Orienting Response Reinstatement and Dishabituation: The Effects of Substituting, Adding and Deleting Components of Nonsignificant Stimuli

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ABSTRACT

This study examined the prediction that stimulus novelty is negatively related to the measure of common features, shared by the stimulus input and representations of preceding events, and positively related to the measure of their distinctive features. This prediction was tested in two experiments, which used sequences of nonsignificant verbal and pictorial compound stimuli. A test stimulus (TS) was presented after 9 repetitions of a standard stimulus (SS), followed by 2 additional repetitions of SS. TS was created by either substituting 0, 1, or 2 stimulus components of SS (Experiment 1), or by either adding or deleting 0, 1, or 2 components of SS (Experiment 2). The dependent measure was the electrodermal component of the OR to both TS (OR reinstatement) and SS that immediately followed TS (dishabituation). The results of Experiment 1 supported the predictions that substituting components of neutral stimuli affects OR reinstatement, and that between-categories substitution has a larger effect than within-categories substitution. Experiment 2 demonstrated that, both adding and deleting components of neutral stimuli affects OR reinstatement with no differences between these two manipulations.

Descriptors: Orienting Response, Dishabituation, Stimulus Novelty, Feature-matching Theory, Skin Conductance Response

INTRODUCTION

A great deal of research efforts have been devoted to the study of Orienting Responses (ORs) and habituation processes since the early work of Sokolov (1963, 1966). The concept of the orienting reflex was introduced originally by Pavlov (1927) to describe the reflex which brings about an immediate response (both behavioral and physiological) to the slightest change in the environment. The definition of the OR as a response to a change in stimulation implies that repeated presentations of the same stimulus would result in a gradual decline in response magnitude. Such a pattern was termed "habituation".

Siddle (1991) classified the theoretical approaches, proposed to account for orientation and habituation, into two categories: (a) comparator, or two-stage theories, which postulate that ORs reflect the mismatch between stimulus input and expectations; and (b) noncomparator, or one-stage theories. After reviewing the results of many studies, Siddle (1991) concluded that the noncomparator approaches can be ruled out. The comparator theory, which dominated OR literature, was proposed by Sokolov (1963), who postulated that repeated presentations of a given stimulus result in an internal representation of that stimulus input. This representation, termed as the "neuronal model" by Sokolov, contains the parameters of the stimulus. All input information is compared with the existing neuronal models and a mismatch between stimulus input and the models results in an orientation reaction. If the input matches an existing model, OR is inhibited. Sokolov's approach led to extensive research, which generally produced confirmatory results (e.g., Corman, 1967; Zimny & Schwabe, 1965), although some discrepancies were also observed (e.g., Barry, 1982; Furedy, 1968).

Sokolov (1963) proposed that ORs are determined by a comparator (match-mismatch) mechanism, but no attempt was made by him or by his followers to specify the nature of this mechanism. If, indeed, ORs are determined by stimulus novelty, then there ought to be some mechanism for making distinctions between novel and non-novel stimuli, or assessing the degree of novelty contained in any given stimulus. This lack of specification of the comparator model has led to some confusion in the literature regarding the necessary and sufficient conditions for orientation. The conventional interpretation of Pavlov (1927) and Sokolov (1963) suggests that any perceived change in stimulation is sufficient to produce an orientation reaction. This, however, does not seem very plausible in light of the great variability of our natural environment. A mechanism, which produces an orientation to the slightest change in stimulation, would not be functional.

Indeed, with the accumulation of research data, more and more instances were reported in which a change in stimulation failed to evoke an OR (e.g., Bernstein, 1969; Furedy, 1968; Houck & Mefferd, 1969; Zimny, Pawlick, & Saur, 1969). It is difficult to determine whether these instances should be interpreted as refutations of Sokolov's theory, because it is not clear whether a given change in stimulation was insufficient to create an orientation, or whether the fact that it did not produce a response is an indication that the whole comparator approach is invalid.

An attempt to account for the cases where stimulus change failed to produce an orientation was based on the notion that stimulus novelty in itself is insufficient for OR elicitation, and some level of significance is necessary. This hypothesis is consistent with the idea that a mechanism that produces an orientation to the slightest change in stimulation is implausible because it is not functional. For example, Bernstein (1969, 1979) argued that novelty (i.e., a change in stimulus input) per se is not a sufficient condition for OR elicitation. He further proposed that stimulus significance is an additional and necessary condition for OR elicitation by a change in stimulation. Similar arguments were made by Maltzman (1977) and by Naatanen (1979).

Gati and Ben-Shakhar (1990) attempted to specify the nature of the comparator mechanism, and proposed algorithms for assessing the two critical factors in OR elicitation -- stimulus novelty and significance. They adopted the contrast model proposed by Tversky (1977) to account for OR elicitation, and assumed that both stimulus inputs and stimulus representations (neuronal models) can be characterized by sets of features. It was further assumed that OR elicitation is determined by two independent factors -- stimulus novelty and stimulus significance, and that the assessment of each factor is carried out by a separate feature-matching process.

