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Nominal and physical decision criteria in *same-different* judgments

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We propose a model in which the physical and nominal dimensions of letter pairs are compared independently of whether subjects use physical (shape task) or nominal (name task) identity as the decision criterion. We attempt to explain the fast-*same* effect, the preponderance of false-*different* errors, and the *nominal-physical* disparity as results of congruent and incongruent outputs of physical and nominal comparison devices that function in both tasks. Subjects performed both tasks with and without response deadlines. The stimuli were presented foveally or unilaterally to one or the other hemisphere. With foveal presentations, the *nominal-physical* disparity disappeared when congruent and incongruent cells were compared, the fast-*same* effect occurred only in the shape task, and there was a preponderance of false-*different* errors only in the name task. Response times and error patterns from centrally presented trials conformed to the predictions of the model. Performance patterns from the lateralized trials conformed only partially. The implications of the data are discussed in the context of several theoretical models of *same/different* judgments.

The way in which humans make *same-different* judgments is of interest to cognitive psychologists because these judgments are a component of many paradigms used to investigate a wide variety of cognitive phenomena and because close scrutiny of this seemingly simple task has revealed a number of puzzling and interesting issues. We are specifically interested in the case in which pairs of letters are to be compared for shape or name identity. Much research has focused on this paradigm, and this has resulted in the identification of three robust characteristics of the tasks: (1) the *nominal-physical* disparity—classifying letters by nominal identity (the name task) takes longer than classifying them by physical identity (the shape task); (2) the fast-*same* effect—subjects can classify two identical stimuli as *same* faster than they can classify two nonidentical stimuli as *different*; and (3) error patterns—subjects make more false-*different* errors than false-*same* errors. Farell (1985) has presented an extensive and critical review of this literature.

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The research presented here had two goals: the first was to look closely at differences between performance patterns in the name and shape tasks. We will attempt to explain the *nominal-physical* disparity, the fast-*same* effect, and the error patterns as results of congruent and incongruent outputs of parallel physical and nominal identity comparison processes that function in both tasks. The second goal is a neuropsychological investigation of the tasks. That is, the majority of cognitive models rely on data collected from presentation procedures where stimuli are presented foveally. Given what we know about hemispheric specialization for *same-different* judgments (Boles, 1981; Boles & Eveland, 1983; Eviatar & Zaidel, 1992), we tested the predictions of these models in a lateralized procedure.

Cognitive Models

Posner and Mitchell (1967) reported that subjects took longer to classify letters on the basis of nominal identity than on that of physical identity. They proposed that this discrepancy was due to the deeper levels of processing needed for the name task than for the shape task. Proctor (1981) has called this the *name-physical* disparity and has adopted the levels of processing explanation for this disparity for both "same" and "different" responses under shape and name instructions. Other investigators have suggested that the shape task and the name task are done in different ways such that *same*-shape stimuli are processed faster than other types of stimuli, and that *different* stimuli are processed differently in the two tasks (Bamber, 1972; Beller, 1971; Farell, 1988; Proctor, 1981). We will test this hypothesis by including *same*-name-*different*-case pairs (e.g., Aa) among the *different* stimuli in the shape task. If processing in the shape task utilizes only visual templates, these stimuli should result in faster "different" responses in the shape task than "same" responses in the name task. However, if name processing occurs in the shape task, these stimuli should result in equivalent response times (RTs) in the two tasks, and in more false-*same* errors in the shape task. In this view, the name and physical shape of the stimuli are considered as different dimensions.

In our experiment, the particular combination of experimental conditions resulted in both congruent and incongruent outputs of processing of these dimensions. We propose that in a matching task, these dimensions are processed simultaneously and automatically. The confluence model that we propose makes two basic assumptions. First, both shape and name processing occur for each member of the stimulus pair irrespectively of the decision criterion (shape or name) required for the task. Second, before the response choice is made, the outputs of the two processors are computed automatically and reach a point of confluence where they affect the final decision (even when they are irrelevant). The shape and name dimensions are computed separately via processors of the noisy operator type proposed by Krueger (1978). The combination of outputs from the two processors results in different outcomes for the two experimental tasks. These combinations are shown in Table 1.

For *same*-shape pairs, the outputs of the processors are congruent: both have output = "same." For *different*-shape pairs, the outputs are either congruent (both have output = "different"), or incongruent, as in the case of stimulus pairs of the Aa type. Here the shape processor results in output = "different," but the name processor results in output = "same." This output must be disregarded in order to make the correct response. For name decisions, an opposite pattern of outputs exists: the outputs are always congruent for "different" responses, and sometimes incongruent for "same" responses. In the study described here, we did not use AA-type stimuli in the name task, in order to ensure that "same" responses in this task would always be based on name rather than on physical identity. In our model, congruent conditions result in fast, accurate responses, and incongruent conditions result in slower responses and more errors. Thus, on the basis of congruity alone, we predicted a fast-*same* effect for the shape task together with more false-*same* errors, and a fast-*different* effect for the name task with more false-*different* errors.

It is important to note that we are not claiming that the processing of the different dimensions necessarily takes the same amount of time. Rather, the point is that the response is always based on input from both processors. Classical priming explanations posit that when two processes take differing amounts of time, the fast one will interfere with the slower one more than vice versa. If that were true, the prediction would be that the output of the shape processor would have a greater effect on response choice than would the output of the name processor. That is, there would be more interference in responding "same" to Aa pairs under the name instructions than in responding "different" to these stimuli under the shape instructions. The model we propose predicts that interference will be equivalent in these two conditions.

Previous research supports the hypothesis that the mechanism that produces the fast-*same* effect may not be involved in the name task. Proctor (1981, Experiment 1, Experiment 3A) asked subjects to use the shape and name criteria simultaneously. He found smaller fast-*same* effects for nominally *same* pairs than for physically *same* pairs. Garner, Podgorny, and Frasca (1982) defined stimulus dimensions on a continuum from physical to cognitive, such that a pair to be compared could be defined as *same* on a physical versus a more arbitrary (learned) dimension. They found that when the sameness rule was cognitive, there was no fast-*same* effect (nonsignificant 10-msec advantage for *same* stimuli in Experiment 1A and a nonsignificant 6-msec fast-*different* effect in Experiment 2). *Same*-name stimuli are on the cognitive end of the continuum and *same*-shape stimuli are on the physical end of this dimension.

