stimulus.” (p. 10). According to Cipani (2012), “If the learner has a history of only attending to one element within a compound stimulus presentation, a consistent error pattern would

develop” (p. 10). The pattern is overselectivity. A controlling stimulus relation describes better the attending to which Cipani refers (see Ray, 1969; Skinner, 1953). In strict stimulus control terms, one can argue that if an element of a compound gained control of responding, other elements may not gained it at all. As Dube, Dickson, Balsamo, O’Donnell, Tomanari, Farren, Wheeler, and McIlvane (2010) argued,

A number of factors may be related to restrictions in the range, breadth, or number of controlling stimuli. In normally capable humans, these factors include the number of stimuli or relevant stimulus features, increase in task difficulty, requirements for rapid responding, or some concurrent and distracting activity. (p)

It seems as if only one of the correlated aspects had gained control of LA, AN, and JO responding in Phase 1, and that the same aspect kept controlling most or part of their responding in Phase 4. Certainly, if LA, AN, and JA had been choosing between a green (S+) and red (S-) squares, they would have learned the discrimination in fewer trials. They would have also become under positive control by the former negative stimulus in a reversal condition in just a few trials. The fact that aspects uncorrelated with the consequence did not gain control over LA, AN, or JA responding support the ideas that they became under control by one the relevant features.

In relation to control by aspects of the stimuli uncorrelated with the consequence, data from the present experiments show clearly that components of stimuli uncorrelated with the consequence in human format have a greater chance of gaining control over responding than the same scrambled stimuli. Andrade-Mescouto (2011) had found that most of the participants in her experiment recognized the aspects of the images that did not correlate with the consequence, which indicates that the uncorrelated aspects had gained control of her participants’ responding. Similarly, data from Experiment 2.2 show that the uncorrelated features of the stimuli had gained control over all their participants’ responding in Phase 1

and of some of them in Phase 4. Both in Andrade-Mescouto and Experiment 2.2, the stimuli had human format. In Experiment 3.1, the stimuli were not in human format in any phase. In Experiment 3.3, the stimuli were not in human format in Phases 1, 2, and 3. There was evidence of control by uncorrelated aspects for only one of the participants from Experiment 3.1 and for two participants from Experiment 3.3. These results contrast with those from Experiments 2.1 and 2.2 and those from Experiment 3.2, in which all the participants' responding became under control by features of the stimuli uncorrelated with the consequence.

Nonhuman shapes may also gain control as VA data from Experiment 3.1 and SE and AD from Experiment 3.3 show. Similarly, not always human shapes gain control as LA data showed in Experiment 3.2. Uncorrelated aspects of nonhuman images gained control of the responding of three participants in Experiment 3.2. Presenting human-like images in the first phases facilitated the acquisition of control by the scrambled images. As the scrambled images had the same components that the human-like images, participants kept responding to them as if the images had human format. For instance, while the participants in Experiment 3.1 did not report any particular characteristic of the images, participants of Experiment 3.2, reported that in Phase 4, they responded to the hair, eyes, or shirt of the scrambled images. They kept responding to the scrambled images as if the images had human format.

Human shapes may have a greater chance of gaining control in experiments like these precisely because they are humans. From the beginning of any experiment, participants are already responding to something. They bring a complete behavioral repertoire to the experimental situation. Certainly, participants must have sensory and verbal responses. The probability of sensory contact with each possible source of stimulation is hardly equal. From the beginning, some stimuli have a greater chance to control sensory responses than others. Undoubtedly, a participant must have more sensory contact with the computer in the room

than with any other piece of furniture. Once the experiment begins, most sensory contact must be with what is on the computer's screen. In the experiments by Andrade-Mescouto (2011), Experiments 2.1 and 2.2, and Experiments 3.2 and 3.3, the computer presented human-like images. Participants reported that they had looked for clues to respond in the images' faces at the beginning of the experiment. Later, they tried other clues such as hairstyle or clothing.

Although control by the irrelevant features of stimuli in human format is more likely than in non-human format, irrelevant aspects of stimuli in non-human format might also gain control over responding. There was evidence of control by aspects of the stimuli uncorrelated with the consequence for participants VA from Experiment 3.1 and SE and AD from Experiment 3.3. Other properties besides the arrangement of the stimuli might lead to control by irrelevant features. It is necessary evaluating control by aspects of the stimuli uncorrelated with the consequence with other stimuli.