Thus, the feature-matching approach departs from Sokolov's theory by proposing two separate comparator mechanisms, one for assessing stimulus significance, and one for assessing stimulus novelty. While novelty is negatively related to the degree of match between the input and the activated neuronal models (as hypothesized by Sokolov), the level of significance is positively related to the degree of match between the input and representations of previous significant events. This theory postulates that both comparator mechanisms are underlied by feature-matching algorithms, such that match is positively related to the measure of common features of the input and representations, and negatively related to the measure of distinctive features (for a more detailed description of the model, see Gati & Ben-Shakhar, 1990). The outcomes of the two matching processes are then integrated to produce an OR, which is monotonically related to both significance and novelty.

The feature-matching theory for OR elicitation and generalization has been examined in a series of studies (Ben-Shakhar, 1994; Ben-Shakhar & Gati, 1987, 1992; Ben-Shakhar, Gati & Salamon, 1995; Gati & Ben-Shakhar, 1990; Gati, Ben-Shakhar & Avni-Liberty, 1996; Gati, Ben-Shakhar & Oren, 1986). These studies, which examined several predictions, derived from the feature-matching approach, focused particularly on the stimulus-significance factor. In general, findings supported the hypothesis that the electrodermal component of the OR is positively related to the degree of match (measured by common and distinctive stimulus components) between the input and the representation of significance. All these studies used a variation of the Guilty Knowledge Technique (GKT), where a specific stimulus is singled out as relevant or significant. (e.g., Lykken, 1959, 1960).

Even the few studies that examined predictions from the feature-matching theory, related to the novelty factor, relied on the GKT paradigm. For example, in the experiments reported by Gati and Ben-Shakhar (1990), where the contrast between a test stimulus and the set of preceding stimuli was manipulated, the test stimulus was always either identical to the relevant stimulus, or, at least, partially identical to it. However, if this theory is to enjoy any degree of generality as an OR theory, it should deal with ORs elicited by strictly novel stimuli, which don’t include significant components. Therefore, the goal of this study was to examine predictions of the feature-matching theory regarding the novelty factor, by manipulating common and distinctive components of neutral stimuli. To achieve this goal, two experiments, utilizing habituation, rather than a

GKT paradigm, were conducted. Specifically, these experiments were designed to test the major hypotheses derived from the feature matching theory, namely that the electrodermal component of the OR is a monotonic function of stimulus novelty, which is negatively related to the measure of common features, shared by the stimulus input and representation of preceding events, and positively related to the measure of their distinctive features.

EXPERIMENT 1

In the feature-matching theory, stimulus novelty is defined on the basis of the contrast between a test stimulus and the sequence of standard stimuli preceding it. In Experiment 1, this contrast was manipulated by creating a test stimulus, which was derived from the standard stimulus by substituting 0, 1, or 2 of its components. Two procedures for substituting components were used: A within-category substitution (e.g., substituting one hat by another), and between categories substitution (e.g., substituting a hat by glasses). This design allows for a comparison between two modes of substituting components. It is predicted that substituting components between categories is more effective for OR reinstatement than the within categories substitution. This hypothesis is based on the assumption that the similarity among two components of the same category (e.g., two hats) is greater than the similarity among components belonging to different categories (a hat and glasses).

An additional goal of this experiment is to examine the roles of common and distinctive features in dishabituation (the response to the standard stimulus, which immediately followed the test stimulus, served as a measure for dishabituation). Previous studies conducted in our laboratory utilized the GKT, and were not designed to examine dishabituation effects. OR studies conducted in other laboratories (e.g., Zimny & Schwabe, 1965; Furedy, 1968) examined both OR reinstatement and dishabituation, but these studies used tones or flashes of light, rather than meaningful stimuli, and no attempt was made to manipulate stimulus features. Finally, this experiment may shed further light on the question of whether significance is a necessary condition for OR reinstatement, as proposed by Bernstein (1979).

Method

Participants. 168 undergraduate students (140 females and 28 males) with a mean age of 22.17 (Sd=3.40) participated in the experiment for either course credit or payment.

Instruments. Skin conductance was measured by a constant voltage system, and two Ag/AgCl electrodes (0.8 cm diameter), with an electrode paste which consisted of one part physiological saline mixed with two parts of Unibase following the recipe provided by Fowles, Christie, Edelberg, Grings, Lykken, and Venables (1981). The experiment was conducted in an air-conditioned laboratory, and was monitored from a control room separated from the laboratory by a one-way mirror. A Macintosh II computer was used to control the stimulus presentation and compute skin conductance changes. The stimuli were displayed on a Macintosh 13" color monitor, placed about 50 cm from the subject's eyes.

Design. The stimulus sequences used in this experiment were comprised of nonsignificant verbal (descriptions of people) and pictorial (schematic faces) compound stimuli. A test stimulus (TS), created by substituting components of the standard stimulus (SS) was introduced after 9 repetitions of SS, followed by 2 additional repetitions of SS.

Two between-subjects factors (A & B), and one within-subjects factor (C) were manipulated: (A) The number of stimulus components of SS that were substituted to create TS -- 0, 1, or 2; (B) Type of stimulus change -- within versus between categories; and (C) Stimulus modality -- Verbal versus Pictorial. The dependent measures were the Skin Conductance Responses (SCRs) elicited by the TS (OR reinstatement), and by the SS immediately following TS (dishabituation).