Krueger (1978, 1983) has presented a model of the shape task in which encoding and comparison are assumed to be inherently noisy. The source of the fast-*same* effect is the functioning of a discrepancy counter that operates on these noisy representations. Noise can result in spurious discrepancy counts, resulting in a rechecking procedure that takes time. Noise more often results in a discrepancy count signaling rechecking for *different* than for *same* stimuli, so that the mean time to respond "same" is faster than the mean time to respond "different." In addition, noise more often results in *same* pairs being encoded as *different* than vice versa, so that more errors will be made on *same* stimuli than on *different* stimuli. Krueger and his colleagues (Krueger & Shapiro, 1982; Krueger, Stadtlander, & Blum, 1992) have suggested that internal noise can operate on cognitive representations in the same way as it distorts visual representations. Thus, we assume that internal noise affects the functioning of the name processor in the same way as it affects the functioning of the shape processor. However, the effects of the congruency of the outputs of these processors will have opposing ef-

Table 1
Outcome Combinations of the Processor Output for the Shape and Name Tasks

	Criteria for Correct Response	
Pairs	Name Task	Shape Task
Same	AA* or Aa shape = same or different name = same	AA shape = same name = same
Different	Ag shape = different name = different	Ag or Aa shape = different name = same or different

* AA-type stimuli were not used in this experiment in the name task.

fects on RT and errors, depending on the decision criterion (name or shape) that the subjects are using. In the shape task, congruency will serve to enhance the effects of internal noise on RT (the fast-*same* effect), but to mitigate the effects of internal noise on errors (we predict more false-*same* than false-*different* errors). For the name task, congruency of outputs will mitigate, and may even reverse, the fast-*same* effect, but will enhance the effects of internal noise on errors (we predict a preponderance of false-*different* errors).

Previous research supports the hypothesis that all dimensions of the stimuli are processed automatically. Beller (1971, Experiment 2) found that in the shape task, subjects took more time to reject *different* stimuli that were nominally *same* (e.g., Aa) than they did to reject stimuli that were nominally *different* (e.g., Ag). He also looked at the effects of a priming letter on these decisions and found that when shape and name criteria were used in the same block (subjects responded "same" to either physical or nominal identity), *same*-shape (e.g., AA) decisions were primed even when the prime was different in case from the stimulus. Beller always found a larger priming effect for *same*-name stimuli, but only when the prime was presented acoustically was there a significant difference in the amount of priming between *same*-shape and *same*-name decisions. In addition, in Experiment 2, in which only the shape criterion was used, he found that priming decreased the number of errors for *same*-shape stimuli (AA), but increased them on *same*-name-*different*-shape stimuli (Aa). That is, priming made it even harder for subjects to classify Aa as *different*, even when the name criterion was not used.

Many studies have explored the general effects of extraneous variables on the shape decision judgment (Eriksen, O'Hara, & Eriksen, 1982; Garner, 1988; Hawkins, McDonald & Cox, 1973; Hawkins & Shigley, 1972; Krueger, 1970, 1973; Miller, 1982; Proctor, Van Zandt, & Watson, 1990; St. James & Eriksen, 1991). In general, the finding is that irrelevant aspects of the stimulus displays seem to be processed automatically, and affect both RT and error rates. When irrelevant dimensions are compatible with the correct response ("same" on *same* stimuli and "different" on *different* stimuli), facilitation of the response has been found (this is not true in all cases, but floor effects on RT may explain the exceptions); when the irrelevant dimensions are not compatible ("different" for *same* stimuli and "same" for *different* stimuli), RTs are longer and more errors are made.

Even when no irrelevant stimulus characteristics are manipulated as an independent variable, these paradigms tend to result in a preponderance of false-*different* errors. Eriksen and his colleagues (Eriksen et al., 1982; St. James & Eriksen, 1991) have proposed a response competition model in which information that primes either a "same" or a "different" response accumulates as the percept develops. The percept develops in such a way that global features (which many letters share) develop before more local features, which can distinguish *different* stimuli from each other. Thus, both *same* and *different* stimuli produce early priming for a "same" response. When the stimuli are *different*, this response competes with the correct response. *Same* stimuli do not accumulate priming for the "different" response, so "same" responses are executed faster. Both Eriksen's response competition model and Krueger's noisy operator theory explain the preponderance of false-*different* errors by assuming that random noise in the visual perceptual system results in *same* stimuli appearing *different* more often than *different* stimuli appear identical. Eriksen et al. (1982) believe that errors on *different* trials occur as a result of premature responses, before the percept has developed enough so that fine discriminations can be made between letters. Krueger and Chignell (1985) have shown that under high speed stress, this missing feature principle predominates, whereas the effects of internal noise resulting in rechecking proposed by the noisy operator theory predominate with low speed stress. They found more false-*same* errors in a deadline procedure when the responses occurred in the first 300 msec, and more false-*different* errors when responses occurred at longer deadline intervals.

This hypothesis was tested in the present experiment by having subjects perform both the shape and the name task under two conditions: a conventional letter matching task (the no-deadlines condition), and a response deadline condition. In the latter condition, speed-accuracy tradeoff functions (SATFs) and speed-bias functions were computed for each subject in each experimental condition. The SATFs were calculated by using d', the signal detection index of sensitivity that is a bias-free index of accuracy. Speed-bias functions were calculated by using β, the signal detection index of bias. The bias measure was calculated on the basis of the false-*different* and false-*same* errors. The use of these signal detection measures is based on several assumptions. First, we assume that *same* and *different* letter pairs are perceived as distributed along a single dimension, a "sameness" index that is computed by subjects and applied to both distributions. Second, we assume that these distributions are Gaussian, and that they have equal variances.