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APPENDIX

All the images used in the experiments of Chapter 3

CHAPTER 4

Stimulus Control by Aspects of Visual Stimuli Uncorrelated With the Consequence as

Function of the Proximity of Their Components

Introduction

Some portions of the environment in which reinforcement occurs correlate with the consequence while other portions do not correlate. The correlated portions gain control of the reinforced response depending on the initial, setting conditions as data from Experiments 2.1, 2.2, 3.1, 3.2, and 3.3 show. One of the initial conditions affecting the establishment of control by the correlated portions is the number of stimuli in the situation (Shahan & Podlesnik, 2008). The more components, features, or dimensions of the stimuli in the situation, the more trials require the correlated parts for gaining control over the response (Cowan, 1968). Besides the number of components in the situation, other factors affect the establishment of control by portions uncorrelated with the consequence. Data from Experiments 3.1, 3.2, and 3.3 show that uncorrelated aspects of stimuli with a human-like shape have a greater chance of gaining control than the same stimuli with their components scrambled, which implies that the configuration or arrangement of the stimuli may affect the establishment of control by the correlated and uncorrelated portions.

In Experiments 3.1, 3.2, and 3.3, the visual stimuli appeared in human format and the same images in a scrambled arrangement. The images in human format were characters based on the South-Park television series. The participants had visual simultaneous discrimination tasks in which portions of the stimuli correlated with the consequence and categorization tasks served to evaluate control by features of the stimuli uncorrelated with the during the discrimination tasks. When the images were in human format, the colors of the pants were the portion that correlated with the consequence. When the images were in the scrambled format, the colors of the bottom parts were the part that correlated with the consequence. In each categorization task, the participants had to discriminate between the images that had appeared in the previous simultaneous discrimination task and new images. In the categorization task,

the computer presented the images with pants or bottom parts in black color so that the images lacked the aspect that correlated with the consequence in the discrimination task.

In Experiment 3.1, the computer presented participants only with images in scrambled format. In Experiments 3.2 and 3.3, the computer presented scrambled images first and images in human format subsequently, and other participants with images in human format first and scrambled images subsequently. Altogether, data from Experiments 3.1, 3.2, and 3.3 demonstrate that portions uncorrelated with the consequence have a greater chance of gaining control over responding when they are part of human-like shapes than when they are not. In human format, they also hindered or completely prevented the correlated parts from gaining control over the reinforced response. Although human-like images had a greater chance of gaining control over responding, the scrambled images also controlled the responding of a few participants. Hence, features of non-human shapes uncorrelated with the reinforcer might also acquire control of responding. The distance between the components of the stimuli might have had an effect. Most of the scrambled images in Experiments 3.1, 3.2, and 3.3 had a little space between them. In contrast, there were no spaces between the components of the images in human format. Participants might have responded to images without spaces between their components as a unique stimulus and to each component of images with spaces components as individual stimuli.

Some research has shown that human and nonhuman animals respond to stimuli that constitute a configuration as a whole. Human faces exemplify such stimuli. To discriminate one face from another, it is necessary to attend to a minimum set of points in the face (Cerella, 1980; Gibson, Wasserman, Gosselin, & Schyns, 2005), which implies that different sets of aspects of a face gain control over responding. When the images had a human shape in Experiments 2.1, 2.2, 3.2, and 3.3, participants might have responded to them as wholes at the beginning of the discrimination phases. Some participants might have remained under

control of the whole while other participants became under control of the relevant portion of the stimuli. When the stimuli were in scrambled format, participants might not have responded to them as wholes.

Research on visual attention suggests the influence of Gestalt principles in the establishment of control by visual stimuli over an operant response. As attention and stimulus control are synonyms (Ray, 1969; Skinner, 1953; Vyazovska, Teng, & Wasserman, 2014), if Gestalt principles regulate attention, they might be describing a form of stimulus control of sensory responding. In relation to visual stimuli, the grouping of elements is one of the most important Gestalt principles (Palmer, & Brooks, 2008; Palmer, Brooks, & Nelson, 2003). According to the grouping principle, human and non-human animals respond to objects in the visual field as a set of stimuli or as a single, compound stimulus depending on factors like their similarity and proximity (Kohler, 1970). Kerzel, Born, and Schönhammer (2012) found that people attend to geometrical shapes that are close to each other in such a way that distractors do not catch their attention. They concluded that people attend to configurations that result from perceptual grouping rather than to independent locations. In stimulus control terms, certain configurations of visual stimuli result in different responding patterns.

