The importance of irrelevant-dimension variability in the Stroop flanker task

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Two experiments in which the Stroop flanker task was used were conducted in order to examine the influence of irrelevant dimension invariance on congruency effects. Participants responded manually to a central color patch flanked by a Stroop stimulus. In Experiment 1, invariance in flanker location was found to have no influence on word and color congruency effects. In contrast, invariance of flanker identity led to the disappearance of congruency effects. Experiment 2 indicated that the elimination of a congruency effect was restricted to the dimension that remained constant and did not influence the congruency effect of the other dimension that was presented at the same location. Results suggest that variance is a prerequisite to congruency effects, determining the activation of irrelevant dimensions.

Selective attention allows one to process only a subset of the information available from the environment. The Stroop and flanker tasks have long been used in the study of visual selective attention (Eriksen & Eriksen, 1974; MacLeod, 1991; Stroop, 1935). In both conflict tasks, the failure of selective attention has repeatedly been demonstrated by the fact that the irrelevant and supposedly ignored dimensions of stimuli influence performance. Thus, it takes longer to name a word's color when the word is incongruent (e.g., the word *red* written in the color green) than when the word is congruent (e.g., the word *green* written in the color green). Likewise, by presenting distractor stimuli such as letters connoting an opposite response in a choice reaction task, the identification of a target letter is slowed relative to letters identical to the target. In both cases, the effect of the irrelevant dimension or stimuli is termed the *congruency effect* (MacLeod, 1991).

The Stroop flanker task (Henik, Ro, Merrill, Rafal, & Safadi, 1999) combined the two tasks. In the Stroop flanker task, a color target presented at the center of fixation is flanked to the left or right by a Stroop stimulus (see Figure 1 for examples). Henik et al. examined the effect of the flanker word and that of the flanker color on the central color target. The first effect is consistent with the Stroop congruency effect when the irrelevant word is spatially separated from the color (Dyer, 1973; Gatti & Egeth, 1978; MacLeod, 1998; Merikle & Gorewicz, 1979). The second effect is consistent with the flanker congruency effect when both the target and distractor are colors (Haagenaar & van der Heijden, 1986; La Heij, Helaha, & van den Hof, 1993).

In a somewhat different paradigm also used in the study of selective attention, the Garner interference occurring during speeded classification has been examined (Garner, 1974; Garner & Felfoldy, 1970; Pomerantz, 1986). Typically, participants respond to the identity of a relevant dimension while ignoring an irrelevant one, as in conflict tasks. The performance at baseline, at which the irrelevant dimension is held constant, is compared with performance in a filtering condition, in which the irrelevant dimension is varied orthogonally (as is usually the case in the Stroop and flanker tasks). The Garner interference, pointing to a failure in selective attention, is said to occur when performance in the filtering condition is significantly worse than that at baseline. For example, the identification of whether an arrow is pointing up or down is faster when the position of the arrow, which is irrelevant, remains the same as compared with when it randomly changes from trial to trial (Clark & Brownell, 1976). This paradigm was first used to study the relations between dimensions at the perceptual level (e.g., Garner, 1974; Garner & Felfoldy, 1970). In recent years, however, several authors have used the Garner task to examine the relations between dimensions commonly used in Stroop-like tasks, relating information processing at other stages such as the semantic or response identification stages (Ben-Artzi & Marks, 1999; Melara & Marks, 1990a, 1990b; Melara & Mounts, 1993; Pansky & Algom, 1999).

Although related, congruency effects and Garner interference appear to demonstrate different aspects of the failure of selective attention (e.g., Ben-Artzi & Marks, 1999; Melara & Mounts, 1993). The presence of Garner interference suggests that the observer has failed to ignore the *variation* of the irrelevant dimension. The presence of congruency effects suggests that the observer has failed to ignore the *identity* of the irrelevant dimension in relation to the relevant dimension. Unlike the Garner conditions, for congruency to arise, the irrelevant dimension must have some degree of dimensional overlap (see Kornblum, 1994;

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Flanker identity invariant and location uncertain	Flanker location invariant and identity uncertain	Flanker identity and location uncertain
(in red) (in green)	(in red) (in green)	(in red) (in green)
(in green) (in red)	(in red) (in red) (in red) (in red)	

Figure 1. Two possible examples from the same block in each condition. In each example, the red square is displayed at central fixation, with the flanker to the left or right. The examples include only targets in red (words in italics designate the color of the stimulus). The examples are not exhaustive of all the possible stimuli in a condition. The stimuli presented are only approximations and do not accurately portray the actual relative size of the stimuli (see the Procedure section for more details).