By manipulating the amount of time that subjects had for processing the stimuli in the response deadline condition, we attempted to alter both the quality of the percept on which the comparison stage operated, and the number of rechecking cycles that could be initiated. In addition, unlike in the paradigm used by Krueger and Chignell (1985), the deadlines were varied randomly, in such a way that subjects never knew at the beginning of a trial how much time they had for performing the task. Thus, subjects could not vary their response choice strategy accordingly, and this allowed us to see changes in error patterns resulting from properties of processing, not from preprogrammed changes in decision bias.

Hemispheric Effects

The shape and the name tasks have been used in neuropsychological paradigms because they have been thought to require differential hemispheric abilities. The abilities subserving the shape task have been thought to be specialized in the right hemisphere (RH) or available to both hemispheres, so that this task should result in a left visual field advantage (LVFA) or no visual field advantage. The abilities subserving the name task have been thought to be specialized in the left hemisphere (LH), so that this task should result in a right visual field advantage (RVFA). Boles (1981) reviewed this literature and reported that such results were rare—the modal finding consisted of no difference between the visual fields for both tasks, or contradictory visual field advantages. Boles and his colleagues (Boles, 1986; Boles & Clifford, 1989; Boles & Eveland, 1983) have proposed an alternative to the shape-visual name-phonological account of the letter matching task. Specifically, they propose that shape decisions are made by a visual matching process, while name decisions are made by a visual generation process whereby each member of a pair automatically generates both its upper- and its lowercase representations, and both of these representations are compared. Boles and his colleagues assert that the hemispheres do not differ in their ability to perform these tasks. Furthermore, Eviatar and Zaidel (1992) have shown that the SATFs for these tasks are equivalent in the two hemispheres.

We investigated whether the hemispheres would achieve equivalent performance in the same manner by looking at other indices of performance strategy (the fast-*same* effect and error patterns) and by testing whether they were equivalent in the two visual fields. In the present experiment, stimuli appeared in one of three spatial locations in the visual field: in central vision (CVF), to the left of fixation (LVF), or to the right of fixation (RVF). This allowed us to compare performance when the stimuli were presented as they are in conventional cognitive paradigms (in central vision), and when the stimuli were presented initially only to either the right or the left hemispheres.

To summarize, we proposed that the physical and nominal identity of the stimuli are processed automatically, in parallel, and that they affect responses in such a way that experimental conditions in which the outputs of processing the dimensions are congruent (e.g., AA and Ag) will result in fast, equivalent RTs, and conditions in which the outputs are incongruent (Aa) will result in slower RTs and more errors, irrespectively of the decision criterion. That is, there will be more false-*same* errors in the shape task, and more false-*different* errors in the name task. Krueger and Chignell (1985) have suggested that under high speed stress the missing-feature principle proposed by Eriksen et al. (1982) predominates, resulting in more false-*same* errors, and that when subjects have more time to prepare their response, the internal noise principle predominates, resulting in more false-*different* errors. However, if incongruence of outputs affects performance even in short deadlines, we should see a preponderance of false-*same* errors in the shape task, but reliably more false-*different* errors in the name task. In the long intervals, the internal noise principle predicts a rise in false-*different* errors. Again, we believe that incongruence of outputs will have different effects on the name and shape tasks. For the name task, the incongruence of outputs may enhance the frequency of false-*different* errors, but for the shape task, there should be reliably more false-*same* errors.

Thus, we made four specific predictions. For RT, we predicted two outcomes: (1) a fast-*same* effect in the shape task and a fast-*different* effect in the name task; and (2) facilitation of the response, due to congruent outputs from the shape and name processors, and inhibition of the response, due to incongruent outputs, should be equal under the name and shape instructions. That is, when we compare congruent or incongruent cell means across the tasks, we should see no *nominal-physical* disparity. For errors, we also made two specific predictions: (1) a preponderance of false-*different* errors in the name task, and a preponderance of false-*same* errors in the shape task; and (2) forcing subjects to wait variable amounts of time before they were allowed to respond should result in systematic effects that would enlarge the ratio of false-*different* to false-*same* errors in the name task, but not in the shape task.

In addition, these predictions were tested in the two VFs by our lateralized presentation conditions. One important methodological aspect of our experiment was that the stimuli presented in the peripheral VFs were twice as large as those presented in the center. This was done to avoid additional noisiness in the encoding of these stimuli. This control distinguishes our results from those of Krueger (1985) and Krueger and Allen (1987), who presented stimuli peripherally *in order* to increase noise in encoding.

METHOD

Subjects

The subjects were 6 graduate students and 2 undergraduate students (4 males and 4 females) in the Psychology Department at UCLA. All were native English speakers and strongly right handed. Six of the subjects were paid $500 each for their participation. Two subjects (both graduate students) participated as volunteers; all the subjects except the latter two were naive as to the objectives of the experiment. None of the authors participated as a subject.

Materials and Apparatus

A computerized tachistoscope (Hunt, 1987) running on an IBM XT personal computer was used to present the stimuli. An Amdek Video-310A monitor was used, with black letters appearing on an orange background (reversed video). In order to approximately adjust for the effects of acuity on the differences in performance between the central and peripheral visual fields, the peripheral stimuli were twice as large as those appearing in the center. Central visual field stimuli appeared in the center of the screen and were approximately 0.5×0.5 cm ($0.5° \times 0.5°$) in size. Peripheral visual field stimuli extended $3°$–$5°$ from fixation and were approximately 1.0×1.0 cm ($1.0° \times 1.0°$) in size.

