Configural Processing of Faces in the Left and the Right Cerebral Hemispheres

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This study investigates the rules by which the component features of faces are combined when presented in the left or the right visual field, and it examines the validity of the analytic–holistic processing dichotomy, using concepts elaborated by Garner (1978, 1981) to specify stimulus properties and models of similarity relations as performance criteria. Latency measures of dissimilarity, obtained for the two visual fields, among a set of eight faces varying on three dimensions of two levels each, were fitted to the dominance metric model, the feature-matching model, the city-block distance metric model, and the Euclidean distance metric model. In addition to a right-visual-field superiority in different responses, a maximum likelihood estimation procedure showed that, for each subject and each visual field, the Euclidean model provided the best fit of the data, suggesting that the faces were compared in terms of their overall similarity. Moreover, the spatial representations of the results revealed interactions among the component facial features in the processing of faces. Taken together, these two findings indicate that faces initially projected to the right or to the left hemisphere were not processed analytically but in terms of their gestalt.

Human information-processing capacities are the product of a highly adaptive and versatile nervous system that provides individuals with a large number of alternative means for achieving successful performance on any particular task. This versatility is partly attributed to the functional specialization of the two cerebral hemispheres whereby specific skills are alleged to be unilaterally represented, thus doubling the brain processing capacity while avoiding potential conflicts that would result from promiscuity. This specialization was initially characterized in terms of information that each hemisphere was better equipped to operate on (e.g., Milner, 1971). However, the diversity and heterogeneity of the type of information that each hemisphere could be shown to process, initially in experiments with commissurotomized patients, prompted researchers to inquire about the processes underly-
dering lateralization of functions in an attempt to discover some basic mechanisms that would encompass the range of operations mediated by each hemisphere. Levy-Agresti and Sperry (1968) were the first to suggest specifically that the left hemisphere (LH) and the right hemisphere (RH) were specialized in analytic and holistic processing, respectively. The analytic–holistic dichotomy has proved to be a convenient explanatory framework for research on cerebral lateralization, and it has accommodated a large amount of data. It borrows its concepts from a natural-language distinction, and the passage from this distinction to a psychological model has been made in reference to several formulations developed in experimental psychology. Thus, the cerebral hemispheres have been described as differing in terms of focal–diffuse organization (Semmes, 1968), propositional–appositional mode of thought (Bogen, 1969), serial–parallel processing (Cohen, 1973), and same–different matching operations (Egeth & Epstein, 1972). Recently, Bradshaw and Nettelton (1981) have regarded these formulations as “special cases” of the more basic temporal–analytic/spatial–holistic processing dichotomy. Despite this multiplicity of operational definitions, few experiments have

This research was supported by a grant from the Fonds de la Recherche en Santé du Québec. I am indebted to Yoshio Takane for his advice and suggestions and to three anonymous reviewers for suggesting revisions on an earlier version of this article.

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been designed to test this hypothesis directly, and they have so far yielded inconsistent results. For example, Cohen's (1973) examination of serial and parallel processes as typical of the LH and RH mode of operation, respectively, resulted in equivocal findings. Although Ohgishi (1978) found support for this hypothesis, White and White (1975) did not. Moreover, strictly speaking, and as acknowledged by Bradshaw and Nettleton (1981), these findings are somewhat ambiguous because the former implies decomposition into components, whereas the latter suggests that the whole stimulus is processed as a gestalt.

The purpose of this article is to carry out an investigation into the nature of the processes underlying the operations performed on information presented in the left visual field (LVF) or the right visual field (RVF) and to examine the implications of the results for models of functional cerebral asymmetry. The first step in this approach will be to specify as clearly as possible the nature of analytic and holistic processes in terms appropriate to experimental hypothesis testing. Definitions and their operationalization will be based on concepts proposed by Garner (1974, 1978, 1981), following an explicit suggestion made by Bertelson (1981), and the importance of stimulus characteristics in the implementation of particular processes will be outlined. The empirical part of this investigation will follow an approach different from that employed in previous inquiries into cerebral lateralization. Considering latencies to compare pairs of "different" stimuli as measures of their dissimilarity (Garner, 1978; Shepard, 1978), we will analyze reaction time (RT) data to examine how well they fit theoretical models of similarity relations; this procedure will thus allow the identification of the rules by which the component dimensions of stimuli are combined depending on the hemisphere that initially receives the information.

