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Effects of background symmetry on *same-different* pattern matching: A compromise-criteria account

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Two experiments are reported, which were designed to test predictions of an account of *same-different* matching that assumes that bilaterally symmetric backgrounds provide extraneous evidence toward *same*, whereas asymmetric backgrounds provide evidence toward *different*. When all backgrounds within a block of trials are of the same type, appropriate adjustments of response criteria can be made to accommodate the irrelevant evidence and thus maintain acceptable levels of accuracy. However, when backgrounds of different types are mixed randomly, compromise criteria are adopted. This compromise-criteria account predicts distinctive interaction patterns for reaction times when blocked versus mixed presentations of various background types are compared. The predicted interactions were obtained for asymmetric- and no-noise backgrounds in Experiment 1 and for symmetric-, asymmetric-, and no-noise backgrounds in Experiment 2. The findings support the general view that extraneous display attributes are weighted into the evidence for *same* and *different*, with criteria settings used that minimize errors under the noisiest conditions.

For simultaneously presented pairs of stimuli in *same-different* matching tasks, symmetry about the vertical axis is a characteristic common to many *same* pairs. This bilateral symmetry has been shown to influence reaction time (RT) and accuracy to these pairs (Fox, 1975; Richards, 1978), more so with forms than with letters (Egeth, Brownell, & Geoffrion, 1976; Fox, 1975). The degree of symmetry about the vertical axis can be manipulated by including irrelevant noise characters in the displays. Symmetric noise has been shown to slow responses to *different* pairs more than those to *same* pairs (Krueger, 1970). In contrast, asymmetric noise has a greater interfering effect on responses to *same* pairs (Krueger, 1973). Thus, the attribute of symmetry facilitates the *same* response, while the attribute of asymmetry facilitates the *different* response.

This facilitation can be explained by assuming that symmetry introduces evidence toward *same*, whereas asymmetry introduces evidence toward *different*. When the symmetry or asymmetry is provided by means of noise stimuli, this evidence is not pertinent to the distinction between *same* and *different* pairs of forms. Thus, to avoid spurious *same* or *different* responses due to the noise, the subject must raise the acceptable level of *same* or *different* information on which to base a response. In models of information accumulation of the type that have been applied to *same-different* matching, this adjustment would be achieved through the relative settings of response criteria (Krueger, 1978; Ratcliff, 1981; Vickers, 1979).

Asymmetric noise produces an increase in the amount of evidence toward *different* that accumulates from the display. Therefore, for a subject to accurately respond "different" in blocks of asymmetric-noise trials, the criterion value for that response must be adjusted upward. Furthermore, because the relative amount of evidence for sameness across both *same* and *different* pairs is less in the presence of asymmetric noise, the *same* criterion should be adjusted downward. The opposite criteria adjustments would be expected for symmetric noise. Given that the purpose of such criteria adjustments is to hold the number of false-*different* or false-*same* responses to a minimum in the presence of the distracting noise, the primary effect of the criteria changes will be to increase RT.

When asymmetric-noise trials are mixed randomly with no-noise trials within a block, criteria appropriate for each background cannot be adopted. Rather, the criterion values must be compromises between the values that are appropriate for the blocks in which all backgrounds are of the same type. Krueger (1985; Krueger & Allen, 1987) has referred to such adjustments as *compromise criteria*.

The experiments reported in this study were conducted at Auburn University. We would like to thank Denise Matt for conducting the experiments, and Lester Krueger, Bart Farell, and two anonymous reviewers for their comments on an earlier version of the manuscript. Reprint requests should be sent to Robert W. Proctor, Department of Psychological Sciences, Purdue University, West Lafayette, IN 47907.

He obtained evidence for compromise criteria with blocked or mixed presentation of foveal and parafoveal pairs. Krueger speculated that the parafoveal pairs are influenced more by perceptual noise, thus requiring an increase in the *different* criterion and a decrease in the *same* criterion, relative to the settings used for the foveal pairs. Consistent with Krueger's compromise-criteria account, mixed presentation slowed *different* RTs more than the *same* RTs for foveal pairs, whereas the reverse relation held for parafoveal pairs.