The stimuli were letter pairs from the following set: A, B, D, E, F, G, H, I, J, L, M, N, Q, R, T, Y, and their lowercase counterparts. These letters were chosen because their upper- and lowercase forms do not have the same shape. This was to assure that name decisions could not be made by a template-matching mechanism. Letter pairs were newly created for each subject for each block by a random generation of the ASCII number codes of the letter set, with the frequency of occurrence of each particular letter or letter pairing not controlled. For name decisions, the generation occurred with one constraint: all the stimuli requiring a "same" response consisted of an upper- and lowercase pair of the same letter (e.g., Ee). We did not include physically identical stimuli (e.g., EE) among the *same*-name stimuli. All the stimuli requiring a "different" response consisted of two different letters, with case randomly chosen. For shape decisions, all stimuli requiring "same" responses were the same letter, with both letters in a pair either in upper- or in lowercase. Two types of *different* stimuli in the shape decision occurred with equal frequency: upper- and lowercase of the same letter (Ee) and pairs of different letters (EG, Eb, or ej).

Design and Procedure

The experiment consisted of two parts: a condition in which RTs were manipulated (deadlines condition), and a condition in which subjects responded at will (no-deadlines condition). All of the subjects performed the deadlines condition before the no-deadlines condition.

Deadlines condition. Four independent variables were manipulated: the VF to which the stimulus was flashed (left, right, or central), the RT deadline (50, 100, 200, 300, 400, or 500 msec), the response hand used by the subject (left or right), and the decision type (name or shape).

To map SATFs, the cued response procedure developed by Link (1971) was used. After exposure of the stimulus, the subjects were required to wait a variable amount of time before they were cued to respond. Randomly varying six deadlines makes it possible to plot the sensitivity and error patterns of responses against the time allotted to respond, with some confidence that the subjects did not change their processing strategy to fit the time allowed. The subjects could respond only within a specific time window—in this case, 300 msec from the cue. After exposure of the stimulus, the subjects were required to wait 50, 100, 200, 300, 400, or 500 msec before they heard the response cue.

The subjects sat with their chin in a chinrest which held their head 57.3 cm from the center of the screen; at this distance, 1 cm = 1° of visual angle. The subjects responded by pressing one of two buttons marked SAME and DIFFERENT on a box which they held in their designated response hand. The particular fingers used for "same" and "different" responses were not specified. The response type and time were collected by computer.

The sequence of events on each trial was as follows: a fixation cross appeared at the center of the screen for 2 sec. The cross disappeared and a blank screen was displayed for 200 msec. The stimulus pair was displayed for 20 msec in one of the three VF positions. The screen became blank. The subjects waited 50, 100, 200, 300, 400, or 500 msec, after which they heard a 20-msec beep, which was the cue to respond. The response window lasted for 300 msec, and a second, 100-msec beep signaled the closing of the window. The fixation cross again appeared at the center for 2 sec and the next trial began.

The subjects each performed a total of 38,400 trials. These were run in blocks of 96 trials each. There were 100 blocks in each task (name, shape) × response hand condition; these conditions were manipulated between blocks. All the specific decision type × response hand blocks were run consecutively. The order of these conditions was counterbalanced across subjects by using a Latin square design. VF and deadline were manipulated within the blocks. Each block of 96 trials contained 48 *same* and 48 *different* stimulus pairs. Sixteen of each type of stimulus pair were flashed to each VF. Within each block, the order of VF and the type of stimulus pair were randomly determined. The order of the latency deadlines was also randomly determined, with 8 (4 same, 4 different) trials per VF for the 50- and 100-msec intervals and 4 trials per VF for each of the longer deadlines. The signal detection and raw accuracy measures were computed over 10 blocks of 96 trials. The functions were computed by using 10 d' and 10 beta scores for each data point.

Each subject completed 5 blocks of 96 trials each day, which required approximately 30–45 min. Each block was divided into two subblocks of 48 trials, after each of which the subject was allowed to take a break. The length of these breaks was not controlled. In order to complete a condition, the subjects performed on 100 *good* blocks (a *good* block was one in which there were at least 14 responses to *same* stimuli within the deadline window in each condition over each group of 10 blocks). Before each response hand × decision type condition, the subjects performed on a minimum of 20 practice blocks, plus as many additional blocks as were needed to succeed in responding within the deadline window. Thus, the subjects participated in the experiment for a period of 3–6 months. An attempt was made to have them run at approximately the same time every day, but this time changed with their schedules between academic quarters.

No-deadlines condition. The subjects performed this condition over 2 days, after they had completed all the blocks in the deadlines condition. Four blocks of 192 trials were run with no RT deadlines. Each block represented a decision type (name or shape) × response hand condition. Within each block, 64 of the 192 trials appeared in each VF presentation condition (LVF, RVF, central presentation). Of the 64 stimuli, 32 were *same* and 32 were *different* pairs. For each block, a d' and $\log\beta$ score were computed for each VF presentation condition. The latencies of responses were also recorded. Subjects were given 2 sec to respond and were asked to respond as quickly and as accurately as possible. The order of presentation of decision type × response hand conditions was the same as the one used in the deadlines condition. Before each block, the subjects performed a short (32-trial) practice block. The data collected on the 1st day were not used. Only the data collected from the four experimental blocks on the 2nd day were analyzed.

RESULTS

In the introduction, the hypotheses were presented in terms of specific dependent measures. The results will be presented in the same terms.

Response Times

We predicted two outcomes for RT: (1) that there would be a fast-*same* effect in the shape task and a fast-*different* effect in the name task; and (2) that the congruency of the outputs of the shape and name processors would have similar effects across the tasks.

Fast-*same* and fast-*different* effects. The mean RTs for each task × stimulus type cells from the no-deadlines condition are shown in Table 2. The RTs from central presentation were subjected to a three-way analysis of

Table 2
Mean Response Times (in Milliseconds) to Congruent and Incongruent Conditions in the No-Deadlines Condition

Stimuli	CVF	PVF
Name Task		
Same	421	420
Different	**408**	**419**
Shape Task		
Same	**386**	**384**
Different-shape/ *same*-name	415	410
Different-shape/ *different*-name	**395**	**394**

Note—Response times for congruent cells are given in boldface. CVF, central visual field; PVF, peripheral visual field.

variance (ANOVA) with task (name vs. shape), response hand, and decision type (*same* vs. *different*) as within-subject variables. The analysis revealed an advantage for the shape task (395 msec) over the name task (415 msec) that approached significance [$F(1,7) = 4.25, p = .08$]. Most importantly, there was a significant task × decision type interaction [$F(1,7) = 11.68, p = .01$]. Planned comparisons revealed that the slight (13 msec) fast-*different* effect in the name task was not significant ($p > .1$), and that the 19-msec fast-*same* effect in the shape task was significant [$F(1,7) = 12.77, p < .01$]. No other main effects or interactions approached significance.