To evaluate stimulus control resulting from the grouping of elements, one must use stimuli other than those in Experiments 2.1, 2.2, 3.1, 3.2, and 3.3. Simpler, geometrical shapes are better. The purpose of this study was twofold. On one hand, the experiments evaluated if aspects uncorrelated with the consequence of stimuli other than those from Experiments 2.1, 2.2, 3.1, 3.2, and 3.3 also acquired control of the participant's responding. In the present experiments, the stimuli were colored squares that formed a cross, which were far simpler than the human shapes that had been the stimuli in all the other experiments that this dissertation reports. Finding control by stimuli with a non-human shape would demonstrate that the phenomenon extends to other visual stimuli. It would also demonstrate

that other factors besides the human shape produce control by portions of the environment uncorrelated with the consequence. On the other hand, the experiments assessed if the space between the components of the stimuli had some effect on the establishment of control by features of the stimuli uncorrelated with the consequence. In some conditions, the squares touched each other by their corners. In others conditions, there was space between them. Participants should respond differentially to crosses formed by squares in contact with each other than to crosses formed by squares with distance between them. As people respond to visual stimuli that are close together as a single object, it is possible that the components uncorrelated with the consequence of the crosses formed by squares touching each other by their corners than by squares with spaces between them.

4.1 Experiment

Experiment 4.1 assessed control by aspects uncorrelated with the consequence with a recognition test like the one that Andrade-Mescouto (2011) used. In Phase 1, participants had a discrimination task like the one in Phase 1 in Experiments 2.1, 2.2, 3.1, 3.2, and 3.3. In Phase 2, participants had the recognition test. Instead of using human-like images or their scrambled versions as Andrade-Mescouto (2011) had done, colored squares that formed crosses were the stimuli. In one condition, the colored squares touched each other by the corners (United Squares). In other condition, the squares had a space between them (Separated Squares). Control by components uncorrelated with the consequence as function of the proximity between them would demonstrate that the environmental arrangement influences the establishment of stimulus control.

4.1.1 Method

4.1.1.1 Participants

Twenty-eight undergraduate students of the National University of Colombia from the psychology and Nutrition programs participated in the experiment ($M_{\text{age}} = 22.2$, age range = 18-40). They volunteered after an invitation by their course's professors. They did not receive money or any other benefit for participating in the experiment.

4.1.1.2 Instruments and setting

All volunteers worked individually in a Gesell chamber located at the Attention Psychological Center of the National University of Colombia. Participants worked alone in the room to observe people. The experimenter and his assistants remained in the room at the other side of the mirror so that they could observe the participants without disturbing them. A laptop Lenovo computer with Windows 8 presented the stimuli and recorded the participant's data. A 22" HDTV Monitor and an external mouse were connected to the laptop. The stimuli appeared in the monitor. Participants responded using the external mouse. Three armchairs, a desk, and two chairs were inside the chamber. The three armchairs were in a corner of the room. The monitor and mouse were on the table that was in front of the mirror. Participants sat in a chair in such a way that their backs were against the mirror. The laptop was on the other chair that was by the side of the table out of reach for the participants.

A custom program in Visual Basic 2010 presented the stimuli and collected the participant's responses. The stimuli were two sets of images (see Figure 9, see all the images for the experiments of this chapter in the Appendix). In Phase 1, the computer presented a set of four images composed of four squares that formed a cross. According to the condition, the

squares touched each other by their corners or were 1 Cm distant from each other (see Figure 9A). Each cross in one version had a green bottom square and in another, a red bottom square. In Phase 2, the computer presented a set of 16 images that included those of Phase 1. They were like the ones in Phase 1 but without the bottom square so that three squares composed each image. Again, depending on the condition, the squares touched each other by their corners or were slightly apart from each other. Participants responded by clicking directly on the images on the screen with the left button of the mouse.

4.1.1.3 Procedure

The experiment had two conditions and phases. Each condition corresponded to one of the two experimental groups: United Squares Group (USG) and Separated Squares Group (SSG). Stimuli for the USG were the squares in which the corners of the squares touched each other. The stimuli for the SSG were the same shapes but separated for 1 cm space (see Figure 9A). Phase 1 was a simultaneous discrimination task between the colors of the bottom squares. Phase 2 was a recognition test. In Phase 1, the computer selected and presented pairs of images at random without replacement from the set of four images as in Experiments 2.1, 2.2, 3.1, 3.2, and 3.3. The bottom square of one image was always green, and the bottom square of the other, red. The pairs of images on the screen were always different (see Figure 9B). The colors of the bottom square, red or green, was at random.