Krueger (1985) has interpreted these and other results implicating compromise criteria within the context of his noisy operator theory (Krueger, 1978). However, the use of compromise criteria can be accommodated within a range of accumulator models in which the *same* or *different* response is based on the relative amounts of evidence for each. This includes random-walk models in general (e.g., Ratcliff, 1981), as well as other models such as Vickers' (1979) strength accumulator. Because predictions can be derived from the relative settings of criteria used when presentation is mixed versus blocked, independent of any particular model, we focus only on these settings in the present article.

In Krueger's (1985; Krueger & Allen, 1987) examination of mixed versus blocked presentation conditions, the noise for the parafoveal pairs was induced by limitations in the sensory system; this noise apparently increased the amount of difference for those pairs. If asymmetric noise from extraneous backgrounds affects criteria in a manner similar to parafoveal presentation, then a comparable pattern of results should occur when no-noise and asymmetric-noise trials are intermixed. Krueger (1973) observed such a trend for RTs between experiments in which either blocked or mixed presentation of the different noise types was used, as did Watson (1981). However, within-experiment blocking manipulations of no-noise and asymmetric-noise backgrounds have not been conducted. Experiment 1 was performed to provide such a within-experiment comparison.

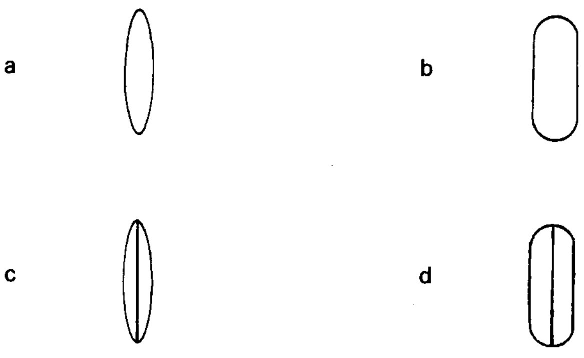

Figure 1. The forms used as target stimuli for the matching task: (a) oval; (b) racetrack; (c) filled oval; (d) filled racetrack. From "The effects of objective and perceived size properties on visual form matching" by H. D. Watson, 1981, *Journal of Experimental Psychology: General*, 110, p. 555. Copyright 1981 by the American Psychological Association. Reprinted by permission.

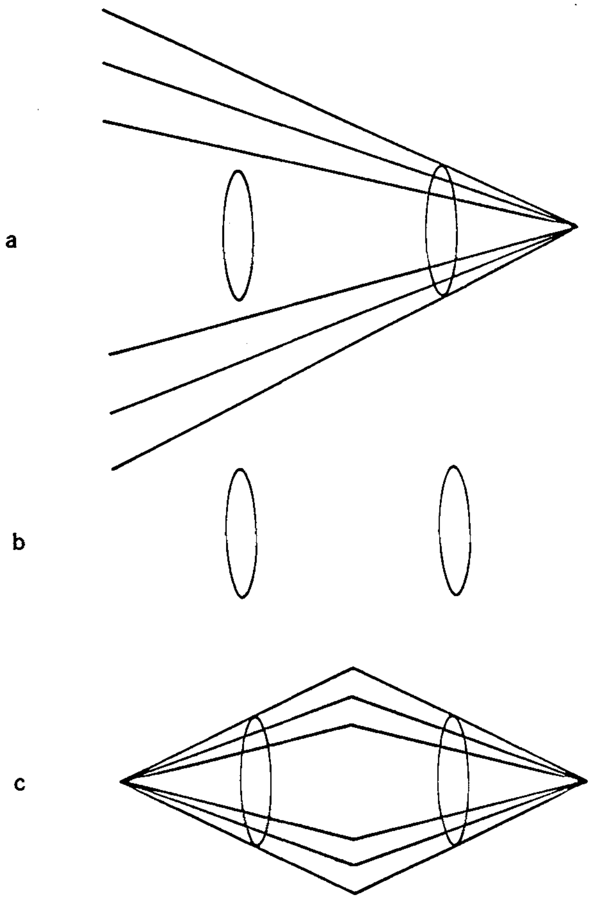

Figure 2. Examples of target forms with the (a) asymmetric-noise, (b) no-noise, and (c) symmetric-noise backgrounds. From "The effects of objective and perceived size properties on visual form matching" by H. D. Watson, 1981, *Journal of Experimental Psychology: General*, 110, p 556. Copyright 1981 by the American Psychological Association. Reprinted by permission.

Symmetric-noise backgrounds should have the opposing effect of increasing the amount of evidence suggesting sameness for both *same* and *different* pairs. The compromise-criteria account makes specific predictions for results that should be obtained when trials with the symmetric background are mixed with trials of the other two types. These predictions were tested in Experiment 2.