Participants were randomly allocated to the three major experimental conditions, such that 40 were allocated to the control condition (Condition #1), where no components were substituted (i.e., TS was identical to SS), and 64 were allocated to each of the experimental conditions (Conditions #2 and #3), where one and two components were substituted, respectively. Participants in Conditions #2, and #3, were randomly divided into two equal-sized subgroups (n=32), such that one was exposed to the within category substitution (e.g., one hat was substituted by another hat), and the other to the between-categories substitution (e.g., a hat was substituted by glasses).

Two types of sequences were used: (a) SS was constant across all experimental conditions, while TS varied between conditions (e.g., the three-component SS was {a, b, c} in all experimental conditions, and TS was {a, b, c} in Condition #1; {a, b, d}, in Condition #2; and {a, d, e} in Condition #3); (b) TS was constant across all experimental conditions, whereas SS varied (e.g., TS was {a, b, c} in all conditions, and SS was {a, b, c}, in Condition #1; {a, b, d}, in Condition #2; and {a, d, e}, in Condition #3). Half of the participants in each condition, and each sub-group were presented with a type (a) sequence, and the other half were presented with a type (b) sequence.

Each participant was presented with two stimulus sequences, verbal and pictorial, with their order counterbalanced, such that half the participants in each condition, and each subgroup were presented with the verbal sequence first, and the other half with the pictorial sequence first.

Stimuli. All stimuli contained three components, a basic component (the basic frame of the face, including eyes, nose and mouth, for the pictorial stimuli, and the individual's occupation for the verbal stimuli), and two additional components chosen from a fixed set of four components (beard and mustache, hat, glasses, and a pipe, for the pictorial stimuli, and city of permanent residence, a hobby, a personality trait, and a physical feature, for the verbal stimuli). Examples of sequences of pictorial and verbal stimuli, used in this experiment are displayed in Figure 1.

Insert Figure 1 about here

Procedure. Two electrodes were attached to the volar side of the index and fourth fingers of the participants' left hand, using masking tape with pressure such that the participant felt comfortable. The participants were requested to sit at ease for a rest period of 2 minutes, to be followed by further instructions. At the end of the resting period, participants were told that they would be presented with two sequences of verbal and pictorial stimuli, and that they should sit quietly and pay close attention to all stimuli, because at the end of the experiment they would be tested about the stimuli they saw. Two sequences of 12 stimuli each (9 presentations of SS followed by a presentation of TS and two additional presentations of SS) were then presented at random intervals ranging from 16 to 24 seconds, with a mean inter-stimulus interval of 20 s. Each stimulus was presented for 5 s. At the end of each stimulus sequence, participants were requested to describe the stimuli they saw. At the end of the experiment they were debriefed and paid.

Response Scoring and Analysis

The maximal conductance change obtained from the subject, from 1 s to 5 s after stimulus onset was computed using an A/D (NB-MIO-16) converter with a sampling rate of 1000 Hz. To eliminate individual differences in responsivity and allow a meaningful summation of responses of different individuals, each participant's conductance changes to the stimuli were transformed into standard scores relative to his or her mean and standard deviation, computed across all stimuli within each sequence[1]. The Z scores to the test stimulus and to the subsequent standard stimulus, were the dependent variables in the statistical analyses, and a rejection region of $p<.05$ was used in all statistical tests. The Greenhouse-Geiser correction was applied to the repeated-measures analyses and statistical-significance criteria were computed accordingly.

Results

Before testing the main hypotheses, using the standardized responses to the test stimuli, we examined whether the raw SCRs to the standard stimuli were affected by stimulus modality. The SCRs elicited by the 9 standard stimuli preceding TS were subjected to a 2 by 9 repeated measures ANOVA (stimulus modality by habituation trials) conducted across experimental conditions. Only the habituation trials factor produced a statistically significant effect ($F_{8, 1104}$=33.79, MSe=0.07, ϵ=0.69), while stimulus modality did not produce neither statistically significant main effect ($F_{1, 138}$=1.23, MSe=0.15), nor an interaction effect with trials ($F_{8, 1104}$=0.47, MSe=0.07, ϵ=0.81).

The Z scores to the test stimuli were then averaged within each of the six experimental conditions. These mean Z scores are presented in Table 1 as a function of number of substituted components and stimulus modality. To examine OR reinstatement, Z scores to the test stimuli were compared with the Z scores to the preceding standard stimuli, using t-tests for dependent samples. The resulting t values (which, as predicted, were statistically significant in all cases, except for the control conditions) are also displayed in Table 1. An inspection of Table 1 reveals that in both modalities the average standardized responses increase monotonically with the number of substituted components.

Insert Table 1 about here

A 3 by 2 ANOVA was conducted on the Z scores to the test stimuli, with the number of substituted components (0, 1, and 2) serving as a between-subjects factor, and stimulus modality (verbal vs. pictorial) as a within-subjects factor. Only the between-subjects factor produced a statistically significant effect ($F_{2, 165}$=23.73, MSe=1.44).