Participants worked in a single session. On arrival, the researcher or one of his assistants assigned each participant to one of the experimental conditions at random, fed the program with the participant's age and gender, asked each participant to read and sign a consent form, and read along with them the instructions on the screen. The instructions, in Spanish, were:

“In the first phase of this experiment, which has two phases, your task is to always earn points. When you earn one point, a +1 will appear on the screen. If you have any

question, call the experimenter. Otherwise, click the button below to begin. In case you need any assistance during the experiment, please call the experimenter or one his assistants”.

A

B

C

En la fase anterior aparecían
cuatro cuadros. Ahora
aparecen los tres cuadros
que iban en la parte superior.
¿Vio esta combinación de
cuadros en la fase anterior?

Sí

No

Figure 9. Examples of images used in Experiments 4.1, 4.2, and 4.3. A) Colored squares separated from each other. B) Colored squares joined by their corners. C) A sample of a trial

in the recognition test of Experiment 4.1.

Trials for both groups were identical. For participants of both groups on each trial, one click with the mouse left-button on any part of the images removed both images from the screen and produced the consequence. One click on the image with the bottom green square produced a plus sign along with a number one (+1) that remained one second on the center of the screen right below and between the two images. A click on the image with the bottom red square produced a zero (0). The Inter Trial Interval (ITI) was of one second, Participants went to Phase 2 by responding without errors during three blocks consecutively (12 trials). If a participant did not reach criterion after 450 trials, the program ended Phase 1 and started Phase 2.

In Phase 2, all participants had a recognition task. The computer presented one by one the 16 images from the second set on the center of the screen along with yes and no buttons and text on its right side. The text said in Spanish: “Images composed of four squares appeared in the previous phase. Now you will see only images with the three upper squares. Did you see this combination of squares in the previous phase?” A mouse click on any button removed the images from the screen. The instructions remained all the time on the screen until the end of the experiment. After a 1.0 sec ITI, the computer presented a new image. The computer repeated the process until the 16 images appeared in randomized order. After the last image, the program produced a message box that instructed the participant to call the researcher. Finally, the computer opened a text box and produced the following text in Spanish: “Please, write a brief explanation of the procedure that you used to obtain points in the text box that is on the computer’s screen.” After the participants had written or explained their responses, the experimenter or one of his assistants debriefed them.

4.1.2 Results and discussion

The number of trials to criterion in Phase 1 and images recognized in Phase 2 were the relevant data. All participants completed the experiment. Right answers in the recognition test measured indirectly if participants of both groups had attended to aspects of the images uncorrelated with the consequence in Phase 1. In other words, right answers indicated if the uncorrelated images had gained control of responding. A right answer was to select the YES button when an image had appeared and the NO button when it had not. A wrong answer was to select the YES button when the image had not appeared and the NO button when it had. As participants could produce a number of right answers just by chance, a Chi Square Tests defined a p value for the responses of each participant in the recognition test.

Most participants learned the discrimination of Phase 1, and all showed recognition above chance level. In relation to the number of trials to reach criterion, there was no statistically significant difference between groups in Phase 1 ($t(26) = -6.46$, $p=0.05$), which means that the distance between the components of the stimuli did not affect the establishment of control by the components correlated with the consequence. One participant from the UGS and two from the SSG did not reach criterion in Phase 1. Although most participants showed evidence of recognition of the uncorrelated features of the images in Phase 1, there was a clear difference between groups ($\chi^2(1, N=28) = 24.27$, $p=0.000$). With such difference between the groups, one must conclude that the distance between the components had an effect on the participant's performance. Features of the stimuli uncorrelated with the consequence gained much more control of the responding of the SSG participants than of the USG. As Figure 10 depicts, almost all the participants from the SSG recognized most of the sets of squares uncorrelated with the consequence in Phase 1. The SSG participant that recognized the fewest number of items recognized more than the USG participant that recognized the largest number of items.

Figure 10. Number of recognized items for the members of the two experimental groups: united and separated squares. The lines crossing the bars indicate the probabilities of recognizing 12, 13, and 14 items.