Kornblum, Hasbroucq, & Osman, 1990; Kornblum & Lee, 1995). Dimensional overlap was defined by Kornblum and colleagues as “the degree to which relevant and/or irrelevant stimulus sets are perceptually, conceptually, or structurally similar to the response set in the task and/or to each other” (Kornblum & Lee, 1995, p. 855; see also Kornblum, 1994; Kornblum, Stevens, & Requin, 1999). This means that when two dimensions are combined in a conflict task, at least one must be congruent or incongruent to allow for a measure of congruity. In contrast, Garner interference can be computed for any two dimensions combined, even if they cannot be congruent or incongruent with each other (i.e., there is no dimensional overlap between them). Color and spatial position provide an example of two dimensions with no overlap. There is no apparent congruity between the dimensions in the sense that red and left are neither more nor less congruent than red and right.

Many studies measuring Garner interference that have examined the relations between dimensions using Stroop-like tasks have also measured congruency effects in both the baseline and filtering conditions. As a rule, a large and consistent congruency effect is found in the filtering condition. The congruency effect in the baseline condition is typically either quite small or completely absent. These studies suggest that variance of the irrelevant dimensions might be a necessary condition for the emergence of congruency effects (Algom, Dekel, & Pansky, 1996; Melara & Marks, 1990b; Sabri, Melara, & Algom, 2001). Unlike these previous studies in which the Garner task has been used, we hoped to use a novel paradigm with several irrelevant dimensions presented simultaneously that were not spatially integrated with the target, but were integrated with each other. This allowed us to use a distractor of the same dimension as the target and to compare the effects of variation in each irrelevant dimension within the same display (see also Ben-Artzi & Marks, 1999).

In the Stroop flanker paradigm presented above, there are three irrelevant dimensions: flanker word, flanker color, and flanker position. One may question the influence of

variance in each of these dimensions on congruency effects and on the overall performance such as general reaction time (RT). There are several differences between the present study and those that have examined Garner interference. First, in this study, the irrelevant flanker dimensions were spatially separated from the target stimulus. Second, there are several irrelevant dimensions instead of a single one (see also Ben-Artzi & Marks, 1999). Finally, in order to avoid strategic influences, the different baseline-like conditions as well as the filtering-like condition were performed by different groups of participants. These differences precluded the examination of a “true” Garner interference within the present paradigm. Since our main concern was the effect of the variance of the irrelevant dimensions on the congruency effects, this does not pose a serious problem.

EXPERIMENT 1

Three irrelevant attributes in the Stroop flanker task can be categorized into two types of dimensions: identity (flanker word and color) and location (flanker position). In Experiment 1, we hoped to determine whether location uncertainty of the irrelevant flanker affects performance in the same way as identity uncertainty. In other words, how does variance in flanker location and variance in flanker identity influence performance.¹ One condition of the experiment constituted varied flanker location and invariant flanker identity. A second condition constituted varied flanker identity and invariant flanker location. In a third condition, both identity and location were varied (see Figure 1 for examples of stimuli in the different conditions). Since different studies used different terms in order to convey similar concepts, the term *variance* in flanker location and identity will be interchangeable with the term *uncertainty* of flanker location and identity.

In several studies, the importance of location uncertainty has been examined in the context of the Stroop and flanker tasks (Glaser & Glaser, 1982; La Heij et al., 1993;

Miller, 1991, Experiment 3; Underwood, 1976). However, these studies varied the location of both target and distractor and compared performance with performance under a condition in which both stimuli were presented in constant locations. All these studies have found that the congruency effects were larger when location was uncertain. Furthermore, these researchers were concerned with the effect of location uncertainty of the target alone and did not consider the possible contribution of the location uncertainty of the distractor (see also Paquet & Lortie, 1990). However, it is possible that location uncertainty of the *distractor* also contributed to the failure of selective attention and to the congruency effect. It seems plausible that when central target location is known and the flanker continually appears at the same location, participants will find it easier to selectively ignore the flanker than when the flanker appears at different locations.