To examine the effect of type of stimulus change (within and between categories), only the data of the experimental conditions were analyzed. Mean Z scores to the test stimulus were computed for each type of substitution, within each condition (1 and 2 substituted components). Figure 2 displays these means as a function of type of substitution and number of substituted components within each stimulus modality. The Figure highlights the differences between the two types of substituting components, as well as the stimulus modality differences. In addition, inspection of Figure 2 reveals that in all 4 cases, a larger mean Z score was obtained when two components were substituted than when a single component was substituted, but this difference was small, especially for the pictorial stimuli.

Insert Figure 2 about here

A 2 by 2 by 2 ANOVA was conducted on the data of Figure 2, with type of stimulus change (within vs. between categories) and number of substituted components (1 vs. 2) serving as between-subjects factors, and stimulus modality serving as a within-subjects factor. Type of substitution produced a statistically significant effect ($F_{1,124}$=7.03, MSe=1.70), with the predicted pattern of larger Z scores under the between-categories substitution. Neither the number of substituted components, nor the interaction between the two between-subjects factors produced significant effects. This means that substituting two components did not result in a significantly larger orientation than a substitution of a single component. Thus, the statistically significant effect obtained for the number of substituted components, in the previous analysis, reflects the difference between the control condition, in which no components were substituted, and the two experimental conditions. Stimulus modality produced a statistically significant main effect ($F_{1,124}$=8.74, MSe=1.01), with the verbal stimuli producing larger relative responses than the pictorial stimuli. Thus, it seems that, although verbal and pictorial stimuli produce similar SCRs during the habituation trials, substituting components of verbal stimuli is associated with larger orientation. None of the interactions between modality and the between-subjects factors produced any statistically significant results.

To examine dishabituation effects, two ANOVAs (parallel to the previously described ANOVAs) were conducted on the Z score to the standard stimulus subsequent to the test stimulus (i.e., the 11th stimulus in the sequence). No statistically significant outcome was obtained, in this analysis, for the number of substituted components, but type of substitution did produce a statistically significant effect on the Z score to the 11th stimulus ($F_{1,118}$=7.01, MSe=0.64), indicating that between-categories substitution produced larger dishabituation than the within-category substitution. These results indicate that although the evidence for dishabituation was much weaker than the evidence for OR reinstatement, there were some indications that dishabituation might be demonstrated when stimulus components are substituted.

Discussion

The results of Experiment 1 demonstrated that OR elicitation by a nonsignificant change in stimulation is affected by substituting stimulus components. As predicted by the feature-matching theory (e.g., Gati & Ben-Shakhar, 1990), OR reinstatement was affected by common and distinctive stimulus components of the test stimulus and the standard stimuli preceding it, but the relationship between OR magnitude and the number of novel components was not linear.

These results indicate that significance is not a necessary condition for OR elicitation, because, unlike previous experiments designed to examine the feature matching theory, the test stimuli used in the present study did not include any significant component (i.e., a component that had a signal value for the subjects). In this respect, the present results are consistent with those reported by Ben-Shakhar, Asher, Poznansky-

Levy, Asherowitz, and Lieblich (1989). Both studies showed that introducing a non-significant stimulus change after a simple stimulus sequence (a sequence consisting of a single stimulus repeated several times), produces an OR. The results of the ANOVAs suggest that the major effect of stimulus change reflects a difference between any change in stimulus components and no change, while the amount of change (1 vs. 2 components) did no affect OR magnitude. In addition, the results of Experiment 1 confirmed the hypothesis that a between-categories substitution is associated with larger ORs than a within-category substitution. This result is consistent with findings reported by Siddle, Kyriacou, Heron and Matthews (1979) who demonstrated that a change in word category affected the electrodermal component of the OR, while a change in word within a semantic category did not produce an OR. In that experiment complex habituation sequences were used and thus the fact that no effects were demonstrated for the within-category manipulation is consistent with the results reported by Ben-Shakhar et al. (1989). Finally, only minor dishabituation effects were obtained in this experiment, and it is possible that a more pronounced change in stimulation is required to produce a reliable dishabituation.

EXPERIMENT 2

Experiment 2 was designed to test similar hypotheses, but with a different manipulation of the contrast between the test and the standard stimuli. Specifically, in this experiment, instead of substituting components, the test stimulus was derived from the standard stimulus by either adding to, or deleting from the latter 0, 1, or 2 components. This experiment allows for a comparison between the addition and deletion procedures. This comparison is interesting because it is related to the issue of "stimulus omission", which is an unresolved issue in the study of ORs (e.g., Barry, 1984; O'Gorman, 1989; Packer & Siddle, 1989; Siddle, 1985; Siddle & Packer, 1987). According to the contrast model, similarity relations are not necessarily symmetrical. Asymmetry is represented, in this model, by the different weights assigned to the two sets of distinctive features (Tversky, 1977). This unique characteristic of the feature-matching model, which does not characterize other prevalent models of similarity relations (e.g., the geometrical model), may be important in the present context because ORs may reflect such asymmetrical similarity relations. For example, Ben-Shakhar, et al. (1989) found that adding components to a neutral verbal stimulus, produced larger OR reinstatement than subtracting components. They accounted for this result, suggesting that the mismatch created by deleting components reflects only a change in the gestalt (the occurrence of individual components previously bound together), whereas the mismatch created when components are added results not only from a change in the gestalt, but also from the novelty of the added components. This account, however, was not supported by the results reported by Gati et al. (1996). The present experiment may shed further light on the roles of adding and deleting neutral stimulus components in OR reinstatement and dishabituation.