EXPERIMENT 1

The target-stimulus pairs and the noise stimuli were those used by Watson (1981). The two target stimuli on each trial were selected from four forms, oval or "racetrack" figures that either contained or did not contain a centered vertical line (see Figure 1). In Experiment 1, we examined blocked versus mixed presentation of two different background conditions—an asymmetric-noise background (a variant of the Ponzo illusion; see Figure 2a) or a plain, no-noise background (see Figure 2b).

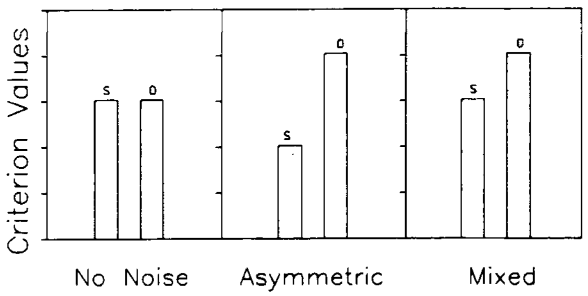

Figure 3. Relative levels of response criteria under no-noise, asymmetric-noise, and mixed blocking conditions.

Figure 3 illustrates the relative change in criterion values across presentation conditions, with the ordinal properties providing the basis for predictions. The criteria for the no-noise block are shown arbitrarily as being equal, because the current framework specifies only the changes in criteria across conditions relative to the no-noise baseline. In the asymmetric-noise block, the noise that is present on all trials makes all pairs look more different, resulting in the *different* criterion being raised and the *same* criterion lowered, relative to the criteria used in the no-noise block. When the asymmetric- and no-noise conditions are randomly intermixed, compromise criteria should be adopted. Assuming that these criteria are set conservatively to minimize errors, the *same* criterion should be elevated relative to that used in the asymmetric-noise block and the *different* criterion should be elevated relative to that used in the no-noise block. Thus, the compromise-criteria hypothesis predicts that mixing the two types of backgrounds should slow *different* RTs relative to *same* RTs in the no-noise condition and *same* RTs relative to *different* RTs in the asymmetric-noise condition.

Method

Subjects. The subjects were 48 students enrolled in undergraduate psychology courses at Auburn University. Each subject participated in two sessions on successive days for extra credit toward his or her course grade.

Apparatus. The stimuli were presented in a Gerbrands Model T-AB two-field tachistoscope, with the stimulus and interval durations timed by the tachistoscope's control unit. Responses were made by pressing one of two microswitches positioned under the left and right index fingers. For half of the subjects, the left-hand switch was assigned to the *same* response and the right-hand switch to the *different* response, whereas for the other half of the subjects the relation was reversed. The RTs were recorded to the nearest millisecond on a digital counter.

Stimuli. The stimuli for the matching task were pairs of forms from the set shown in Figure 1. These forms (oval and racetrack figures, with and without a centered vertical line) were used initially by Watson (1981). The standard forms all measured 2.85 cm in height, subtending a visual angle of approximately 3° in height as viewed by the subject. The standard oval and racetrack figures subtended widths of 0.75° and 1.08°, respectively.

The matching-task stimuli were presented against either a plain background or an asymmetric background (a six-line variant of the Ponzo illusion; see Figure 2a). In the context of the asymmetric-noise background, however, the forms appear unequal in size. Watson (1981, Experiment 2) determined that for most subjects the form at the base of the illusion (the open end) appeared to be as large as the form at the apex (the closed end) when its height was increased by 0.28 cm. Therefore, an objectively unequal size condition (for which the size of the target stimuli was subjectively equal in the context of the asymmetric-noise background) was used in addition to one in which the forms were objectively equal in size. When unequal, one of the two forms had a height of 3.13 cm. Against the asymmetric-noise background, this larger form was always at the base of the background.

The centers of the two forms for each pair were separated by a visual angle of 4.67°. The forms appeared laterally and equidistant from a red fixation dot. The field containing the fixation dot was kept on at all times other than when the stimulus was presented. Each trial consisted of a 0.5-sec warning tone of 1 kHz, followed by a 0.5-sec interval, and then by presentation of the stimulus pair for 1 sec.