There is a different way in which location uncertainty can be viewed within the present paradigm. Location can be viewed as a dimension of equal standing with color and word. In contrast to the two flanker dimensions, there is no apparent dimensional overlap between target color and flanker location (as was explained previously). Hence, we would not expect location uncertainty to influence congruency effects.

Method

Participants. Forty-eight students participated in the experiment for course credit. All had normal or corrected-to-normal visual acuity and color vision, Hebrew was their native language, and none had previous experience in Stroop tasks. The participants were assigned randomly to three groups of 16 participants each.

Apparatus. An IBM-compatible 286 computer with a 14-in. VGA monitor controlled the experiment. Manual responses were collected using a key-activated relay interfaced with a clock card with millisecond precision.

Stimuli and Procedure. The participants were tested individually and were instructed to respond to the central target and to ignore the irrelevant flanker (they were not told about the possible changes to the flanker). Speed and accuracy were emphasized equally. The participants were seated approximately 60 cm from the screen. Each stimulus was composed of a central square color (1×1 cm) flanked by a word (0.9×2.5 cm) in color. The target and flanker could be colored either red or green, and the flanker word could be either the word *red* or the word *green* in Hebrew (both consist of four letters). The flanker could appear to the left or right of the target (0.5 cm between the nearest edge of the flanker and the edge of the target). Therefore, the flanker word could be either incongruent (i.e., flanker word *green* and a red target) or congruent (i.e., flanker word *red* and a red target). Flanker color could also be incongruent or congruent with the central target color.

In each trial, a fixation cross appeared for 500 msec and was immediately followed by the presentation of the target and the flanker. The target and the flanker remained in view until the participant's keypress. The following trial began 2,500 msec after the onset of the response to the target. Error trials were repeated between the 3rd and 10th trial following the error. All participants completed four blocks of 80 trials each. The first two groups were given 16 practice trials before each block, whereas for the third group, 16 practice trials before the first block were considered to be sufficient.

In the first group, flanker identity was held constant within a block, and the flanker location was varied randomly between the left and right side of the target. Thus, both flanker word and color were kept constant within each block. For half the participants in this condition, the flanker word was compatible with the flanker color for the first two blocks and was incompatible for the last two blocks. The order was reversed for the other half of the participants. For the second group, flanker location was held constant within a block, and the flanker identity was varied randomly. For half the participants in this condition, the flanker was always presented to the right in the first two blocks and to the left in the last two blocks. The order was reversed for the other half of the participants. For the third group, both flanker identity and flanker location were varied independently within each block.

Results and Discussion

For each participant mean RT in each condition was computed for the correct responses. These means were subjected to a three-way analysis of variance (ANOVA). The between-subjects variable was dimensional uncertainty (location invariant, identity invariant, or all dimensions uncertain), and the within-subjects variables were the congruency of flanker word and flanker color. Error rates were low (1.8%) and were not analyzed. The analysis of RTs indicated main effects of flanker word [$F(1,45) = 33.59$, $MS_e = 456.11$, $p < .001$] and color [$F(1,45) = 13.0$, $MS_e = 577.6$, $p < .001$]. Incongruent words yielded longer RTs (500 msec) than did congruent words (482 msec), and the same pattern was found for flanker color (497 vs. 484 msec, for incongruent and congruent colors, respectively).