Perceiving multidimensional stimuli necessarily involves mutual interplay between a stimulus and an observer. On the one hand, a stimulus contains specific attributes that relate to one another in particular ways to afford structured information that may be useful to an observer. On the other hand, the perceiving organism must be equipped ("attuned") to extract this information and to use it for adaptive purpose. It is therefore necessary to examine the properties of a stimulus that make the analytic and holistic processes possible and then to consider the implications for the organism.

Properties of a Stimulus

Multidimensional stimuli have properties that vary with the nature of, and the interrelations between, their component attributes, and these properties form a basis for the implementation of processing along either the stimulus component or the whole stimulus. Garner (1981) identified two main categories of components: dimensions and features. This distinction is not critical in the present investigation, except to say that the stimuli used in the experiment, line drawings of faces, were generated from dimensions, where "a dimension is an attribute that exists for each stimulus in the relevant set, and at some positive, mutually exclusive value" (Garner, 1978, p. 104). The independent processing of these component attributes characterizes an analytic operation.

Garner (1981) described three types of "wholistic" properties, two of which, the "simple whole" and the "template," refer to a stimulus perceived in its entirety as being the sum of its components. Strictly speaking, neither a simple whole nor a template requires the perception of interrelations among components (a gestalt, e.g., Köhler, 1969), and comparing two stimuli along either of these properties can be achieved through a simultaneous point-by-point matching of independent components.

A third "wholistic" property of a stimulus described by Garner is the configuration that is considered an emergent property resulting from some combination or interaction of the stimulus components. An emergent configural property implies that a stimulus is different from the sum of its components and that these components are not perceived independently of one another. Thus, configural properties ex-

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1 Throughout this article, the word "feature," because of its usual meaning with respect to faces, will be used as synonym for "dimension" and not in the sense of Garner's (1978) terminology.
ist in addition to component properties, and, as noted by Garner (1978), this raises questions as to which properties are used in any particular task. Whether components combine or do not combine to give rise to a configural perception is a function of the particular stimulus as well as of the ability of the perceiving organism to implement such a combination.

Properties of the Perceiver

Within an information-processing framework, processing operations functionally determine the relations among stimulus attributes. One distinction initially made by Shepard (1964) and later developed by Garner (1974) refers to the particular rules by which stimulus components are related to one another depending on whether they are perceived as separate and independent or as integral and dependent on their global structure. In the former case, the dimensions of the stimuli are perceived as "separable" or "analyzable" in that they are perceptually distinct and do not interfere with one another. In the latter case, the stimuli are perceived as "integral" or "unanalyzable" in that they are compared to one another on the basis of their global similarity instead of their component dimensions.

Although these two categories are usually attributed to stimulus sets (e.g., Garner, 1978; Handel & Imai, 1972; Hyman & Well, 1967), mainly because some stimulus sets are easily analyzable (e.g., geometric forms) whereas some others are essentially unanalyzable (e.g., Munsell colors), they can also be used to describe the nature of the processing mechanisms (e.g., Lockhead, 1972; Ward, 1983), in that the capacities of the processing organism determine whether a stimulus is perceived as integral or separable. For example, Shepp (1978) has shown that stimuli that are analyzable by normal adults are treated as integral and unanalyzable by children, suggesting that the particular properties of the stimulus are not sufficient to account for the way dimensions are combined. There is also evidence that, among normal adults, a subject's cognitive style influences whether stimuli are perceived along their global structure or their component dimensions (J. D. Smith & Baron, 1981), illustrating the interdependence of the stimulus and the processor.

Implications

Two main implications can be drawn from the foregoing discussion. One is that the work of Garner provides a useful framework and operational definitions for the investigation of the analytic–holistic dichotomy. The concept of analyzable perception is directly applicable to the notion of analytic processing because it implies independence of the component attributes and comparison of stimuli along their separable dimensions. On the other hand, the concept of configuration provides the notion of holistic processes with a construct appropriate for hypothesis testing, and it suggests operations by which the components of a stimulus are combined in an interactive manner.

The second implication is that the properties of a stimulus are relevant only with respect to an observer, and the latter may become predominant if one employs stimuli, such as faces, that lend themselves to both analytic and holistic processing. In fact, configural properties coexist with component properties, and "the same stimulus has components that may be used in analyzed perception and configural properties that may be used in unanalyzed perception" (Garner, 1981, p. 126). Thus, if the RH is essentially specialized for processing stimuli along their holistic properties, pairs of face stimuli presented in the LVF should be compared in terms of their overall similarity. On the other hand, if the LH is specialized for analytic processing, one should expect faces presented in the RVF to be compared along their dimensions processed independently of one another.