4.2 Experiment

Experiment 4.2 assessed control by aspects uncorrelated with the consequence with an operant procedure like that of Experiments 2.2, 3.1, 3.2, and 3.3. In Phases 1 and 4 participants had a discrimination task. In Phases 2, 3, and 5 participants had tests in which they had to discriminate between two sets of stimuli. The components of the stimuli

uncorrelated with the consequence during the discrimination tasks constituted the positive set. New stimuli constituted the other, negative set. In Phases 1, 2, and 3 of the present experiment, the squares touched each other by their corners. In Experiment 4.1, features uncorrelated with the consequence did not gain control over responding so that in the present experiment, irrelevant aspects of the stimuli should not gain control over responding in Phase 1.

4.2.1 Method

4.2.1.1 Participants

Four undergraduate students mostly from the nutrition program of the National University of Colombia enrolled in an introductory course to Psychology participated in the experiment ($M_{\text{age}} = 22.2$, age range = 18-40). They volunteered after an invitation by their professor of the course. They did not receive money or any other benefit for participating in the experiment.

4.2.1.2 Instruments, setting, procedure

Instruments and setting were identical to those from Experiment 4.1. The procedure was identical to the one in Experiments 2.2, 3.1, 3.2, and 3.3. In the present experiment, in Phases 1, 2, and 3, the computer presented images with united squares. In Phases 4 and 5, the computer presented images with separated squares. As Table 6 depicts, the computer presented the first set of images (1_u to 4_u) in Phase 1. In Phase 1, the green bottom-square was the positive stimulus, and the red bottom-square was the negative stimulus.

In Phase 2, the computer presented the old set of images (1_u to 4_u) as the positive stimulus without the bottom square, and a new set of images (5_u to 8_u) as the negative

stimulus. In Phase 3, the computer presented two sets of new images. One set (9 to 12) was the positive stimulus, and the other set (13_u to 16_u) was the negative stimulus. In Phase 4, the computer presented the images (17_s to 20_s). In Phase 4, the red bottom-square was the positive stimulus and the green bottom-square the negative stimulus. In Phase 5, the set of images (17_s to 20_s) was the positive stimulus, and the set of images (21_s to 24_s) the negative stimulus. An important difference with the Experiments 2.1, 2.2, 3.1, 3.2, and 3.3 was that to reach criterion, participants had to obtain 18 points consecutively.

Table 6

Images used in each one of the five experimental phases in experiment 2. The subscript s indicates separated squares. The subscript u indicates united squares. The numbers indicate the name of the image.

Phase	1(Training)		2(Test)		3(Baseline)		4(Training)		5(Test)	
Consequence	S+	S-	S+	S-	S+	S-	S+	S-	S+	S-
Bottom Color	Green	Red	None		None		Red	Green	None	
Stimuli	1 _u -4 _u		1 _u -4 _u	5 _u -8 _u	9 _u -12 _u	13 _u -16 _u	17 _s -20 _s		17 _s -20 _s	21 _s -24 _s

4.2.2 Results and discussion

As in the previous experiments, trials to criterion are the important data. In this experiment, the computer presented four squares arranged as a cross in Phases 1 and 4 in which participants had a discrimination task. In Phase 1, the cross with the green bottom-square was the positive stimulus, and the cross with the red bottom-square was the negative stimulus. As Figure 11 depicts, no participant responded in the first 18 trials to the reverted contingency. Participant SE did not learn the Phase 1 discrimination. Participants VA and AD required about the same number of trials to reach criterion in Phases 1 and 4, which implies

that they had to learn the Phase 4 discrimination anew. Participant HE showed the same pattern that some participants had in Experiments 3.1 and 3.3. He required more trials to reach criterion in Phase 4 than Phase 1. Hence, participants might have been only under control of one of the correlated aspects.

Participant HE learned the Phase 1 discrimination, but he did not reach criterion in Phase 4. As with the participants from the experiments by Clavijo (2014b), features of the stimuli uncorrelated with the consequence did not gain control over his responding. As argued in the discussion of Chapter 3, reaching criterion by chance in the discrimination tasks of Experiments 3.1 and 3.3 was highly unlikely. In Experiments 2.1, 2.2, 3.1, 3.2, and 3.3, participants had to obtain 12 points consecutively for reaching criterion. In the present experiment, participants had to obtain 18 points consecutively, which rules chance out. HE data confirm that under certain circumstances, aspects of the stimuli uncorrelated with the consequence produce an odd pattern in which responding seem to become under control by only one of the two relevant aspects.