Method

Subjects. 304 undergraduate students (242 females and 62 males), with a mean age of 22.70 (Sd=3.86) participated in the experiment for either course credit or payment.

Instruments. The instruments were identical to those used in Experiment 1.

Design. The stimulus sequences were similar to those used in the previous experiment, but TS was created either by adding 0, 1 or 2 components to SS, or by deleting 0, 1 or 2 components from SS. Thus, a factorial design with two between-subjects factors (A & B), and one within-subjects factor (C) was employed: (A) The number of stimulus components of SS that were added or deleted to create TS -- 0, 1, or 2; (B) Type of stimulus change -- addition versus deletion; and (C) Stimulus modality -- Verbal versus Pictorial.

Participants were randomly allocated to five experimental conditions, such that 48 were allocated to the control condition, where no components were added or deleted (i.e., TS was identical to SS), and 64 were allocated to each of the 4 other conditions created by crossing the deletion/addition procedure with the number of components added or deleted. The stimuli and the procedure were identical to those used in Experiment 1. Sequences of pictorial and verbal stimuli, used in this experiment, are illustrated in Figure 3. The dependent measures and the response scoring procedures were also identical to those used in the previous experiment.

Insert Figure 3 about here

Results

As in the previous experiment, we conducted a preliminary analysis to examine whether the raw SCRs to the standard stimuli were affected by stimulus modality. The SCRs elicited by the 9 standard stimuli preceding TS were subjected to a 2 by 9 repeated measures ANOVA (stimulus modality by habituation trials) conducted across experimental conditions. Only the habituation trials factor produced a statistically significant effect ($F_{8, 2240}$=65.92, MSe=0.17, ϵ=0.47), while stimulus modality did not produce neither statistically significant main effect ($F_{1, 280}$=0.42, MSe=0.28), nor an interaction effect with trials ($F_{8, 2240}$=0.40, MSe=0.13, ϵ=0.57).

The hypotheses testing were conducted in two stages, as in Experiment 1. First, the data were collapsed across the addition/deletion procedures, and the Z scores to the test stimuli were averaged within each of the 3 main experimental conditions (a change of 0, 1, or 2 stimulus components), and within each stimulus modality. These mean Z scores are presented in Table 2, by experimental condition and stimulus modality. To examine OR reinstatement, Z scores to the test stimuli were compared with the Z scores to the preceding standard stimuli, using t-tests for dependent samples. The resulting t values (which were statistically significant in all cases, except for the control conditions) are also displayed in Table 2.

Insert Table 2 about here

Inspection of Table 2 reveals that the monotonic relationship between the mean Z scores and the number of added/deleted stimulus components was observed only with the verbal, but not with the pictorial stimuli. This deviation from monotonicity, however, is not inconsistent with the results of Experiment 1, because in both experiments no statistically significant differences in OR magnitude were obtained when the single component and the two components conditions were compared. The results of the present experiment reveal negligible OR differences between a change of just one component and a change of two components.

A 3 by 2 ANOVA was conducted on the data of Table 2, with the three levels of change (0,1,2) serving as a between-subjects factor, and stimulus modality (verbal vs. pictorial) as a within-subjects factor. Only the first factor produced a statistically significant effect ($F_{2, 301}$=21.51, MSe=1.71).

To examine whether deleting and adding stimulus components have different effects on OR amplitude, only the data of the four experimental conditions were analyzed. Mean Z scores to the test stimulus were computed for each type of stimulus change (addition and deletion), within each condition (1 and 2 components). Figure 4 displays these means as a function of type of stimulus change and number of components added or deleted, within each stimulus modality. The Figure shows that the monotonic relationship between OR magnitude and degree of stimulus change (number of components added or deleted), can be observed only when components are deleted, but not when they are added.

Insert Figure 4 about here

A 2 by 2 by 2 ANOVA was conducted on the data of Figure 4, with type of stimulus change (addition vs. deletion) and number of added/deleted components (1 vs. 2) serving as between-subjects factors, and stimulus modality serving as a within-subjects factor. The only statistically significant effect obtained in this analysis, was an interaction between the number of components changed and the type of change ($F_{1, 252}$=5.35, MSe=1.89). This indicates that the differences between a change of two components and a change of a single component were larger under the deletion condition, where the expected monotonic relationship between OR and number of novel components was observed, than under the addition condition, where the monotonic relationship was violated. Finally, no statistically significant effects were obtained for the stimulus modality factor, and its interactions with the between-subjects factors.

To examine dishabituation effects, two ANOVAs (parallel to the previously described ANOVAs) were conducted on the Z scores to the 11th stimulus. No statistically significant effects were obtained in these analyses. These results indicate that dishabituation was not affected by the present manipulation.