Similarity-Relations Models

There is a multitude of ways by which the components of a stimulus can be related to one another, and several of them have been formally described in models of similarity-relations based on some measures of dissimilarity between stimuli of a set. Four such models were chosen as a function of their property to specify the particular combinatorial rules by which stimuli are perceived. Three of these models postulate that dimensions are independent and separable, and they imply an analytic mode of processing. The fourth model suggests that dimensions are not processed in-
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dependently of one another but interact with each other. The description of these models will be made in nontechnical terms, because the mathematical developments and the derivatives necessary for the analyses have been recently described by Takane and Sergent (1983).

**Dominance-Metric Model**

One of the most frequently described analytic models of stimulus comparison is the serial self-terminating model (Bamber, 1969; Nickerson, 1978; E. E. Smith & Nielsen, 1970). It suggests that each dimension of a stimulus pair is compared one after the other until a difference is found. Thus, the sooner a difference is detected, the faster the response. When multidimensional stimuli such as faces are used, the respective salience of the dimensions become critical in determining the order in which the dimensions are compared (Sergent, in press). There is considerable evidence that the components of a face are not equally salient (see Bruyer, 1983; Davies, Ellis, & Shepherd, 1981, for reviews), and that the most salient feature is processed first (Shepherd, Davies, & Ellis, 1981; Walker-Smith, 1978). Thus, a serial self-terminating processing of faces is equivalent to the dominance-metric model (e.g., Coombs, 1964), which suggests that a judgment of dissimilarity is made entirely in terms of the one dimension that is perceptually “dominant” (more salient) for that pair. This model implies that, when a pair of stimuli differs along two or more dimensions, it is only the more salient difference that determines the response, whereas the less salient differences have no effects on the judgment. This is a strong case of independence of dimensions as assumed in an analytic mode of processing.

**Contrast Model**

Tversky (1977) has proposed a set-theoretical approach to similarity relations by which multidimensional stimuli are represented as collections of features, and similarity is described as a feature-matching function. This model takes into consideration the contribution of any particular feature, common and distinctive, to a dissimilarity judgment between two stimuli, and it considers dissimilarity as the additive effect of independent judgments on each elementary feature. This model is thus a “feature-analytic” model (Keren & Baggen, 1981), and it is consistent with a parallel mode of processing with summation of the independent outcome of the decisions on each component.

**Spatial Models**

The analysis of similarity relations among a set of stimuli has most often been treated as distance (proximity) in a representational space. The perceived dissimilarities among stimuli are considered as having the property of a distance metric and can be represented as “psychological” distances in an n-dimensional coordinate space. The particular form of the space in which the psychological distances can be embedded is determined by the function that best relates perceived dissimilarities to distance on the component dimensions, and this function specifies the rules by which stimulus dimensions are combined. Two spatial models will be examined, the “city-block” model and the Euclidean model. In the city-block model, dissimilarity between two stimuli of a set is described by the difference on each dimension combined additively, suggesting that the dimensions are perceptually distinct and processed independently of one another. In the Euclidean model, the overall distance among stimuli is determined by the dimension differences related by means of the Pythagorean theorem, thus nonadditively. Perceived dissimilarities that fit this model are based on comparisons of stimuli in terms of their overall similarity determined by the particular interrelations between the dimensions of each stimulus. These two models have been extensively used in research on similarity relations, and they have clearly differentiated analyzable (separable) from unanalyzable (integral) stimuli (see Garner, 1974; Hyman & Well, 1967; Torgenson, 1958). Thus the distance metric of a set of multidimensional stimuli that best represents perceived dissimilarities is determined by the particular rules by which stimulus dimensions are combined. In addition to suggesting a psychological model about stimulus–observer interactions in perceived dissimilarity, the spatial models provide a convenient method for describing and displaying proximity data.
Experiment