There was no evidence of control by aspects of the stimuli uncorrelated with the consequence for any participant. The decreasing number of trials from Phase 2 to Phase 5 demonstrates that the participants' responding was not under control of irrelevant aspects of the stimuli. They learned how to discriminate between the sets of images from test phase to test phase. Results in relation to control by the uncorrelated features are consistent with those from Experiment 1 in which participants from the United Squares Group recognized fewer items than those from the Separated Square Group.

Figure 11. Trials to criterion for Experiment 2. Phases 1 and 4, on the left, correspond to the simultaneous discrimination between colors. Phases 2, 3, and 5, on the right, correspond to tests. The dark grey segment of the bars and the numbers within them indicate responses that resulted in points. Numbers within the light grey segment indicate responses that did not result in points.

4.3 Experiment

Experiment 4.2 assessed control by aspects uncorrelated with the consequence with an operant procedure like the one in Experiments 2.2, 3.1, 3.2, 3.3. Experiment 4.3 was identical, but in Phases 1, 2, and 3, the computer presented crosses formed by separated squares. In Phases 4 and 5, the computer presented crosses formed by united squares. Components uncorrelated with the consequence of crosses formed by separated squares should control responding. On the contrary, uncorrelated components of crosses formed by united squares should not show such control.

4.3.1 Method

4.3.1.1 Participants

Four undergraduate students from the nutrition program of the National University of Colombia enrolled in an introductory course to Psychology participated in the experiment ($M_{\text{age}} = 22.2$, age range = 18-40). They volunteered after an invitation by their course's professors. They did not receive money or any other benefit for participating in the experiment.

4.3.1.2 Instruments, setting, procedure

Instruments, setting, and procedure were identical to those from Experiment 2. The only difference was that in Phases 1, 2, and 3, the computer presented separated squares, and in Phases 4 and 5, united squares. Table 7 depicts the stimuli that the computer presented.

4.3.2 Results and discussion

Again, the number of trials to reach criterion are the important data. Only the responding of participant AD became under control by the relevant stimuli: the green and red bottom-squares (see Figure 12). Nevertheless, as with other participants, AD did not show discrimination reversal in Phase 4. AD took 48 trials to reach criterion in Phases 1 and 2. He reported at debriefing that in Phase 1 he had clicked the green bottom-square, but he did not notice the red-bottom square. In Phase 4, he tested each square again and some relations between the squares until he identified the red bottom-square as the relevant one. In Phase 4, he identified the green bottom-square as the negative stimulus. Participants PA and CA did not learn the Phase 1 discrimination, but they learned the Phase 4 discrimination. Both of them reported that the relevant stimulus in Phase 4 was the red bottom-square. None of them reported any thing about the red bottom-square. Participant LU did not reach criterion in Phase 1 or 4. However, in Phase 1, LU committed too many errors, which suggest a non-random performance. LU reported that she had been responding to a combination of colors. At the beginning of the procedure LU had 9 consecutive right responses. It might be that the combination that LU reported coincided with the points so that she kept responding to them. The responding of two participants, PA and CA, became under control by aspects of the stimuli uncorrelated with the consequence. Neither PA nor CA reached criterion in Phase 1. As observed previously, control by irrelevant features of the stimuli hindered or completely prevented the acquisition of control by the aspects of the stimuli correlated with the consequence. LU did not reach criterion in Phase 2 and 3. It is clear that uncorrelated features did not gain control over her responding in Phase 1. Uncorrelated features did not gain control over AD's responding. AD showed a learning pattern from Phases 2 to 5.

Table 7

Images used in each one of the five experimental phases in experiment 3. The subscript s indicates separated squares. The subscript u indicates united squares. The numbers designate the images.

Phase	1(Training)		2(Test)		3(Baseline)		4(Training)		5(Test)	
Consequence	S+	S-	S+	S-	S+	S-	S+	S-	S+	S-
Pants' Color	Green	Red	Black		Black		Red	Green	Black	
Stimuli	1 _s -4 _s		1 _s -4 _s	5 _s -8 _s	9 _s -12 _s	13 _s -16 _s	17 _u -20 _u		17 _u -20 _u	21 _u -24 _u

Figure 12. Trials to criterion for the five phases of Experiment 4.3. Phases 1 and 4, on the left, correspond to the simultaneous discrimination between colors. Phases 2, 3, and 5, on the

right, correspond to tests. The dark grey segment of the bars and the numbers within them indicate responses that resulted in points. Numbers within the light grey segment indicate responses that did not result in points.