There was an interaction between dimensional uncertainty and word [$F(2,45) = 10.32$, $MS_e = 456.11$, $p < .001$] and between dimensional uncertainty and color [$F(2,45) = 4.03$, $MS_e = 577.6$, $p < .05$]. Both interactions are presented in Table 1. Additional comparisons indicated that the word and color congruency effects were not significant for the identity invariant (location uncertain) group (for both, $F < 1$). The pattern and magnitude of the effects did not differ between the remaining two groups of location invariant and all dimensions uncertain ($F < 1$, for all comparisons). In the location invariant and all dimensions uncertain groups, the color and word effects were signifi-

Table 1
Mean Reaction Times (in Milliseconds) According to Flanker Word and Flanker Color Attributes for the Three Conditions of Variance

Group	Flanker Word			Flanker Color		
	Incongruent	Congruent	Congruency Effect	Incongruent	Congruent	Congruency Effect
Identity invariant/location uncertain	446	448	-2	446	448	-2
Location invariant/identity uncertain	506	480	26*	503	484	19*
Location and identity uncertain	547	518	29*	543	522	19*

* $p < .001$.

cant [$F(1,45) = 53.85$, $MS_e = 456.1$, $p < .001$, and $F(1,45) = 20.96$, $MS_e = 577.6$, $p < .001$ for word and color effects, respectively]. No other interactions approached significance.

The main effect of dimensional uncertainty was marginally significant [$F(1,45) = 2.91$, $MS_e = 40,374.1$, $p < .065$]. Despite the fact that this effect did not reach significance, owing to its theoretical importance concerning Garner interference, an analysis of planned comparisons was conducted. It was found that the identity invariant group responded significantly faster (447 msec) than the all dimensions uncertain group (533 msec) [$F(1,45) = 5.82$, $MS_e = 40,374.1$, $p < .05$]. Furthermore, an additional comparison between the identity invariant group and the other two groups was also significant [$F(1,45) = 4.61$, $MS_e = 40,374.1$, $p < .05$]. However, responses of the location invariant group (493 msec) did not differ significantly when compared with the all dimensions uncertain group ($F < 1$). Although these results cannot be considered to be Garner interference, it seems that the invariance in identity of the flanker led to significantly faster responses regardless of the particular identity. In contrast, invariance in flanker location did not result in a significant decrease in response latencies compared with the all dimensions varied condition.

The present findings indicate that congruency effects occurred when flanker identity varied and were absent when flanker identity was invariant. The sizes of the congruency effects are comparable with those found in Henik et al. (1999). Unlike variance in flanker identity, variance in flanker location did not modulate the presence of congruency effects. Thus, even if the participants did not know where the flanker would appear, they could effectively ignore it when its identity remained constant. This last observation also indicated that even though previous studies concerned with target location uncertainty had not controlled for flanker location uncertainty, this did not affect their conclusions (Glaser & Glaser, 1982; La Heij et al., 1993; Miller, 1991; Underwood, 1976).

EXPERIMENT 2

The purpose of Experiment 2 was to examine in greater detail the influence of identity uncertainty of the flanker. The irrelevant stimulus in the Stroop flanker task has two attributes: word and color. Each of the attributes can be kept constant or can be varied independently from the other. Is it possible to note the variance in one attribute and be influenced by that attribute (e.g., word), while at the same time managing to completely ignore another attribute (e.g., color)? Alternatively, does the variance in one feature call attention to the stimulus as a whole (Kahneman & Henik, 1981), thereby leading to more comprehensive processing even of those features that are held constant? If this alternative is correct, this would mean that once selective attention has failed in a certain spatial location or object, owing to the uncertainty of a particular

attribute, all other attributes in that location or object will be processed regardless of their variance. A different but related issue is whether the attribute that remains constant leads to a reduced flanker effect of the attribute that is varied. It is possible that attributes that remain invariant lead to inhibitory attentional processes or simply to habituation of all attributes in the same spatial location. Such processes could lead to less efficient processing of all the attributes at that location.

Method

Participants. Thirty-two students participated in the experiment for course credit. All had normal or corrected-to-normal visual acuity and color vision, Hebrew was their native language, and none had previous experience in Stroop tasks. The participants were assigned randomly to two groups of 16.

Apparatus. The apparatus was identical to that in Experiment 1.

Stimuli and Procedure. The stimuli used were the same as those in Experiment 1. Two groups of 16 participants completed four blocks of 80 trials each. The procedure was the same as that in Experiment 1, with the exception that the flanker attributes were held constant within each block. Flanker side was varied randomly within each block for all groups in this experiment. Half of the participants in the first group performed two blocks in which flanker word was held constant within a block (but changed between blocks), followed by two blocks in which flanker color was held constant within a block. The other half completed the tasks in the opposite order. For the second group, both flanker word and flanker color were varied independently within each block (replicating the all dimensions uncertain group of Experiment 1).