Response times from the lateralized presentations were subjected to a four-way ANOVA with task, response hand, decision type, and visual field (LVF vs. RVF) as within-subject variables. As in the CVF data, there was a main effect of task [$F(17) = 7.24, p < .05$], with the shape task responded to faster than the name task (393 vs. 420 msec). The task × decision type interaction approached significance [$F(1,7) = 5.51, p = .051$]. Planned comparisons showed that, as in central presentation, decision type had no significant effect in the name task ($p > .5$), and there was a significant 18-msec fast-*same* effect in the shape task [$F(1,7) = 8.23, p < .05$]. No other main effects or interactions approached significance.

Effects of congruency of outputs. To test the effects of the congruence and incongruence of outputs of the shape and name processors according to the confluence model, we separated the *different* stimuli in the shape task into those that had the same name (e.g., Aa) and those that were different letters (e.g., Ag).

In the CVF, we subjected these and the rest of the data to a two-way ANOVA with stimulus type across tasks (for the name task, *same*-name, *different*-name; for the shape task, *same*-shape, *different*-shape/*same*-name, *different*-shape/*different*-name) and response hand as within-subject variables. These variables did not interact, nor was there a main effect of response hand. Stimulus type did have an effect [$F(4,28) = 3.51, p < .02$]. The planned comparisons of interest here are between conditions in which the presumed outputs of the shape and name processors were congruent or incongruent. The outputs were congruent in three conditions: *different*-name stimuli in the two tasks (e.g., Ag, name = 408 msec, shape = 395 msec) and *same*-shape stimuli (e.g., AA, 386 msec). In the two former conditions, both outputs signaled "different"; in the latter condition, both outputs signaled "same." These three conditions did not differ from each other ($p > .1$). The outputs of the processors were incongruent for *different*-shape/*same*-name stimuli (e.g., Aa). These required a "same" response in the name task (421 msec) and a "different" response in the shape task (415 msec). These conditions also did not differ from each other ($p > .5$).

The same analyses were performed on the data from the lateralized presentations. There were no main effects or interactions involving response hand or VF. There was a main effect of stimulus type [$F(4,28) = 4.99, p < .005$]. Here the pattern is a little different. Congruence of outputs did not result in equivalent RTs: *different*-name (Ag) stimuli in the name task resulted in longer RTs than did *same*-shape stimuli (AA) in the shape task (419 vs. 385 msec) [$F(1,7) = 8.13, p < .05$]. *Different*-name stimuli also took longer to classify as *different* in the name task (419 msec) than in the shape task (394 msec) [$F(1,7) = 6.91, p < .05$]. However, incongruence of outputs did have the same effect in the two tasks; it took subjects 420 msec to classify Aa-type stimuli as "same" in the name task and it took them 410 msec to classify these stimuli as "different" in the shape task ($p > .3$). Thus, in the peripheral visual fields (PVFs) we found no facilitation of congruent outputs together with inhibition due to incongruent outputs.

Errors

We predicted two outcomes for errors: (1) that there would be a preponderance of false-*same* errors in the shape task and a preponderance of false-*different* errors in the name task; and (2) that in the deadlines condition, for the name task there would be a rise in the ratio of false-*different* errors to false-*same* errors, because subjects had to wait longer to respond. We predicted that this would not happen in the shape task.

False-*same* and false-*different* errors. The mean percent errors from the no-deadlines condition in each task × response hand × visual field condition for *same* and *different* stimuli are shown in Table 3. These accuracies were subjected to a four-way ANOVA with task, response hand, VF, and pair type (*same* vs. *different*) as independent variables. This analysis revealed four significant effects: a main effect of task [$F(1,7) = 8.27, p < .05$], with more errors in the name task (14.43%) than in the shape task (10.83%); a main effect of pair type [$F(1,7) = 13.44, p < .01$], with more errors on *same* pairs (14.90%) than on *different* pairs (10.37%); and most importantly, a task × pair type interaction [$F(1,7) = 21.23, p < .005$], with significantly more errors on *same* (19.48%) than on different (9.37%) stimuli in the name task [$F(1,7) = 101.80, p < .0001$], and no difference between the pair types in the shape task (10.31% vs. 11.35%, $p > .5$).

Effects of response deadlines. An analysis of the accuracy scores for the response deadlines condition from each task × response hand × VF × pair type was per-

Table 3
Mean Percent Errors in the Task × Response Hand × Visual Field for Same and Different Stimuli in the No-Deadlines Condition

		Task			
		Name		Shape	
Visual Field	Hand	*Same*	*Different*	*Same*	*Different*
CVF	left	21.88	8.13	13.75	8.13
	right	23.75	10.63	6.88	8.75
LVF	left	18.75	5.63	10.0	9.38
	right	13.75	5.63	5.63	16.88
RVF	left	20.63	13.13	15.0	13.75
	right	18.13	13.13	10.63	11.25

Note—CVF, LVF, RVF=central, left, and right visual fields, respectively.