Lists were constructed for presentation of the background conditions in blocks of only one type and in sets for which they were intermixed randomly. For blocked presentation, series of 96 trials (48 *same* and 48 *different*) were constructed. Half of the *same* and half of the *different* pairs were objectively equal in size, with the remainder being objectively unequal. These factors (*same-different*; objectively equal and unequal) were varied randomly within the blocks. For mixed presentation, the only change was that the type of background (no-noise, asymmetric noise) was also varied randomly from trial to trial, so that there was a single set of 192 trials, rather than two blocks of 96. In both the blocked and the mixed conditions, the asymmetric-noise pattern could have its apex toward the left or right side of the display, with the two orientations used equally often.

Procedure. Subjects participated in a practice session and a test session. Twenty-four subjects received blocked presentation of the backgrounds in the practice session, and the other 24 subjects received mixed presentation. Half of the subjects from each of these groups were tested with blocked presentation in the test session, whereas half were tested with mixed presentation. No effects of the nature of practice were apparent in either this experiment or Experiment 2, so the results are collapsed across the presentation schedule used for the practice session.

The subjects received five warm-up trials prior to each block in the blocked condition and five warm-up trials prior to the mixed condition. The subjects were instructed to base their judgments only on the forms of the figures (i.e., the shape and presence/absence of a bar), disregarding any size differences that were present. The instructions stressed that the subjects should respond as quickly and accurately as possible while making few errors. Error trials were repeated at the end of the session. Only correct responses were included in the analysis of RT data.

Results

Mean RTs and percentages of errors were obtained for each subject in the test session, as a function of pair type (*same*, *different*), background (no noise, asymmetric noise), blocking condition (blocked, mixed), and objective size relation (equal, unequal). RTs greater than 2 sec ($<1\%$) were excluded from the computation of mean RTs.

An analysis of variance performed on the RT data indicated significant main effects for pair type [$F(1,46) = 30.1$, $p < .001$] and background [$F(1,46) = 129.9$, $p < .001$]. (See Figure 4.) These effects are attributable to responses being faster for *same* pairs ($M = 538$ msec)

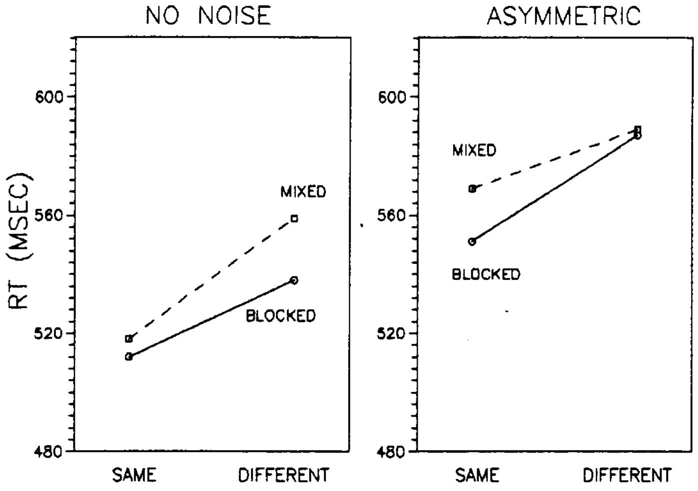

Figure 4. Mean RTs in Experiment 1, as a function of pair type (*same*, *different*) and blocking (blocked, mixed), for no-noise (left panel) and asymmetric-noise (right panel) backgrounds.

than for *different* pairs (M = 568 msec) and faster with the no-noise background (M = 532 msec) than with the asymmetric-noise background (M = 574 msec).

There was no significant main effect for blocking ($F < 1.0$). However, the three-way interaction of blocking × background × pair type was significant [$F(1,46) = 6.57$, $p < .02$]. This interaction is attributable to mixed presentation slowing primarily the RTs to *different* pairs for the no-noise background and the RTs to *same* pairs for the asymmetric-noise background (see Figure 4), as predicted by the compromise-criteria hypothesis.

The only other significant effects for the RT data were the size × background and the size × background × pair type interactions [Fs(1,46) = 6.60 and 52.6, ps < .02 and .001, respectively]. (See Table 1.) These terms reflect replication of Watson's (1981) perceived-size effect. *Same* responses were slowed 24 msec by the presence of an objective size difference for the no-noise background, but were speeded 27 msec by the presence of an objective size difference for the asymmetric background. Reversed effects of lesser magnitude were evident for the *different* pairs, with responses speeded by 12 msec when an objective size difference existed on the no-noise background and slowed by 7 msec by an objective size difference on the asymmetric background. No higher order interactions of size with blocking were significant. Thus, although the size illusion induced by the asymmetric noise influenced RTs systematically, the magnitude of the perceived-size effects did not depend on whether the noise was presented in a blocked or a mixed manner.