The experiment consisted of a facial discrimination task, with two faces simultaneously presented to the left or to the right of central fixation. The use of faces for testing the analytic-holistic dichotomy seemed quite appropriate because it is widely held that the RH processes physiognomies holistically, whereas the LH operates analytically (e.g., Bradshaw & Sherlock, 1981; Carey & Diamond, 1977; Sperry, 1974). Sperry (1974), for example, has suggested that "in dealing with faces, the right hemisphere seems to respond to the whole face as a perceptual unit, whereas the left hemisphere seems to focus on salient features and details to which labels are easily attached, and then used for discrimination" (p. 14). In normals, empirical support for analytic processing of faces presented in the RVF and for holistic processing in LVF presentations comes from a series of experiments in which performance was examined as a function of feature manipulation. Thus, Fairweather, Brizzolara, Tabossi, and Umiltà (1982), Patterson and Bradshaw (1975), and Sergent (1982a) found a RVF superiority in the comparison of faces differing in one feature but not when the faces differed in several features; Bradshaw and Sherlock (1981) found that detecting a change in one feature between two faces was better achieved in RVF presentations, whereas detecting a change in spatial location of the features was better performed in LVF presentations; Ross and Turkewitz (1981) observed that subjects displaying an initial RVF superiority in recognizing faces were more affected in a subsequent task in which one feature was hidden than were subjects displaying an initial LVF superiority. In all these studies, it was assumed that a difference in one feature between two faces required an analytic mode of comparison that was thus operative in RVF presentations, whereas faces differing in several features were assumed to be compared holistically in LVF presentations (e.g., Patterson & Bradshaw, 1975).

The analytic-holistic dichotomy hypothesis therefore predicts that latency measures of dissimilarity among faces should be best fitted by a model that entails independent processing of the component dimensions of faces presented in the RVF. By contrast, latencies to compare faces presented in the LVF should be best fitted by the Euclidean model.

An alternative prediction can be made on the basis of Sergent's (1982b) suggestion that both hemispheres are equipped to process information analytically or holistically, but they do not operate on the same representation of the visual stimuli. This hypothesis predicts that the same similarity-relations model should provide the best fit of the data for both RVF and LVF presentations, implying similar processes in the two hemispheres. However, because these processes are assumed to operate on different representations in the two hemispheres, one should expect the best solution for each visual field to be qualitatively different.

Two particular aspects of the experiment deserve special consideration. One concerns the use of line-drawing faces as stimuli, which are obviously artificial and lack ecological validity. This was made necessary to ensure control over the dimensions in which the faces differed and because two of the selected models of similarity relations require the specification of the relevant dimensions. Real faces would not lend themselves to such an investigation. Although it has been argued that such artificial stimuli prevent the identification of the processes underlying face perception and may encourage a serial mode of comparison (e.g., Ellis, 1981), there is as yet no strong evidence that these stimuli necessarily elicit operations different from those involved in processing real faces (see Sergent, in press). In fact, Tzavaras, Hecaen, and Le Bras (1970) found that RH-damaged patients were defective in recognizing both real and schematic faces, and that performance on these two types of faces was significantly and positively correlated.

The second aspect concerns the necessity to "induce" an RVF superiority in the processing of faces so that performance in RVF presentations would not be simply the result of transfer from the LH to the RH, which is often considered as specialized in face processing. One way of producing such an RVF superiority is to use a difficult discriminative task in conditions that minimize the degradation of the input. Whereas task difficulty resulting from stimulus degradation is better dealt with by the RH than by the LH (e.g., Hellige, 1982), task difficulty resulting from fine discrimination produces LH superiority over the RH
(e.g., Fairweather et al., 1982; Patterson & Bradshaw, 1975). This differential efficiency of the hemispheres as a function of the nature of task difficulty has been clearly demonstrated by Haun (1981) by manipulating the levels of state- and process-limitations (see Sergent, 1983, for a review). Thus, by using faces not too dissimilar from one another and by using relatively long exposure, we expected that RVF presentations would yield faster latencies than would LVF presentations, at least for faces differing in few features.

Method

Subjects

Four male subjects (from 24 to 32 years old) participated in the experiment. They all had normal uncorrected visual acuity. Prior to the experiment, they completed the Edinburgh Handedness Inventory (Oldfield, 1971), a hand-tapping task, and a dichotic listening test. The 4 subjects, who were right-handed, claiming preferential use of their right hand in all tasks inventoried in Oldfield’s questionnaire and having no familial sinistrality, showed at least 8% faster right- than left-hand tapping. They all displayed a right-ear superiority in the identification of stop-consonants dichotically presented. Following the main experiment, the subjects were further tested on two tachistoscopic tasks individually. They all showed an RVF advantage in the identification of bilaterally presented three-letter words, using a procedure identical to that of Hines (1975). The second tachistoscopic task consisted in a male/female face categorization experiment, with a stimulus unilaterally presented for 40 ms at 3-ML (9.5 cd/m²) luminance, using a procedure identical to that of Sergent (1982c), and all the subjects displayed an LVF superiority in latency; 1 subject showed a similar effect in accuracy, whereas the other three had no field difference in the number of errors. These additional experiments were carried out to ensure that the 4 subjects were representative of the general male right-handed population as established in previous studies.