Results and Discussion

The analysis was conducted in two parts. Initially, only the first group was analyzed in order to examine the effects of varying one of the flanker attributes while keeping the other constant. However, even if congruency effects were to be found, one could ask whether they were of the same magnitude as those that would be found by varying both attributes independently. Therefore, a second analysis included both experimental groups.

The first analysis was carried out on the data from only the first group, in which either flanker attribute was varied. A three-way repeated measures ANOVA was conducted on correct response times. The three within-subjects variables were attribute invariance (word and color) and the congruency of flanker word and flanker color. Error rates were low (less than 1%) and were not analyzed. The main effect of flanker word was significant [$F(1,15) = 9.65$, $MS_e = 226.6$, $p < .01$], as was that of flanker color [$F(1,15) = 7.8$, $MS_e = 401.17$, $p < .05$]. The participants responded more slowly when the flanker word was incongruent (443 msec) than when it was congruent (435 msec) and more slowly when the flanker color was incongruent (444 msec) than when it was congruent (434 msec).

Furthermore, there were two-way interactions between attribute uncertainty and word [$F(1,15) = 5.11$, $MS_e = 278.3$, $p < .05$] and attribute uncertainty and color [$F(1,15) = 11.2$, $MS_e = 282.82$, $p < .01$]. The corresponding means are shown in Table 2. Analyses of simple effects indicated that flanker word influenced responses when it was the un-

Table 2
Mean Reaction Times (in Milliseconds) of Flanker Word and Flanker Color Attributes
for the Two Uncertainty Conditions in the Group Where They Were Varied Separately

Condition	Flanker Word			Flanker Color		
	Incongruent	Congruent	Congruency Effect	Incongruent	Congruent	Congruency Effect
Color invariant/word uncertain	441	426	15*	433	433	0
Word invariant/color uncertain	446	444	2	455	425	20*

* $p < .001$.

certain attribute [$F(1,15) = 13.49$, $MS_e = 264.63$, $p < .01$], but not when it remained constant ($F < 1$). The same pattern was found for flanker color, which influenced responses when it was the uncertain attribute [$F(1,15) = 22.94$, $MS_e = 274.62$, $p < .001$], but it had no effect when it remained constant ($F < 1$). Therefore, when one of the attributes was varied and one was kept constant, only the attribute that varied led to a congruency effect. Despite processing information's coming from the same spatial location, the participants were able to ignore an invariant attribute to a degree that it had no effect on performance.

Finally, an interaction between flanker word and color was found [$F(1,15) = 5.56$, $MS_e = 378.39$, $p < .05$] (see Table 3). Additional comparisons suggested that responses were faster when the flanker contained both a congruent word and color [$F(1,15) = 5.56$, $MS_e = 378.4$, $p < .05$]. The presence of only one incongruent attribute was enough to slow down performance. Furthermore, when both flanker attributes were incongruent, this did not lead to a longer response relative to when only one of them was incongruent.

The second analysis compared the data of the first group, in which either flanker attribute was varied, with that of the second group, in which both flanker attributes were varied. The aim was to examine whether the flanker attribute that was kept constant influenced the processing of the attribute that was uncertain for that block. Since in the second group, the two flanker attributes varied independently, the variable of attribute uncertainty was renamed *block*. For the first group, the first block contained the trials in which the word was uncertain, and the second block contained the trials in which color was uncertain. For the second group, the attributes were uncertain in both blocks. The data was subjected to a mixed four-way group $\times$ block $\times$ word $\times$ color ($2 \times 2 \times 2 \times 2$) ANOVA. There were main effects of block [$F(1,30) = 4.20$, $MS_e = 4,717.0$, $p < .05$], word [$F(1,30) = 19.32$, $MS_e = 860.21$, $p < .001$], and color [$F(1,30) = 19.95$, $MS_e = 963.94$, $p < .001$].² In addition, there were two-way interactions between group and block [$F(1,30) = 11.49$, $MS_e = 4,717.0$, $p < .01$] and between group and word [$F(1,30) = 4.59$, $MS_e = 860.21$, $p < .05$].