GENERAL DISCUSSION

The results obtained in the two experiments may be summarized as follows: First, both experiments demonstrated clear effects of a neutral change in stimulation on OR magnitude (a difference between any change and no change at all). This effect was observed in both modalities, and under all types of stimulus change (substitution, deletion, and addition). Second, both experiments revealed only small OR differences as a function of whether two components or just a single component were changed. However, while in Experiment 1 these small differences were in the expected direction, in Experiment 2 the pattern was more complex, and it seems that type of stimulus change might moderate the effect of the amount of stimulus change. Finally, the effect of stimulus modality on OR magnitude was observed only in the experimental conditions of the first experiment.

Both experiments clearly demonstrate that a neutral change in stimulation is sufficient for OR reinstatement. Thus, our data are inconsistent with the hypothesis proposed by Bernstein (1969, 1979) that some level of stimulus significance is necessary for OR reinstatement. Furedy (personal communication, September 29th, 1998) suggested that stimulus significance may be confounded with stimulus modality, and that verbal stimuli, which require conceptual processing may be more significant than pictorial stimuli, which call for perceptual processing. Moreover, both types of stimuli may be more significant than tones and lights used in previous experiments (e.g., Furedy, 1968). However, as our analyses demonstrated, similar habituation curves were obtained for the standard verbal and pictorial stimuli. In addition, it is important to note that our definition of stimulus significance is relativistic (e.g., a specific stimulus, or a sub-set of stimuli is more significant for an individual, in a particular context, than other stimuli). Particularly, stimulus significance can be created either through conditioning, or by specific instructions that single out a particular stimulus or a particular stimulus category (e.g., making a particular stimulus a signal for future action, or even simply pointing out that a particular stimulus is important).

It can also be argued that instructing participants to pay attention to the stimuli introduced a certain level of significance to the test stimulus, which differed from all the other stimuli. However, such an argument confounds the concepts of stimulus significance and stimulus novelty, because it implies that any perceived change in stimulation is significant to the organism. Instructing participants to pay attention to all stimuli is necessary because otherwise they might fall asleep and stop watching the monitor. Such instructions may increase general arousal, but it does not single out any particular stimulus. Furthermore, previous studies demonstrated that instructing participants to pay attention to the stimuli is in itself insufficient for OR elicitation by a neutral change in stimulation (Ben-Shakhar et al., 1989; Gati et al., 1996). These studies demonstrated that a stimulus change introduced after a complex stimulus sequence did not produce an OR, even when participants were instructed to pay attention to the stimuli. The present experiments used only simple stimulus sequences, and the results obtained are consistent with those reported by Ben-Shakhar et al. (1989).

Although the present results demonstrated that OR reinstatement can be produced by a non-significant stimulus change, it is possible that the effect of stimulus change depends on the level stimulus significance as hypothesized by Bernstein (1979). In the present study, only neutral test stimuli have been used, and therefore our results cannot shed light on the question of whether ORs are determined by an interaction between stimulus significance and novelty.

The results of this study demonstrated that the feature-matching theory for OR reinstatement enjoys more general validity and is not restricted to the GKT paradigm, where expectations for a significant stimulus always play a role. This conclusion is significant because the concept of Orienting Response was introduced to explain effects of stimulus change, regardless of whether the change is significant to the organism or not. Thus, it was necessary to examine the theory under neutral conditions. The results of both experiments clearly demonstrated that substituting, adding, or subtracting non-significant stimulus components is sufficient for OR reinstatement.

However, the fact that no differences emerged, in this study, between a change of two components and a change of a single component may indicate that in contrast to our theory the level of stimulus novelty does not affect OR magnitude. Indeed, the specific relationship between OR magnitude and the number of manipulated components is unclear, and the present results indicate that it is not linear. However, there is no reason to think that this relation should be linear, and the present findings, based on a psychophysiological measure are consistent with previous results, which used similarity judgments. For example, Gati and Tversky (1984) demonstrated, using schematic faces and verbal descriptions of people, similar to the stimuli used in the present study, that the marginal effect of adding (or deleting) a stimulus component on similarity judgment was significantly smaller when it was added in conjunction with another component than when it was added alone. Future studies, which would use a larger variation of stimulus components added, deleted, or substituted, might shed more light on this issue.

The results of both experiments did not demonstrate dishabituation effects. Dishabituation is predicted by Sokolov's theory because presentation of the test stimulus must change the neuronal model, and therefore when the subsequent standard stimulus is reintroduced, the stimulus input no longer matches the existing neuronal model. However, it is not clear whether a single presentation of a novel stimulus is sufficient for this purpose. It is also possible that there is no uniform answer to this question, and that it depends on how salient the test stimulus is. Thus, perhaps a more pronounced stimulus change might have produced a reliable dishabituation effect. Some indications for this possibility are provided by the present results, because the between-categories substitution produced larger responses to the dishabituation stimulus than the within-category substitution. In a recent review article, Siddle and Lipp (1997) discussed the issue of dishabituation and noted that a number of studies have not been able to demonstrate this phenomenon, even when an intermodality change was used. They suggested that variations in inter-stimulus intervals across studies might account for whether or not dishabituation was demonstrated.