Subjects 1, 2, and 3 had no prior experience with the stimuli nor with a lateral tachistoscopic task. Subject 4 had had extensive exposure to the stimuli 21 months earlier and was Subject 2 in the experiment described by Takane and Sergent (1983) that involved central presentation of the face stimuli. His inclusion as an additional subject in this experiment was intended to compare performance in central and lateral presentation. The subjects were paid $5.00 per hour for their participation.

Stimuli and Equipment

The stimuli were eight line drawings of front-view faces derived from a larger set of faces (Sergent, 1982a). The faces were made by combining each of two levels of three dimensions: hair style (H), eyes and eyebrows (E), and jaw and chin (J). Nose, mouth, and ears were kept constant across faces.

Each possible different pair of faces was mounted on a slide, one face above the other, yielding a total of 56 different pairs, 28 for each visual field; 16 same pairs, 8 for each visual field, were mounted in the same manner. The stimuli appeared in black and white, at a luminance of 15.75 L (47.7 cd/m²), on a white background of 3-ML (9.5 cd/ m²) luminance, for a duration of 250 ms. Although most visual laterality studies are conducted with an exposure duration of 180 ms or less, a 250-ms exposure was chosen to ensure an input of high clarity. Although this duration is longer than the time necessary to initiate eye movement, it may be adequate for an RT task in which latency is measured from the onset of stimulus, because there is additional time required to move the eyes and to focus on the stimulus after eye movement. Moreover, Bryden (1982) mentioned evidence suggesting that it may take up to 300 ms to initiate an eye movement when the subject does not know which of two locations will be stimulated.

When projected on a translucent screen (18 cm × 13 cm), the faces appeared either to the left or the right of a black dot (0.35") located in the center of the screen and serving as fixation point, with the inner extremity of each face 1.1" away from the vertical medial axis. Each face subtended a visual angle of 4.3" in height and 3.3" in width, and the separation between the bottom of the top face and the top of the bottom face was 1.3". This mode of stimulus presentation differs from that used in Sergent’s (1982a) experiment in which a target was presented centrally for 1 s and immediately followed by a test face laterally presented for 250 ms at the same horizontal level as the target. The present mode of presentation was chosen to ensure that the two faces were initially projected to only one hemisphere. This made the task more difficult than in Sergent’s (1982a) previous experiment, because two faces had to be processed simultaneously instead of successively. In addition, the relative salience of the facial features was modified by this presentation compared to the previous experimental conditions (Sergent, 1982a). The thin line describing the jaw and chin of the bottom face was located more than 5" from fixation, whereas the lower part of the hair of the upper face, which was the discriminative clue between two hairstyles, appeared less than 4" from fixation. This made the discrimination of the two hairstyles easier than that of the two jaws, and this was confirmed in a short control experiment in which the facial features were presented separately.

The slides were placed in a Kodak random-access projector. Presentation was controlled by a PDP 11/20 computer, which selected the slides in a random order. Within a session, each different slide appeared four times and each same slide appeared 14 times, yielding a total of 448 trials per session. When a subject made an error, that slide was presented again later in the sequence. Exposure duration, recording of RTs and of response type, and intertrial interval of 4 s were controlled by the computer. Presentation was made through a Lafayette (Model 43016) iris-type shutter installed on the projector. In front of the subject was a response panel made of two-Morse keys, one ahead of the other along the midline axis. Subjects 1 and 2 responded with their right index and middle fingers, whereas Subjects 3 and 4 responded with the same left fingers.

Procedure

The subject sat 57 cm from the screen, in a dimly lit room. His head was adjusted on a chin- and forehead-rest so that his eyes were constantly at the level of the fixation...
point. The subject wore headphones through which the warning tone was delivered, and he had one hand on the response panel. A 500-ms tone warned the subject to fixate the central point. The stimuli appeared 1 s after the onset of the warning tone, and the subject was to press one key if the two faces were the same and the other key if they were different. The subjects were told to respond as quickly and accurately as possible, and the necessity to keep focusing on the central dot from the warning signal to response execution was stressed in the instructions. Each subject participated in five sessions of 448 trials, one session on consecutive days. The first session was used as practice, and the results were not included in the analysis. Each of the experimental sessions was preceded by a practice session of 50 trials. An entire experimental session lasted about 1 hr.