Error rates were low and generally consistent with the RT data (see Table 2). The only effect to attain significance for the error data was the blocking × background interaction [$F(1,46) = 8.18$, $p < .01$]. This interaction reflects the fact that although there was little difference in error rates between blocked and mixed presentation for the no-noise background, error rates were less with blocked than with mixed presentation for the asymmetric-noise background.

Discussion

Responses were slowed in the asymmetric-noise block, relative to the no-noise block. This overall slowing likely reflects increased difficulty in discriminating *same* and *different* pairs when background noise is present. More important, intermixing no-noise and asymmetric-noise trials had opposing effects for the two types of background. For the asymmetric background, *same* RTs were increased when presentation was mixed relative to blocked, whereas for the no-noise background, *different* RTs were increased. This interaction pattern is predicted by a compromise-criteria account of the type proposed by Krueger (1985).

Such an account assumes that subjects base their responses on the overall similarity or dissimilarity of the

Table 1
Mean Reaction Times (in Milliseconds) and Percentages of Errors in Experiment 1, as a Function of Size Relation, Background (No Noise, Asymmetric), and Pair Type (*Same*, *Different*)

	Size Relation			
	Objectively Equal		Objectively Unequal	
Pair Type	RT	% Error	RT	% Error
	No Noise			
Same	503	1.2	527	2.7
Different	554	1.5	542	1.8
	Asymmetric			
Same	574	1.9	547	2.6
Different	584	2.0	591	2.2

Table 2
Mean Percentages of Errors in Experiments 1 and 2, as a Function of Blocking, Background (Symmetric, No Noise, Asymmetric), and Pair Type (*Same*, *Different*)

	Background					
	Symmetric		No Noise		Asymmetric	
Blocking	*Same*	*Different*	*Same*	*Different*	*Same*	*Different*
			Experiment 1			
Blocked			2.1	1.7	1.4	1.7
Mixed			1.8	1.6	3.1	2.5
			Experiment 2			
Blocked	1.7	1.4	0.7	1.9	1.0	1.9
Mixed	1.4	1.6	1.7	3.3	3.8	2.1

stimulus displays. The asymmetric-noise background increases the dissimilarity of the displays because of the asymmetry that it introduces between the two display sides. When presentation is blocked according to background, criteria are adjusted so that the relative effects of the asymmetric background can be accommodated. However, when the no-noise and asymmetric backgrounds are intermixed randomly, compromise criteria are adopted. The *same* criterion apparently is set approximately as it is when only the plain background is possible, whereas the *different* criterion is set as it is when only the asymmetric background is possible. This conservative strategy will minimize the proportion of false-*same* errors for no-noise trials, as in the blocked no-noise condition, while minimizing the proportion of false-*different* errors for the asymmetric-noise trials, as in the blocked asymmetric-noise condition.

EXPERIMENT 2

To provide an additional test of the compromise-criteria account, in Experiment 2 the symmetric background was also included (see Figure 2c). Blocked versus mixed presentation of the no-noise, symmetric, and asymmetric backgrounds was evaluated. The relative change in criterion values across presentation conditions is shown in Figure 5. Again, the criteria for the no-noise block are portrayed arbitrarily as being equal. The relative shifts in criteria for blocks of asymmetric noise are the same as those described for Experiment 1. Furthermore, in blocks of symmetric noise, the *same* criterion is elevated and the *different* criterion lowered, relative to those in the no-noise blocks.

When the types of background are intermixed, the criteria should be adjusted to minimize the false-*same* and false-*different* responses induced by the noisy background conditions. The *same* criterion should be set at approximately the same level as for the symmetric-noise block and the *different* criterion at the same level as for the asymmetric-noise block (see Figure 5). Thus, an interaction pattern for the symmetric- and asymmetric-noise trials is predicted that should be qualitatively similar to that observed for the no-noise and asymmetric-noise trials in Experiment 1.