Finally, while the present results clearly show that a change in neutral stimulus components can be effective in producing OR reinstatement, the relative effects of the various types of stimulus change are less clear. As expected, Experiment 1 demonstrated that a between-categories substitution is more effective than a within-category substitution. This finding means that ORs are sensitive not only to the occurrence of a change, but also to the magnitude of this change. In other words, it seems that OR reinstatement is not a threshold phenomenon, as might be concluded from the lack of differences between a change of two components and a change of a single component. On the other hand, the comparison between the addition and deletion conditions, conducted in Experiment 2, did not yield a clear and consistent outcome. The results indicate that the effect of adding versus deleting stimulus components depends on the number of stimulus components manipulated. This result cannot be accounted for, neither by the feature-matching theory, nor by any other theory of stimulus similarity. Overall, there were no mean OR differences between the addition and deletion conditions. This is consistent with previous findings reported by Gati et al. (1996), but not with the results reported by Ben-Shakhar et al. (1989), who obtained a more pronounced effect when stimulus components were added than when they were deleted.

The above discussion suggests that several issues require additional research. It should also be kept in mind that in this study, only a single component of the OR was measured, and it is not clear whether the results of this study would generalize to other OR components. Barry (1982) argued for a fractionation of OR measures, and if his theory is adopted, our conclusions should be limited to the electrodermal component of the OR. Taking these qualifications into account, we conclude that the feature-matching theory provides a fruitful tool to investigate orienting and habituation processes in humans.

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FOOTNOTES

1. The standardization procedure is base on the assumption that the standard stimuli in the various experimental conditions are equivalent. To test this assumption a 3 by 2 ANOVA was conducted on the mean unstandardized SCRs, computed across the 9 standard stimuli, in each experiment (the 3 experimental conditions by the two stimulus modalities). No statistically significant outcomes were obtained in these analyses, neither for experimental conditions, nor for stimulus modality, as well as their interaction. Thus, no evidence indicating that the different standard stimuli used in the various conditions were not equivalent was found.

Table 1. *Results of Experiment 1*

Number of substituted components	Subjects (n)	Pictorial stimuli	Verbal stimuli	Total
0	40	-0.25 (0.86) t = -0.74	-0.39 (0.45) t = -1.32	-0.32 (0.45) t = -1.45
1	64	0.49 (1.07) t = 4.27*	0.78 (1.26) t = 5.27*	0.64 (0.92) t= 6.66*
2	64	0.59 (1.15) t = 5.16*	1.04 (1.21) t = 8.17*	0.81 (0.97) t = 8.40*
Total	168	0.35 (1.10)	0.60 (1.32)	0.47 (0.96)

Note: Mean Z score (SD's) to the relevant stimulus and corresponding *t* values as a function of the number of substituted components and stimulus modality.
*Statistically significant ($p<.05$).

Table 2. *Results of Experiment 2*

Number of substituted components	Subjects (n)	Pictorial stimuli	Verbal stimuli	Total
0	48	-0.23 (0.73) t = -0.74	-0.37 (0.73) t = -1.32	-0.30 (0.53) t = -1.45
1	128	0.60 (1.20) t = 8.12*	0.59 (1.28) t = 5.27*	059 (0.96) t= 6.66*
2	128	0.56 (1.08) t = 7.51*	0.84 (1.39) t = 10.04*	0.70 (0.99) t = 11.56*
Total	304	0.45 (1.12)	0.54 (1.32)	0.50 (0.98)

Note: Mean Z score (SD's) to the relevant stimulus and corresponding *t* values as a function of the number of added/deleted components and stimulus modality.
*Statistically significant ($p<.05$).

FIGURE CAPTIONS

Figure 1. Examples of a sequence of Pictorial stimuli (schematic faces) and a sequence of verbal stimuli (descriptions of people) used in Experiment 1 (substitution).

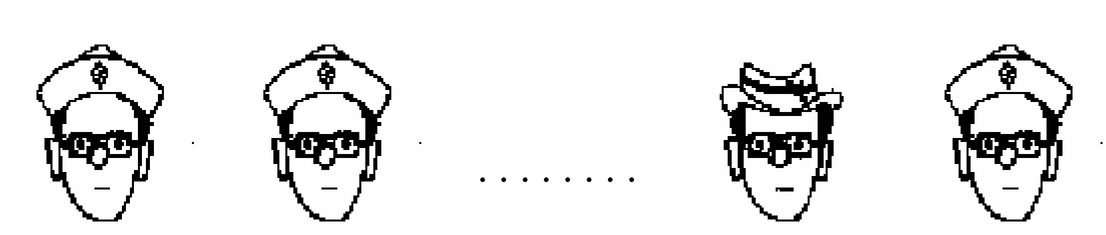
Figure 2. Means of standardized responses elicited by the test stimuli as a function of number of substituted components and type of substitution.

Figure 3. Examples of two sequences of Pictorial stimuli (schematic faces) and two sequences of verbal stimuli (descriptions of people) used in Experiment 2 (addition and deletion).