Of specific interest were the two three-way interactions of group, block, and word [$F(1,30) = 7.87$, $MS_e = 501.09$, $p < .01$] and group, block, and color [$F(1,30) = 7.89$, $MS_e = 414.63$, $p < .01$]. Further analyses indicated that when the word was uncertain and the color was invariant in the first group, the effect of the flanker word was no different from

that of the second group ($F < 1$). Likewise, when the color was uncertain and the word was invariant in the first group, the effect of flanker color was no different from that of the second group ($F < 1$). This means that not only did the attribute that was varied have a congruency effect, but that the congruency effect was comparable to that obtained when both attributes varied. In other words, this adds to the impression gained from the earlier analysis that the invariant attribute had no effect on the processing of the other attribute. Finally, we compared overall RT to look for Garner-like interference. Additional analyses compared RT in the filtering-like condition (Group 2) and each block of baseline-like condition (Group 1). No significant differences were found for either comparison.

GENERAL DISCUSSION

The results of the two experiments indicate that variance of an irrelevant dimension is important for congruency effects to occur (see also, Sabri et al., 2001). This is true when an irrelevant attribute is of the same dimension as the target and even when the irrelevant dimensions are spatially separated from the target. Experiment 1 revealed that whereas invariance in the identity of a flanking stimulus led to the disappearance of the congruency effects, invariance in flanker location had no influence on the congruency effects. Furthermore, a Garner-like interference effect was found only when comparing the filtering-like condition (all dimensions uncertain) with the condition in which identity was kept constant. In Experiment 2, either flanker word or flanker color remained constant. It was found that only the congruency effect involving the attribute that remained invariant disappeared. The congruency effect of the other attribute remained the same as in the condition in which both attributes were varied independently. Therefore, the variance or lack of it in one attribute had no effect whatsoever on the congruency effect of the other attribute. Finally, in contrast to previous re-

Table 3
Mean Reaction Times (in Milliseconds) of Flanker Word and
Flanker Color for the Group in Which Each was Varied
Separately, Indicating the Interaction Between Them

Flanker Color	Flanker Word	
	Incongruent	Congruent
Incongruent	444	444
Congruent	443	426

sults (Henik et al., 1999), an interaction between flanker word and flanker color was found.

One result of Experiment 1 seems counterintuitive in the sense that uncertainty of flanker location had no influence on the extent of flanker processing. It would have seemed likely that once the participants knew where the irrelevant stimulus would appear, they could ignore it more effectively. Moreover, uncertainty in flanker location also did not slow performance significantly. The critical factor appears to be the uncertainty in location of the target (Glaser & Glaser, 1982; La Heij et al., 1993; Miller, 1991; Underwood, 1976). Other studies examining the relation of the spatial visual location in the context of the Garner task, have found that variance in location (or position) does influence performance (Baldo, Shimamura, & Prinzmetal, 1998; Clark & Brownell, 1976; Melara & Marks, 1990a, 1990b). Moreover, these studies treated location as a dimension of the same kind as dimensions determining identity (e.g., words, arrows, etc.). A fundamental difference between these studies and those cited in the previous paragraph is that the dimension of location had a large degree of dimensional overlap with the relevant dimension. Only the two dimensions of identity in the present study have dimensional overlap with the target. It is possible that a certain degree of dimensional overlap is a prerequisite for a dimension to have a modulating effect. That is, uncertainty of an irrelevant dimension will exert its influence only when this dimension overlaps with target features.

Experiment 2 revealed several interesting findings. Although variance in identity is important in determining the extent of the congruency effect, it is important only for the particular dimension involved. The word congruency effect was not influenced by the invariance in color, as was the case in the reverse. These findings support the suggestion of Henik et al. (1999) that "unattended flankers may be disassembled into their attributes" (p. 207) and may affect attended attributes separately (Treisman & Gelade, 1980; Treisman & Schmidt, 1982). However, there was an interaction between flanker word and color in this experiment, indicating that independent processing of the flanker attributes is not as straightforward as may seem. Ben-Artzi and Marks (1999) using the traditional Garner task and three different dimensions (pitch, location, and word) found that interference from two irrelevant dimensions were additive. Thus, two incongruent attributes were worse than one, unlike the present findings. However, the procedure was quite different since all the attributes that were varied were spatially integrated, and a different semantic dimension was used with different dimensional overlap between stimuli and responses (high vs. low) and a different modality (auditory stimuli). Yet, in keeping with the present study and with Henik et al.'s conclusion, Ben-Artzi and Marks concluded that performance depended on the congruency between each of the irrelevant dimensions and the relevant dimension.