Two additional predictions can be made for Experiment 2. First, because the criteria shifts between blocked and mixed presentation are more extreme than in Experiment 1, the interaction should be of greater magnitude. Second, whereas the blocking manipulation affected only *different* RTs for the no-noise trials in Experiment 1, both *same* and *different* RTs for these trials should be slowed when all three backgrounds are mixed. This prediction is made because the *same* criterion in the mixed condition should be set to accommodate the symmetric-noise background. Thus, both the *same* and *different* criteria should be more conservative than they were in the block of no-noise trials (see Figure 5).

Method

Forty-eight students from the same subject pool as in Experiment 1 served as subjects, none of whom had participated in that experiment. Each subject performed two sessions, the first of which was practice. Twenty-four subjects then were tested using mixed presentation and 24 using blocked presentation of the backgrounds. The remaining variables, pair type and type of background, were manipulated within subjects.

The experiment was conducted on the apparatus used for Experiment 1. The stimuli and procedure were similar to those used previously, with the following exceptions. Only the objectively equal target stimuli were used. Blocked sessions consisted of three blocks (one for each background) of 48 trials each. Mixed sessions included 144 trials, 48 for each background, randomly intermixed.

Results

Mean RTs and error rates in the test session were obtained for each subject as a function of pair type, background, and blocking. The RT data (see Figure 6) showed main effects for pair type [$F(1,46) = 53.3$, $p < .001$] and background [$F(1,46) = 96.1$, $p < .001$]. As in the previous experiments, responses were faster to *same* pairs ($M = 551$ msec) than to *different* pairs ($M = 581$ msec) and with the no-noise background ($M = 526$ msec) than with either the asymmetric ($M = 598$ msec) or symmetric ($M = 573$ msec) backgrounds.

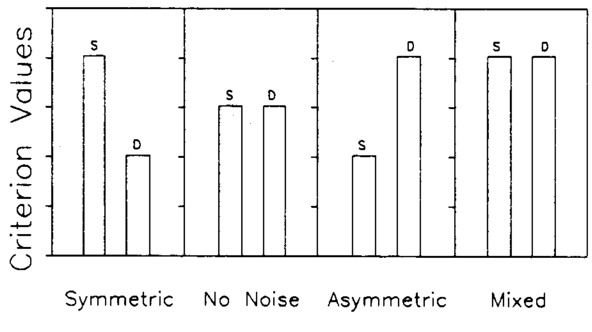

Figure 5. Relative levels of response criteria under symmetric-noise, no-noise, asymmetric-noise, and mixed blocking conditions.

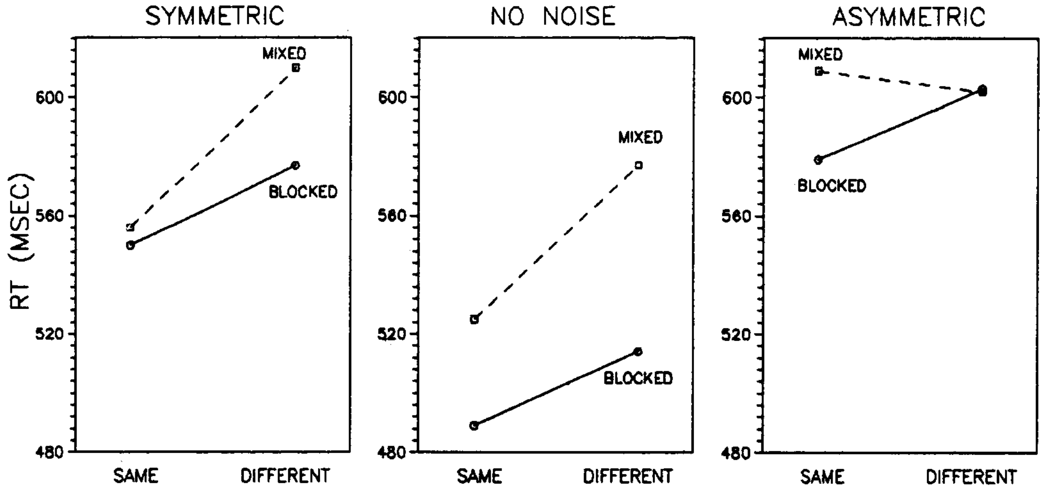

Figure 6. Mean RTs in Experiment 2, as a function of pair type (*same*, *different*) and blocking (blocked, mixed), for symmetric-noise (left panel), no-noise (center panel), and asymmetric-noise (right panel) backgrounds.