4.4 General discussion

The arrangement of the components of the stimuli was a key factor in determining control by features of the stimuli uncorrelated with the consequence and the number of trials that participants required for reaching to criterion. Components uncorrelated with the consequence of the crosses formed by separated squares gained control over responding while those of the crosses formed by united squares did not gain control over responding. Several issues around these findings require explanation. First, data from the present experiments along with those from Experiments 2.1, 2.2, 3.1, 3.2, and 3.3 demonstrate that features of the stimuli in which a response produces a reinforcer gain control over responding under certain circumstances. Why aspects of the stimuli uncorrelated with the consequence gain control over responding at all? Second, in the present experiments, a rather small difference between the stimuli resulted in a large difference in the participant's performance. Why did participants become under control by irrelevant aspects of crosses formed by separated squares?

Different factors may result in control by irrelevant features of the environment. Experiments from Chapter 3 demonstrated that irrelevant components of stimuli in human format have a greater chance of gaining control over responding than stimuli with the same components in nonhuman format. Certain shapes facilitate control by features uncorrelated with the consequence. Data from the present experiments indicate that the shape of the visual stimuli is not the only factor that result in control by irrelevant features. The arrangement of

the components of certain stimuli also facilitates control by irrelevant aspects of the stimuli. Explaining control when the aspects uncorrelated with the consequence are part of human shapes seems easier than explaining control by the squares in the present experiments. For humans, human shapes are strong stimuli because their biological and cultural importance. It is worth assuming that the initial sensory contact with stimuli in human format differs from the initial sensory contact with other stimuli. A human shape as a whole may control the initial sensory responding. A person might respond to a human shape as an entire stimulus in a first place, or at least, to the sets of features that control in daily bases the responding to human shapes. However, the same argument does not apply to the squares in the present experiments. It would not make much sense arguing that crosses formed by squares distant from each other have a greater chance of controlling initial sensory contact than other stimuli. At the moment, there is not a clear explanation about why the irrelevant features of separated squares gained control of responding.

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APPENDIX

All the images used in the experiments in Chapter 4

CHAPTER 5

General conclusions

General conclusions

This section includes the main conclusions that derive from the data of the experiments in the present dissertation. The presentation in this section is descriptive. An extended, integrative discussion of the data as a whole is not possible at the time.

Conclusion 1. The portions of the environment that correlate with the consequence do not gain control always.

The eight experiments reported in this dissertation demonstrate that the portions of the environment that correlate with the consequence do not gain control over the reinforced response always. The experiments in this dissertation encompassed three types of tasks. All the experiments included at least one phase with a simultaneous discrimination task. Most of the experiments involved categorization tasks to evaluate the control that features of the stimuli uncorrelated with the consequence might have acquired during the simultaneous discrimination tasks. Finally, one of the experiments contained a recognition task. In none of the experiments, the correlated portions of the stimuli in the simultaneous discrimination task gained control over the responding of all the participants in the experiment. In contrast, in the experiments that had categorization tasks, the relevant stimuli gained control over most of the participants' responding. In some experiments with categorization tasks, the relevant stimuli gained control over the responding of all the participants in the experiment.

The gaining of control by the correlated portions changed in function of the arrangement of the stimuli. The stimuli had human format in Experiments 2.1 and 2.2 in all the phases and in Experiment 3.2 in Phase 1. In these experiments, the stimuli in the

categorization tasks had by far a greater chance of gaining control than the portions of the stimuli in the simultaneous discrimination tasks. The stimuli in all the phases of Experiments 3.1 and Phase 1 of Experiment 3.3 had the same components that the stimuli in human format but in a scrambled arrangement. In these experiments, the stimuli in the categorization task still had a greater chance of gaining control than the portions of the stimuli in the discrimination task. However, the overall chance was lesser than in Experiments 2.1, 2.2, and 3.2. Finally, in the experiments of Chapter 4, the portion that correlated with the consequence had a greater chance of gaining control over responding than the stimuli in the categorization tasks. The stimuli of the experiments in Chapter 4 were simpler than those in the other experiments.