Analyses

Preliminary analyses of variance of latencies and errors averaged across subjects were conducted for comparison with previous studies. Several characteristics of the main analyses are outlined below, as they differ from the conventional approach. The main analyses were based on 16 replications for each subject and visual field of each possible different pair comparison.

Maximum likelihood estimation. Any statistical process of fitting a model to data must employ a criterion to assess the fit. In the analysis of variance, the criterion is based on least-squares estimation. In the present investigation, an alternative criterion is used, based on the principle of maximum likelihood estimation (e.g., Freund, 1971). In this estimation procedure, a fitting criterion called the likelihood is maximized by determining the parameters' values yielding its highest possible value. The parameters include everything that must be estimated to specify a model and therefore vary from one model to another. The maximum likelihood estimation procedure aims at finding the values of these parameters that maximize the likelihood. Because a logarithmic transformation of data preserves their order, reduces the skewness inherent in RT distribution, and facilitates computations, all the analyses were performed on the logarithm of the RT of each trial for each subject.

Error model. One requirement when using a maximum likelihood estimation procedure is to specify the random-error components present in the data. Any type of dissimilarity judgment is error perturbed, and specifying the distribution of the error components in the data is critical in attempting to fit a model, especially when the dependent variable is RT, which is typically a "noisy" measure. In the present analyses, it is assumed that errors are log normally distributed, which is intuitively adequate because the size of the error is increasing with an increase in RT. Takeane and Ser gent (1983) validated this assumption by examining the normalized residuals of RT measures of dissimilarity in a quantile plot. Thus, each different judgment is assumed to be a function of a particular combination of stimulus dimensions that is somehow perturbed by error components whose distribution is considered as being log normal.

Goodness of fit. The goodness of fit of a model is a function of the likelihood of its parameters' values. However, because it is always possible to fit any data and to increase the likelihood by increasing the number of parameters, a criterion of goodness of fit of a model must be taken into consideration, not only the maximum likelihood but also the number of parameters. One such criterion is the Akaike Information Criterion (AIC, Akaike, 1977), which can be used to compare any model derived from the same sample and which allows for control of parsimony by penalizing the use of additional parameters from one model to another. Only relative magnitudes of AIC are meaningful, and the model with a smaller value is considered a better model.

Results

Preliminary Analyses

The task proved a difficult one, despite the long practice, and the grand mean RT was of the same order as that obtained by Sergent (1982a) when the same faces differing in only one feature were presented in easier experimental conditions. The percentage of errors was 13.56%. A two-way repeated-measure analysis of variance on the errors showed no main effect of response type and visual field nor of interaction. However, there was a trend toward more errors in the LVF than in the RVF (7.69% and 5.87%, respectively), $F(1, 3) = 2.92, p > .10$. A similar analysis of variance of the errors for different responses with visual field, session, and condition (the seven types of difference between faces) as factors showed a main effect of session, $F(3, 9) = 4.12, p < .05$ indicating improved accuracy with practice, and a main effect of condition, $F(6, 18) = 4.58, p < .05$, showing more errors on eyes and jaw than on hair. No effect involving the visual fields reached a reliable level of significance, $F < 1.2$, and the errors will not be considered any longer.

Response latencies of each subject in each visual field, averaged across sessions and across pairs as a function of the nature of the difference, are presented in Table 1 for same and different judgments. An initial analysis showed no significant effect of responding hand, and this factor was not further included in the analyses.

A repeated-measure analysis of variance was carried out on RTs with response type (same-different) and visual field as factors. The main effect of response type was significant, $F(1, 3) = 13.42, p < .05$, with different responses being faster than same responses (732 ms and 769 ms, respectively). As shown in Table 1, this result emerged from averaging different
Table 1
Mean Latencies (in ms) of Each Subject to the Seven Different Conditions, Averaged Over Different (D) and Same (S) Responses as a Function of the Visual Field of Presentation