Table 4
Cell Means of Percent Errors in the Task × Response Hand × Visual Field × Pair Type Conditions for Each Response Time (RT) Deadline

RT		LVF		RVF		CVF	
Deadline	Hand	*Same*	*Different*	*Same*	*Different*	*Same*	*Different*
				Name Task			
50	left	47.1	33.3	43.7	37.1	49.0	33.6
	right	37.9	40.0	43.9	34.8	47.4	37.6
100	left	37.0	27.7	35.2	28.4	43.6	25.5
	right	30.3	33.1	32.8	30.7	38.4	29.4
200	left	17.0	14.8	16.1	14.2	19.5	13.8
	right	13.5	18.3	16.1	19.0	21.0	16.0
300	left	8.9	7.5	7.8	9.6	13.2	6.2
	right	8.0	9.2	8.9	9.9	13.0	8.3
400	left	6.0	5.9	5.8	7.3	9.3	5.8
	right	6.8	6.7	8.2	7.8	10.4	5.2
500	left	6.7	4.1	5.5	5.3	8.6	4.9
	right	5.5	6.0	6.0	7.1	9.8	6.1
				Shape Task			
50	left	42.7	27.2	39.4	32.1	38.8	23.9
	right	36.6	33.2	42.5	31.7	37.7	28.9
100	left	28.6	22.5	26.1	23.2	27.1	18.4
	right	27.4	26.3	30.9	26.1	29.5	22.1
200	left	11.0	9.2	12.1	11.4	9.2	6.0
	right	11.8	12.3	12.9	14.4	10.1	9.9
300	left	6.7	5.2	5.6	6.0	5.0	3.0
	right	8.1	6.3	5.8	6.8	5.6	4.5
400	left	4.1	3.5	4.1	4.7	3.6	2.6
	right	5.1	4.8	4.7	5.4	3.7	3.1
500	left	3.6	2.8	5.0	4.5	3.4	2.6
	right	5.5	4.7	4.8	5.3	4.9	3.1

formed. The cell means for this analysis are shown in Table 4. The analysis revealed that subjects were more accurate in the shape task (14.2% errors) than in the name task (18.7% errors) [$F(1,7) = 61.09, p < .0005$]. There is also a task × VF interaction [$F(2,14) = 36.03, p < .005$]. The *nominal/physical* disparity is larger in the CVF than in the PVFs. These means are shown in Table 5.

In order to look specifically at the effects of speed stress on error patterns, the errors in each of the response deadlines were computed as speed-bias functions. These accuracies were transformed into beta scores by taking the ratio of the height of the normal density curve of the probability of correct "same" responses to the height of the curve of the probability of false-*same* responses. Thus a beta score that is larger than 1 indicates a bias to respond "different," and a beta smaller than 1 indicates a bias to respond "same." A score of beta that is equal to 1 indicates unbiased responses; that is, when subjects made errors, these were equally distributed between false-*same* and false-*different* errors. These ratios were transformed into natural logarithms in order to normalize their distribution. This resulted in a score that reflected the ratio of false-*same* to false-*different* errors, independently of the number of errors in each RT deadline. When $\log\beta = 0$, this indicates that there were an equal number of false-*same* and false-*different* errors. When $\log\beta$ is a positive number, this indicates that there were more false-*different* than false-*same* errors (a bias to respond "different" when processing was incomplete), and when $\log\beta$ is a negative number, this indicates that there was a preponderance of false-*same* over false-*different* errors (a bias to respond "same" when processing was incomplete). The functions for each task × response hand × VF condition are illustrated in Figure 1.

Table 5
Mean Percent Errors in the Response Deadlines Condition for the Name and Shape Tasks in Each Visual Presentation Condition

	Task	
Visual Field	Name	Shape
LVF	18.0	14.6
RVF	18.4	15.2
CVF	19.8	12.8

Note—LVF, RFV, CVF = left, right, and central visual fields, respectively.

The data from central presentation were subjected to a three-way ANOVA with task, response hand, and RT deadline as within-subject variables. The only effect to reach significance was a task × RT deadline interaction [$F(5,35) = 2.60, p < .05$]. Planned comparisons revealed a systematic effect of response deadline on error types in the name task [$F(5,35) = 2.51, p < .05$], but not in the shape task ($p > .5$). In the name task, the preponderance of false-*different* errors found at long deadlines steadily shrank and then vanished as the deadline decreased. In the shape task, there was a consistent shift toward more false-*different* errors (mean $\log\beta = .238$) that is significantly different from zero [$F(1,7) = 15.02, p < .01$].

Comparisons of the first three deadlines versus the last three deadlines revealed that with central presentation, only the name task resulted in less false-*different* errors in the early versus the late deadlines [$F(1,7) = 7.00, p < .05$]. The shape task did not reveal this pattern, nor did any conditions in the lateralized presentations.

The data from the lateralized presentations were subjected to a four-way ANOVA with response hand, task, VF, and deadline as within-subject variables. The only effect that approached significance was the three-way interaction between response hand, task, and VF [$F(1,7) = 4.92, p = .06$]. Planned comparisons showed that there was a response hand × VF interaction in the name task [$F(1,7) = 8.82, p < .05$], but not in the shape task ($p > .5$). In the name task, $\log\beta$ is higher in the LVF with the left hand than in all the other conditions combined [$F(1,7) = 9.21, p < .05$]. Biases in both tasks were not significantly different from zero ($p > .2$).

d' Scores

The speed d' functions from the response-deadlines procedure, and the d' scores from the no-deadlines procedure are illustrated in Figure 2. Detailed analyses of these patterns are reported in Eviatar and Zaidel (1992). In general, the no-deadlines procedure resulted in no significant effects, while analyses of the slopes of the speed d' functions revealed a main effect of task [$F(1,7) = 10.41, p = .014$], with performance improving in the shape task faster than in the name task.