Variance of the irrelevant dimension appears to be a prerequisite for congruency effects. Perceiving the irrelevant dimension is not enough, even when it can potentially

activate the same response codes as the relevant dimension. MacLeod (1998) suggested that when the color and the word are spatially separated, the only factor remaining to account for the congruency effect is response competition. This would imply that in the context of the present study, in which an irrelevant attribute was invariant, no response competition occurred since there was no congruency effect. Thus, the results indicate that variance of the irrelevant dimension leads to response competition.

The results of this study cannot determine unequivocally whether the invariant dimension reached the level of semantic activation or not, although it was clearly perceived (since the other dimension lead to a congruency effect). This finding challenges conventional accounts for the automatic processing of words in conflict tasks (e.g., Cohen, Dunbar, & McClelland, 1990; MacLeod, 1991), which would predict that once attention is allocated to the flanker word, its meaning and response code would necessarily be activated (see also Besner & Stolz, 1999). It also challenges the suggestion by Kahneman and Henik (1981), that once an object is attended (in this case, the flanker), all its attributes will be processed. The present results indicate that the task context (i.e., the identity of the stimuli preceding it) is a crucial factor in the production of congruency effects (see Pansky & Algom, 1999; Sabri et al., 2001, for similar conclusions).

It is uncertain what mechanisms account for the importance of variance and at what stage of processing they come into play. Possibly, there is some active suppression of information pertaining to an invariant dimension. Alternatively, information that remains constant undergoes some process of habituation³ and cannot gather sufficient activation that would lead to a congruency effect. This would be adaptive, since situations in which entities do not change in the environment should not affect our actions. Changes in the irrelevant dimensions could either be informative or could tap into a basic sensitivity to change. In all likelihood, different dimensions lead to different levels of sensitivity to change. Some dimensions might require less subjective change than others to influence performance. Thus, even though considered a failure of selective attention, it may be in our best interest to process surrounding irrelevant information and allow it to influence our actions, especially when it is constantly changing.

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NOTES

1. The type of dimensions varied and their number have been confounded in this experiment (we thank Robert Melara for pointing this out). In the identity invariant condition, only one dimension (location) was varied, whereas in the location invariant condition, two dimensions (word and color) were varied. The pattern of results suggests that this is not a problem, since the congruency effects were either absent altogether (in the identity invariant condition) or of the same magnitude as in the control task, in which all dimensions were varied (in the location invariant condition). Furthermore, the overall reaction time (RT) complements the pattern of congruency: When location was invariant, overall RTs did not significantly differ from the RTs when all dimensions were varied. If the number of dimensions, and not their type, determines the congruency effect and the overall RT, we would expect a smaller congruency effect and faster RTs in the location invariant condition (in which two dimensions were varied) as compared with the all dimensions vary condition (in which three dimensions were varied).

2. The main effects were also found when we analyzed the second group alone, replicating the results of the all dimensions uncertain group in Experiment 1. The first block (513 msec) was slower than the second block (466 msec) [$F(1,15) = 10.3$, $MS_e = 6,742.6$, $p < .01$]. Responses were slower for incongruent words (502 msec) relative to congruent words (478 msec) and were slower for incongruent colors (502 msec) relative to congruent colors (477 msec) [$F(1,15) = 12.3$, $MS_e = 1,493.8$, $p < .01$, and $F(1,15) = 12.9$, $MS_e = 1,526.7$, $p < .01$ for words and colors, respectively]. All interactions involving this group did not reach significance.

3. An analysis of the present data did not yield any evidence for habituation. However, habituation might have taken place during the practice trials, or within the first few trials. Such a possibility could be examined by using a more traditional Garner task, with a large participant group.

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