<table>
<thead>
<tr>
<th>Subject and field</th>
<th>Condition</th>
<th>Response</th>
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<tbody>
<tr>
<td></td>
<td>H</td>
<td>E</td>
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<tr>
<td>1</td>
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<td></td>
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<tr>
<td>LVF</td>
<td>806</td>
<td>912</td>
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<tr>
<td>RVF</td>
<td>718</td>
<td>870</td>
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<tr>
<td>2</td>
<td></td>
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<tr>
<td>LVF</td>
<td>769</td>
<td>877</td>
</tr>
<tr>
<td>RVF</td>
<td>722</td>
<td>833</td>
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<tr>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LVF</td>
<td>696</td>
<td>813</td>
</tr>
<tr>
<td>RVF</td>
<td>626</td>
<td>785</td>
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<tr>
<td>4</td>
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<tr>
<td>LVF</td>
<td>684</td>
<td>843</td>
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<tr>
<td>RVF</td>
<td>635</td>
<td>804</td>
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<tr>
<td>M</td>
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</tr>
<tr>
<td>LVF</td>
<td>739</td>
<td>861</td>
</tr>
<tr>
<td>RVF</td>
<td>675</td>
<td>823</td>
</tr>
</tbody>
</table>

Note. LVF = left visual field; RVF = right visual field.
H = hair; E = eyes; J = jaw.

responses over conditions, because not all different pairs were compared faster than same pairs. Although latencies were shorter in the RVF than in the LVF (743 ms and 759 ms, respectively), this difference failed to reach a reliable level of significance, F(1, 3) = 7.22, .05 < p < .10. However, the trend in the direction of RVF superiority is consistent with findings from previous studies involving difficult comparison of faces (Fairweather et al., 1982; Patterson & Bradshaw, 1975; Sergent, 1982a).

Because the main analyses were to be performed on the data from all the experimental sessions, it was necessary to ensure that no change in the pattern of results occurred across sessions. Subjects had considerable practice to stabilize their performance by the first experimental session. A repeated-measure analysis of variance was thus performed on different latencies, with session, visual field, and condition (the seven types of differences between faces) as factors. No main effect and interaction involving the sessions proved significant. Subjects were as fast in the first as in the third and fourth sessions (719 ms, 729 ms, and 724 ms, respectively), but were somewhat slower in the second session (754 ms). The main effect of condition was significant, F(6, 18) = 149.31, p < .001, as was that of visual field, F(1, 3) = 31.66, p < .02, showing an RVF superiority over the LVF (718 ms and 745 ms, respectively). More important, the interaction of visual field by condition was significant, F(6, 18) = 2.83, p < .05, confirming a previous finding by Sergent (1982a) and suggesting that the processing of faces is qualitatively different for the two visual fields. This interaction is illustrated in Table 1, which shows that the difference in latencies between the two visual fields is not constant across conditions, being larger in the one-difference conditions and null in Conditions HJ and HEJ.

Although it is the purpose of the main analyses to investigate the rules by which features were combined when faces were presented in the LVF or RVF, it is possible to examine what could be inferred about the underlying processes using the conventional analysis of variance. The different latencies were combined as a function of the number of differences between the comparison faces and were subjected to an analysis of variance with visual field and number of differences (one, two, and three) as factors. In addition to the main effect of visual field similar to that found in the previous
analysis, the main effect due to the number of differences was highly significant, \( F(2, 6) = 134.18, p < .001 \), and this effect was similar in the two visual fields as shown by the absence of interaction \( (F < 1) \). There was therefore a significant decrease in latency with an increase in the number of differences between faces, similar in both visual fields, and this pattern of results is usually taken as indication of analytic (serial or parallel) mode of comparison. Indeed, the linear trend analysis carried out on these data for each visual field was highly significant: RVF, \( F(1, 6) = 124.31, p < .001 \); LVF, \( F(1, 6) = 145.55, p < .001 \). The quadratic trend was not significant: RVF, \( F(1, 6) = 1.17 \); LVF, \( F(1, 6) = .17 \). Considered in the context of the analytic–holistic dichotomy, this finding would rule out any form of holistic processing as underlying performance in either hemisphere, as suggested by Bagnara, Bole, Simon, and Umiltà (1982). This conclusion is not justified, however, because the linear trend does not carry with it its explanation and does not specify the operations that produce this monotonic decrease in RTs with an increase in the number of differences between faces. This issue will be further addressed in the Discussion section.

**Main Analyses**

In fitting the models of similarity relations, each different trial was considered as a dissimilarity judgment, and each different RT was used in the analysis, yielding 16 replications by subject and by field of dissimilarity measures among each of all possible different pairs. All the analyses were carried out separately for each visual field of each subject.