The other significant terms were the interactions of background × blocking [$F(2,92) = 6.37$, $p < .01$], background × response [$F(2,92) = 8.65$, $p < .001$], and background × blocking × response [$F(2,92) = 7.55$, $p < .01$]. The first of these interactions is attributable to responses' being faster overall with blocked presentation ($M = 501$ msec) than with mixed presentation ($M = 551$ msec) for the plain background [$F(1,46) = 6.33$, $p < .02$], but not for the other two backgrounds ($Fs < 1.0$). This predicted main effect of blocking for the no-noise trials contrasts with the results of Experiment 1, in which only the *different* RTs were slowed by blocking.

The background × response interaction reflects correct *same* responses being faster than correct *different* responses for the no-noise and symmetric backgrounds, with only a slight tendency in this direction for the asymmetric background. The most critical term is the three-way interaction, which reflects a pattern similar to that obtained in Experiment 1. For the asymmetric background, blocking interacted with pair type [$F(1,46) = 6.40$, $p < .02$]: *same* RTs were 30 msec slower with mixed presentation than with blocked presentation, whereas *different* RTs were 1 msec faster. In contrast, for the symmetric- and no-noise backgrounds, blocking had a greater effect on *different* RTs than on *same* RTs [$Fs(1,46) = 6.77$, $p < .02$, and 3.86, $p < .06$, respectively]. For the symmetric background, *different* responses were 33 msec faster with blocked than with mixed presentation, whereas *same* responses were only 6 msec faster; for the no-noise background, the corresponding advantages with blocked presentation were 63 msec for *different* responses and 36 msec for *same* responses. Thus, mixed presentation slowed *same* responses with the asymmetric background, but slowed *different* responses relative to *same* responses with the symmetric and no-noise backgrounds.

The error rates were low and showed trends consistent with the RT data (see Table 2). The pair type × background interaction was significant [$F(2,92) = 3.88$, $p < .025$]. False-*same* errors outnumbered false-*different* errors with the no-noise background, false-*different* errors predominated with the asymmetric background, and the two types of errors occurred approximately equally often with the symmetric background. The three-way interaction of pair type and background with blocking also was significant [$F(2,92) = 3.18$, $p = .05$], indicating that the predominance of false-*different* errors for the asymmetric background was only present when the backgrounds were mixed.

Discussion

The results are consistent with the view that when no-noise, symmetric, and asymmetric backgrounds are intermixed, compromise criteria are adopted to minimize the false-*same* and false-*different* responses that could occur under conditions of noise. Consequently, *different* responses were slowed for symmetric-noise trials in the mixed condition relative to the blocked condition, whereas *same* responses were slowed for asymmetric-noise trials. This interaction was approximately twice the magnitude of that obtained when just the no-noise and asymmetric backgrounds were used in Experiment 1.

Furthermore, unlike in Experiment 1, *same* RTs as well as *different* RTs were slowed for the no-noise trials when they were mixed with the other background conditions. This finding is predicted by the compromise-criteria hypothesis as a function of the composition of the mixed lists in the respective experiments. In Experiment 1, in which only no-noise and asymmetric-noise trials were mixed, the *same* criterion in the mixed condition would correspond to that used in the no-noise block. However, when all three backgrounds were mixed, as in Experiment 2, the *same* criterion would be set higher in the mixed condition than in the no-noise block to accommodate the additional evidence toward similarity contributed by the symmetric noise.

Although mixed presentation slowed both *same* and *different* responses on no-noise trials in Experiment 2, the *different* responses were slowed more than the *same* responses. The magnitude of this interaction was similar to that for the symmetric-noise trials. However, the comparison of the relative magnitudes for the no-noise and symmetric-noise trials is not meaningful. For the symmetric-noise trials, the *same* criterion in the mixed condition should be comparable to that used in the blocks of symmetric noise. Thus, the relative change in RTs that occurs in moving from the blocked to the mixed condition can be attributed primarily to the adjustment made in the *different* criterion. In contrast, for the no-noise trials, both the *same* and *different* criteria should change when presentation is mixed as opposed to blocked. Consequently, the relative change in the criteria settings is not known. Although mixed versus blocked presentation had similar effects on *different* responses for no-noise and symmetric-noise trials, it may not reflect analogous criteria adjustments.