Figure 4. Means of standardized responses elicited by the test stimuli as a function of number of components changed and addition versus deletion.

Figure 1:

Substituting one component of pictorial stimuli.



Substituting one component of verbal stimuli[1].

Carpenter Slim Responsible	Carpenter Slim Responsible	. . . .	Carpenter ***Slim*** Distracted	Carpenter Slim Responsible

(1) Translated from Hebrew

figure 2

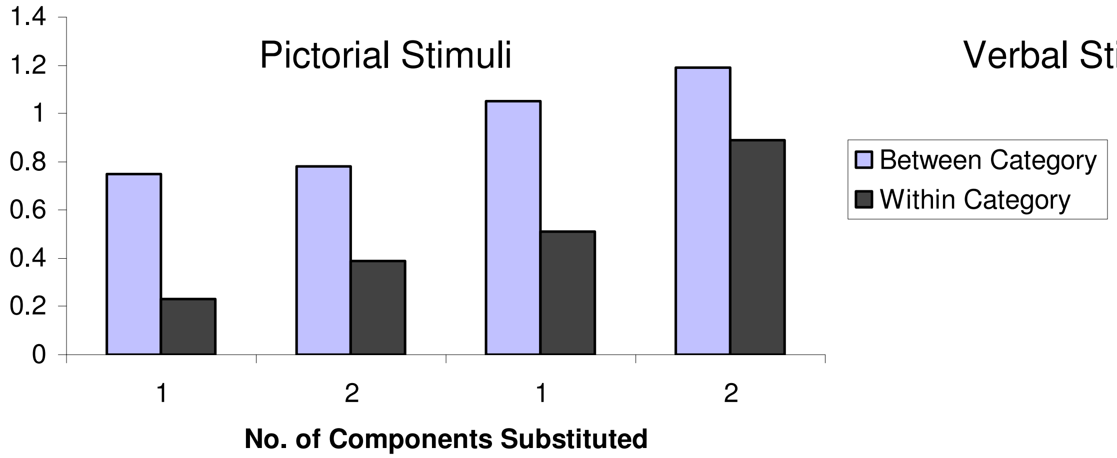

1.4
1.2
1
0.8
0.6
0.4
0.2
0
Pictorial Stimuli
Verbal Sti
Between Category
Within Category
1
2
1
2
No. of Components Substituted

Figure 3:

Adding one component of pictorial stimuli.

Adding one component of verbal stimuli.[2]

Carpenter Likes poetry Lives in Ashkelon	Carpenter Likes poetry Lives in Ashkelon	. . . .	Carpenter Likes poetry Lives in Ashkelon Responsible	Carpenter Likes poetry Lives in Ashkelon

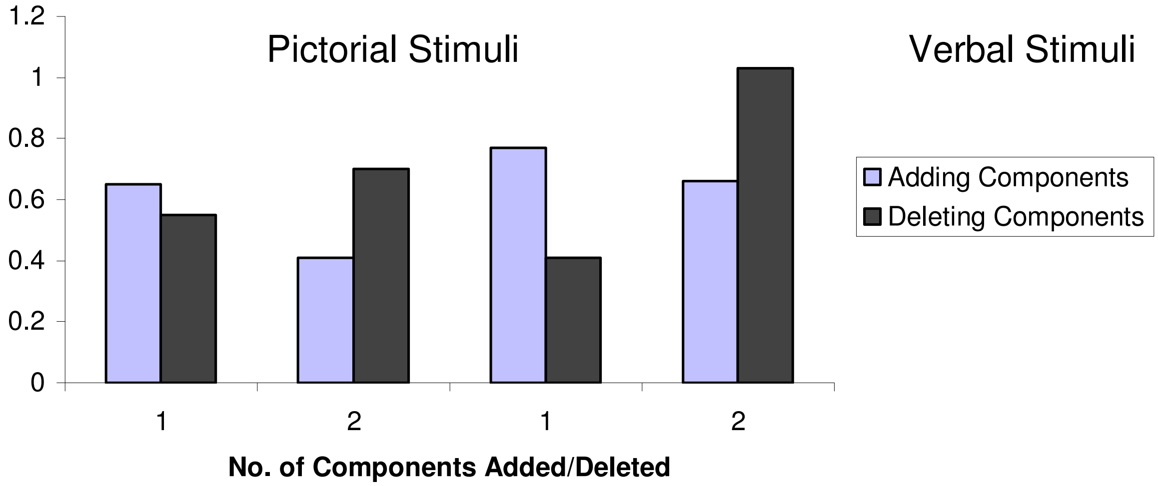
Deleting one component of pictorial stimuli.

Deleting one component of verbal stimuli.

Director Likes Poetry Lives in Tiberias	Director Likes Poetry Lives in Tiberias	. . . .	Director Likes Poetry	Director Likes Poetry Lives in Tiberias

(2) Translated from Hebrew.

figure 4


1.2
1
0.8
0.6
0.4
0.2
0
Pictorial Stimuli
Verbal Stimuli
Adding Components
Deleting Components
1
2
1
2
No. of Components Added/Deleted