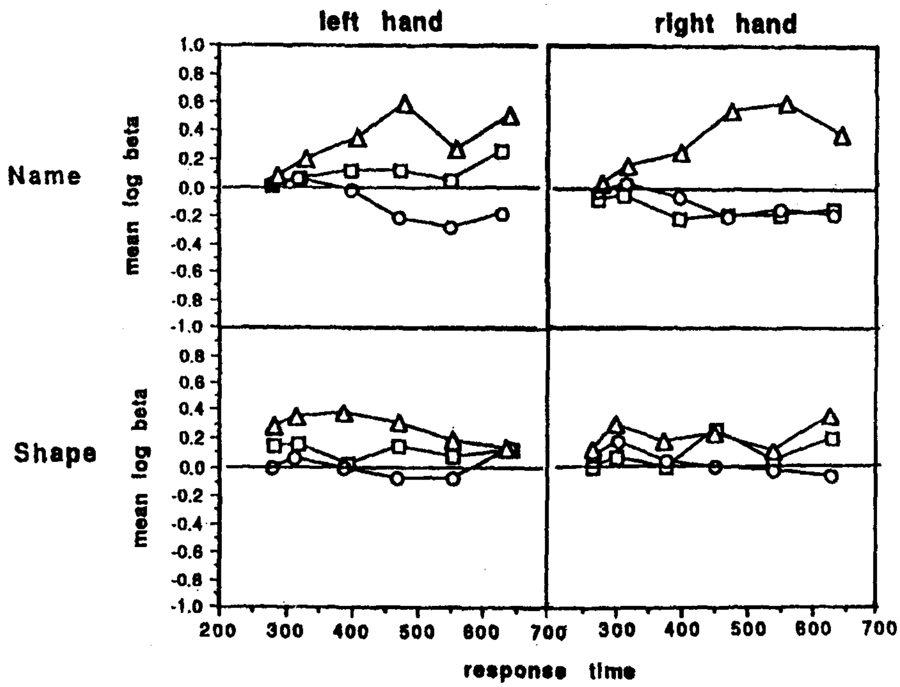

Figure 1. Speed-bias functions for the name and shape tasks.

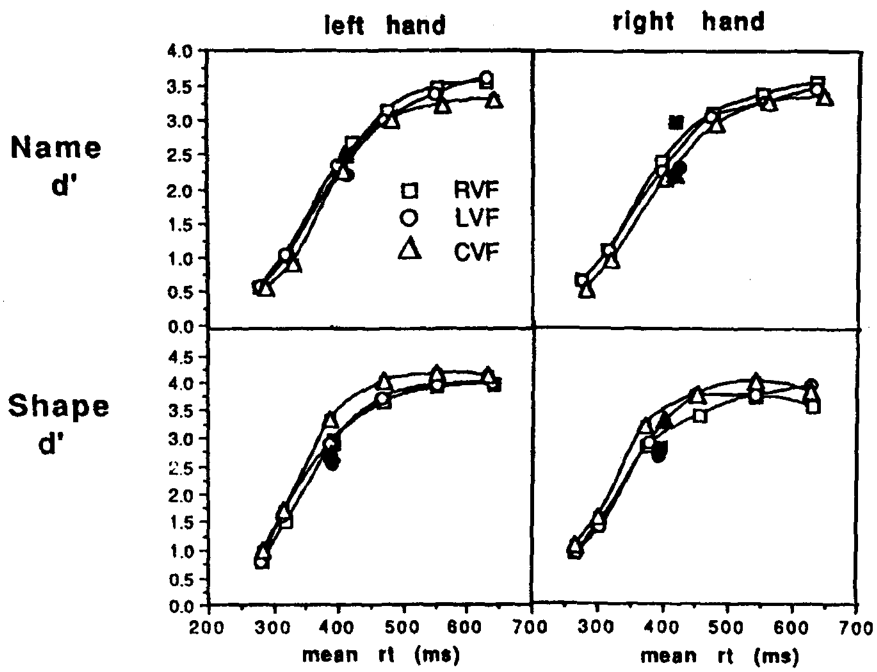

Figure 2. Speed-sensitivity functions for the name and shape tasks. (Filled symbols represent scores in the no-deadlines conditions.)

DISCUSSION

The confluence model presented here proposes that the shape and the name task are performed by the same mechanisms, in such a way that physical and nominal identity are processed automatically in both tasks. The congruence and incongruence of these dimensions is proposed to affect performance to the same extent, irrespectively of the decision criterion. Our RT data from the no-deadlines condition support this hypothesis. In the central presentation condition, RTs to stimuli when the outputs were congruent were equivalent in the two tasks, even when they required different responses. This was also true for the effects of incongruent outputs. These data constitute evidence against the classical priming account, which predicts more interference due to misleading shape information than to misleading name information. For the incongruent Aa-type pairs, responding "same" under name instructions did not take significantly longer than responding "different" under shape instructions. These data also weigh against Proctor's (1981) hypothesis that name codes are not used by subjects when they are using a shape criterion.

In the peripheral visual fields, we found an effect of incongruence, such that stimuli of the Aa type were responded to at the same speed in the two tasks. However, there was an effect of task in the congruent conditions, in which responses in the trial blocks using the shape criterion were faster than responses in trial blocks using the name criterion. *Same* stimuli under the shape instructions were responded to faster than *different* stimuli under the name instructions (AA vs. Ag). We will return to this point below.

An important difference between our data in the shape task and previous findings is that the fast-*same* effect disappeared when we deleted *same*-name stimuli (Aa) from the *different* items. That is, stimuli differing on both dimensions (Ag) were responded to as quickly as *same* stimuli (AA) in the shape task. We prefer to explain this on the basis of congruent and incongruent outputs. However, the fact that our subjects were extremely well trained (they performed the no-deadlines condition after 3–6 months of participating in the deadlines condition for an hour every day) suggests several alternative explanations for our data. It is possible that such an amount of training resulted in a change in strategy of processing of these *different* stimuli, such that the subjects were able to use the lack of physical identity as a basis for fast "different" responses. In addition, when we computed visual similarity ratings (Boles & Clifford, 1989), the mean for *same*-name (Aa) stimuli is 2.84, and the mean for *different*-name (Ag) stimuli is 1.58. Thus, it is still possible that visual similarity and not nominal identity of Aa type stimuli inhibited the "different" response in the shape task. Two points argue against this interpretation. One is that it is not clear what aspects of the letter pairs were in fact used by Boles and Clifford's subjects in their similarity ratings. It could very well be that nominally *same* pairs (Aa) were rated as more similar than nominally *different* pairs (Ag) *because* of their nominal identity. The second point is that greater visual similarity between nominally *same* pairs should have resulted in a fast-*same* effect for the name task (we found a tendency toward a fast-*different* effect). However, if, as Boles (1981, 1986; Boles & Eveland, 1983) suggests, opposite-case members were automatically generated in the name task, similarity of shape may not have had an effect in the name task. This hypothesis assumes that visual generation occurs only when subjects are asked to use the nominal criterion and weakens the case for its being automatic. In addition, Farell's (1988) suggestion that *different*-shape stimuli are responded to on the basis of the output of encoding plus a default delay may be supported as well, for it may be the case that training resulted in a shortening of the default delay or in its disappearance altogether.