GENERAL DISCUSSION

In previous studies, it has been demonstrated that extraneous properties of stimulus displays can influence RTs in *same-different* matching tasks. For example, Krueger (1970, 1973) and others have shown that symmetric- and asymmetric-noise backgrounds have opposing effects on RTs. We propose that these effects occur because the properties of symmetry and asymmetry cause spurious accumulations of evidence toward *same* and *different*, respectively. Because this evidence does not discriminate between *same* and *different* pairs, the response criteria must be adjusted if accuracy is to be maintained.

When asymmetric noise is added to the displays, the amount of evidence for difference accumulated to trigger a *different* response will necessarily be more than the amount required when no noise is present. Conversely, the amount of evidence for sameness that is required for subjects to respond *same* should be less. Thus, asymmetric noise should affect not only the buildup of information, but also the settings of the *same* and *different* response criteria.

When the trials with asymmetric noise are mixed with no-noise trials, thus making the presence of noise from trial to trial uncertain, subjects must adopt compromise criteria. The *same* and *different* criteria should be set to avoid many false-*same* and false-*different* responses, respectively. Thus, the *same* criterion will be relatively close to that employed for blocks of no-noise trials, and the *different* criterion will approximate that used for blocks of asymmetric-noise trials. This formulation leads to the prediction that *different* responses for no-noise trials should be slowed when those trials are mixed with asymmetric-noise trials, whereas *same* responses should be slowed for the asymmetric-noise trials.

This prediction was tested in Experiment 1, with the stimuli employed by Watson (1981). The predicted three-way interaction of pair type × background × blocking was obtained. This pattern of results suggests that the criteria chosen for the mixed conditions represent a conservative choice. That is, criteria are adopted to minimize errors for the types of trials on which they are most likely to occur, without regard to optimization of RTs for the trial types in which errors are less likely to occur. For the latter trials, errors will be minimal, but RTs will show an increase over those obtained in blocked conditions.

Symmetric-, asymmetric-, and no-noise backgrounds were intermixed in Experiment 2. Conservative criteria would correspond to the *same* criterion used for the symmetric-noise block and the *different* criterion used for the asymmetric-noise block. This would produce an interaction for these backgrounds similar to that obtained for the no-noise and asymmetric-noise backgrounds in Experiment 1, but of greater magnitude. Also, both the *same* and *different* criteria should increase for the mixed no-noise trials relative to the blocked, unlike in Experiment 1, thus slowing both the *same* and *different* RTs. These predicted results were obtained.

Thus, the results of the two experiments are consistent with an account that applies Krueger's (1985) compromise-criteria hypothesis to the accumulation of evidence. Specifically, symmetric and asymmetric noise influence the accumulation of information indicating sameness and difference, respectively, as well as the choice of criteria that are used to select responses. The criteria employed when noise types are intermixed reflect a compromise necessary to maintain accuracy on the noisiest trials.

Three general features characterize the account that we propose. First, symmetry and asymmetry directly affect the accumulation of information indicating sameness and difference, even when irrelevant. This may influence the discriminability of the *same* and *different* pairs. However, contrary to accounts that attribute the qualitative effects of symmetry to early perceptual and comparison processes (e.g., Fox, 1975; Richards, 1978), ours assumes that these effects are due to response-selection processes. Second, in blocks of trials that contain only one kind of noise, opposing shifts of the *same* and *different* response criteria occur to compensate for the relative changes in sameness and difference. For asymmetric noise, the *different* criterion is raised and the *same* criterion lowered, whereas for symmetric noise, the *same* criterion is raised and the *different* criterion lowered. Third, when two or more types of noise are mixed from trial to trial, compromise criteria are adopted. These criteria settings are chosen conservatively to minimize the number of errors produced on the noisiest trials.

Although models of information accumulation are widespread in psychology (see, e.g., Luce, 1986), there has been relatively little understanding of the factors that determine placement of the response criterion. In Ratcliff's (1987) words, "There are few accepted psychological theories of criterion placement" (p. 277). Yet, without theoretical accounts of why particular response criteria are adopted in specific situations, the value of accumulation models as psychological explanations is greatly reduced (Proctor, 1986; Proctor & Weeks, 1989). Thus, perhaps the most important contribution of Krueger's (1985; Krueger & Allen, 1987) work on compromise criteria and the extension provided by the present investigation is the demonstration of general principles of criterion placement in speeded matching tasks. These principles should provide a foundation for the development of psychological theories of criterion placement.

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