Conclusion 2. The portions of the stimuli uncorrelated with the consequence affected the acquisition by the correlated portions.

In these experiments, the computer presented participants with two types of stimuli. In the simultaneous discrimination tasks, the stimuli were compounds that had a portion that correlated with the consequence while the other portions did not correlate. In the other tasks, the stimuli were sets of compounds in which all the components correlated with the consequence or that produced no consequence at all. In general, participants required more trials to reach criterion, or they did not reach it at all when a portion of the compound correlated with the consequence. In contrast, virtually all of the participants reached criterion in fewer trials when all the components of the stimuli correlated with the consequence.

If the stimuli in the simultaneous discrimination tasks had consisted of simpler shapes, the performance of the participants would have been very different to the one

that they showed in these experiments. If the stimuli had been two colored rectangles, participants would have reached criterion in a few trials. The color in which presence participants produced points would have become the positive stimulus, and the color in which presence participants did not produce them would have become the negative stimulus. Participants would have been able to report how to produce points. Finally, if the contingencies reverted, the participants would have reverted their responding as well. The mere presence of other elements that did not correlate with the consequence resulted in a very different pattern of responding. All the participants required more than a few trials to reach criterion. For some participants, the two stimuli correlated with the consequence did not acquire their positive or negative function. Some of the participants who reached criterion could not put in words what they had to do to obtain points. Finally, most of the participants that reached criterion in a discrimination task did not show reversion when the contingencies reverted. Clearly, the presence of components uncorrelated with the consequence affected the establishment of control by the correlated components.

The probability that the correlated portions gained control over the participant's responding depended on the characteristics of the compound stimuli. When the compound stimuli were in human format in Phase 1 – Experiments 2.2 and 3.2–, the probability that the correlated portions gained control over responding was lower than with abstract geometrical shapes with the same components – Experiments 3.1 and 3.3. In turn, when more simple geometrical shapes composed the compound, the correlated portions had a greater chance of gaining control. In particular, the experiments that Chapter 4 describe show that the arrangement of the components of the stimuli in which presence a response produces a consequence affect the establishment of control by the relevant components. Data from the experiments in Chapter 4 suggest a

differential control by visual stimuli depending on their configuration in such a way that some of the principles that the Gestalt psychology have proposed. For instance, all else equal, grouped objects may control responding in a different way than the same ungrouped objects.

Conclusion 3. Portions of the stimuli uncorrelated with the consequence may gain control over responding.

Portions of the stimuli uncorrelated with the consequence gained control in some of the experiments that this dissertation reports. Components of stimuli in human format had a greater chance of gaining control over responding than the same stimuli with their components scrambled. Components of crosses formed by colored squares gained control over the participants' responding when the squares had spaces between them and not when they touched each other by their corners. Altogether, these results demonstrate that the arrangement of the stimuli in which presence a response produces a consequence affects the establishment of control by irrelevant components of the stimuli. Data from the experiments in Chapter 4 suggest a differential control by visual stimuli depending on their configuration in such a way that it would be worth evaluating some of the principles that the Gestalt psychology have proposed. For instance, all else equal, grouped objects may control responding in a different way than the same ungrouped objects.

As Experiments 2.1, 2.2, 3.1, 3.2, and 3.3 showed, the arrangement of the components of the stimulus in which presence a response produces a consequence may result in control by the components of the stimulus uncorrelated with the consequence. When they have a human shape, the chance that irrelevant components gain control

over responding is greater than when they do not have a human shape. Altogether, experiments from Chapter 4 show that certain configurations facilitate the gaining of control by irrelevant components of stimuli. In Chapter 4, components of crosses formed by squares that touched each other by the corners uncorrelated with the consequence did not gain control over responding. When there was space between the components, the irrelevant squares gained control.

Conclusion 4. Control gained by features of the stimuli uncorrelated with the consequence may hinder or completely prevent that the correlated features gain control.

In particular, data from Experiments 2.1, 2.2, 3.1, 3.2, and 3.3 show that when the uncorrelated features of the stimulus in which presence a response produces a consequence gain control over responding, the correlated features may not gain control of the reinforced response. However, this data assertion requires confirmation, and it does not always happen. Data from the experiments in Chapter 4 show that stimuli uncorrelated with the consequence may gain control over responding and not to prevent the gaining of control by the correlated portions of the stimuli.