We had also predicted that the name task would result in a higher preponderance of false-*different* errors, and that the shape task would result in more false-*same* errors. The first part of this prediction was supported. Both central and peripheral presentations in the no-deadlines condition resulted in a preponderance of false-*different* errors that was significantly larger than zero in the name task. The shape task resulted in generally unbiased responses (i.e., subjects made the same number of errors on *same* as on *different* stimuli).

In looking at the effects of speed stress on error patterns, we found evidence against Eriksen's missing-feature principle. Neither task resulted in more false-*same* errors in early deadlines. For the name task, responses in the CVF condition were generally unbiased in early deadlines, and more false-*different* errors were made as more time passed between stimulus exposure and the response. This pattern is consistent with Krueger and Chignell's (1985) formulations of the effects of internal noise. There are two alternative explanations for this pattern. One involves the combination of the constructs posited by the confluence model and the noisy operator theory that was proposed in the introduction. That is, both the shape and the name dimensions of the stimuli are processed by the kind of difference counter proposed by Krueger. This results in a shift toward more false-*different* errors. The congruence of these outputs also affects responses as posited by the confluence model, in such a way that more false-*different* errors are made in the name task, but there is a shift toward false-*same* errors in the shape task. Thus, in the shape task there is no systematic change in error types as more time is given to process the stimuli, because the congruence of outputs (which shifts errors toward more false-*same*) and the internal noise principle (which shifts errors toward more false-*different*) cancel each other out, resulting in unbiased performance in the PVFs. In the central condition we found a consistent, significant preponderance of false-*different* errors. This may have arisen because the stimuli in the center were relatively small, so that internal noise had stronger effects at the encoding and comparison stages that were not cancelled by the congruency effects.

An alternative explanation of the different error patterns in the two tasks uses Boles's visual generation model in conjunction with Krueger's noisy operator theory. That is, if name decisions are based on representations of generated opposite-case letters, noise at encoding could have the same effect as in the shape task, because the noisy operator operates on these representations in the same manner as on stimuli that have actually been presented. If this generation does not occur when subjects are performing the shape task, the effects of internal noise will be greater for name than for shape decisions.

The pattern in the PVFs complicates the picture, because it does not completely conform to these explanations of the name task. For the shape task, the patterns of performance in the CVF and the PVFs are essentially equivalent: we see a significant fast-*same* effect in the no-deadlines condition, and stable error patterns in the deadlines condition. In the deadlines condition there is a preponderance of false-*different* errors in the CVF but not in the PVFs. As mentioned above, we believe that this is due to the lower quality of the stimuli in the central than in the peripheral presentations.

For the name task, we find more differences between the visual presentation conditions. Both central and lateralized presentations reveal a preponderance of false-*different* errors in the no-deadlines condition. However, there is no fast-*different* effect in the periphery and a small one in the central condition (1 vs. 13 msec). In addition, the basic predictions of the confluence model were only partially supported in the PVFs: the *nominal-physical* disparity persisted in the conditions that were congruent according to the confluence model. Both these effects are due to long RTs to *different* stimuli in the PVF (419 msec in the PVFs vs. 408 msec in the CVF). Finally, there was a systematic effect of deadlines on error patterns in the central condition, but no such effect in the peripheral conditions. These puzzling differences constitute a problem for our confluence model, because they suggest either that processing is different when the stimuli are presented in central versus peripheral vision, or that our results for central vision are due to other factors than the ones we posit. Further research is needed to clarify these patterns.

Our lateralized presentations resulted in very similar patterns of RTs and error patterns in the two visual fields. These data converge with the sensitivity (d') patterns and suggest that the hemispheres may perform these tasks in the same manner. The only processing dissociation that we found was in the name task, in which deadlines affected the ratio of false-*different* to false-*same* errors in the LVF-left-hand condition, which differed from all the other conditions. Although the VF × response hand interaction in the no-deadlines condition is not significant, the LVF-left-hand condition also resulted in the largest differences in accuracy between *same* and *different* stimuli (see Table 3). This is interesting, because the LVF-left-hand condition is the one condition in which it is most likely that the RH performed the task independently of the LH, which suggests that the hemispheres may differ in their response choice strategy when processing is incomplete. These findings converge with those of Chiarello, Nuding, and Pollock (1988) and Eviatar, Menn, and Zaidel (1990), who have reported that the RH makes a larger proportion of "nonword" than "word" responses in a lexical decision task.

In conclusion, we have proposed a model in which the physical and nominal dimensions of the stimuli are processed automatically and in parallel, irrespectively of the task (cf. Proctor et al., 1990), and in which identity and nonidentity on all of the dimensions affect responses (cf. Miller & Bauer, 1981, and Eriksen et al., 1982). Consistently with the confluence model, we have shown that the name task does not result in a fast-*same* effect and does result in a higher preponderance of false-*different* errors than does the shape task. Alternatively, our data may show that intensive practice may allow subjects to develop a strategy whereby a lack of physical identity can be used as efficiently as physical identity as a basis for responding. Another alternative explanation uses a conjunction of Krueger's noisy operator theory and Boles's visual generation model to account for these patterns. We found some puzzling differences between performance when the stimuli were presented foveally (when, presumably, both hemispheres receive the letter pair) and when they are presented unilaterally to one or the other hemisphere. These differences occur in RT and error data, not in sensitivity (d') patterns. The RT data for the unilateral VFs are similar to each other and are different from those for the central condition. The error patterns suggest that processing in the RH may be more similar to processing in the central condition than to processing in the LH. Further research is needed to replicate and clarify these findings.

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