**Dominance-metric model.** The dominance-metric model, like other spatial models, does not presuppose any prescription of relevant dimensions, but it is extremely difficult to fit this model in such a form. Assuming that the relevant dimensions were the three facial features that were manipulated, this model became a typical linear model and was fitted separately for each of the six possible orders along which the faces could be compared (H-E-J, H-J-E, E-H-J, E-J-H, J-E-H, and J-H-E). Although some of these orders were unlikely, there were nonetheless arguments for each dimension to be considered the more salient. Considerable evidence suggests that the hair is the more salient characteristic of the face (see Davies et al., 1981), and the short control experiment indicated that this was the case under the present experimental conditions; the eyes have been shown to attract the most attention in a face, and they could thus be subjectively the most salient even if they were not objectively so (e.g., Walker-Smith, Gale, & Findlay, 1977); Sergent (1982a) found the jaw dimension of these faces to be the most salient dimension in other experimental conditions, and it could have been dominant for some subjects or even in one of the other visual field.

The goodness of fit of the dominance-metric model under all six possible salience orders is reported in the top part of Table 2. The values presented in this table are the AIC values, \(-2(\log L - np)\) where L is the likelihood and \(np\) the number of parameters. For all subjects and in each visual field, the salience order H-J-E provides the best fit of the data, which is indicated by the AIC values which are the smallest for this solution. This is consistent with the data shown in Table 1, indicating that, in the one-difference conditions, the same order H-J-E in terms of response latency prevailed, and both the analyses of latencies and errors confirmed this finding.

If the dominance metric is the best model to account for the data, all other models should then yield AIC values larger than those obtained in this linear model, which would suggest a self-terminating comparison of the faces. Further examination of Table 1, however, indicates that the dominance metric model is unlikely to provide the best fit of the data. This model postulates that only the most salient dimension is used in comparing the faces, which implies that adding a less salient difference should not influence latency. For both visual fields there are clear deviations from this rule, because some conditions yielded shorter latencies than any of the one-difference conditions. This suggests that a model taking the influence of the less salient features into account should better approximate the perceived dissimilarities.

**Contrast model.** Tversky's (1977) feature-matching model postulates that all the features of a stimulus contribute to the perceived dissimilarities, positively when the features are
different between two stimuli and negatively when they are common to the two stimuli. Tversky's model requires specification of the relevant dimensions, which are thus assumed to be the two-values of the three manipulated facial features. The AIC values obtained by fitting the data of each subject for each visual field to the contrast model are shown in the last row of Table 2. As can be seen by comparing these values to those obtained by fitting the dominance metric model, the feature-matching model provides a better approximation of the data, except for Subject 1 in the LVF. This finding suggests that the perceived dissimilarities are more likely to be based on judgments that take into consideration each feature of the faces than on judgments based only on the more salient difference as implied by the dominance metric model. It thus seems that a self-terminating analytic comparison of the faces was not the process that underlay performance in either visual field, and, at this point, a parallel mode of processing, as entailed by the contrast model, appears to be more adequate to account for the data.

Spatial models. In contrast to the two preceding models, the spatial models do not require prescription of what aspects of the stimuli and how many dimensions are psychologically relevant, and these characteristics are specified by the analysis itself. The city-block model and the Euclidean model were fitted for two, three, and four dimensions. In addition to the AIC statistic that may be used to compare any model fitted to the same sample, one further test can be carried out when one model is a constrained counterpart of another. This statistic, the asymptotic chi-square significant test, allows the comparison between different dimensionalities within a spatial model, and it provides an indication as to whether the addition of a dimension to a solution significantly improves the goodness of fit.

Table 3 displays the AIC values obtained by fitting the city-block and the Euclidean models in two, three, and four dimensions for each subject and each visual field. The underlined values show the best solutions as determined by the AIC and the asymptotic chi-square test. As is apparent in this table, the three-dimensional Euclidean model provides the best approximation of the perceived dissimilarities in all but one case. For Subject 3's LVF, the AIC value for the four-dimensional solution is the smallest, and the chi-square indicates that this solution provides a significant improvement in goodness of fit of the data over the three-dimensional solution, $\chi^2(4) = 19.8, p < .001$. The perceived dissimilarities of Subjects 3 and 4 in the RVF were not significantly better fitted by the four-dimension solution ($\chi^2(4) = 8.00$ and 9.00, respectively, $p > .05$). Although the city block model provides a better approximation of the data than the contrast model, as shown by the smaller
Table 3
Values of Akaike Information Criterion (AIC) Obtained by Fitting the City-Block Model and the Euclidean Model in Two, Three, and Four Dimensions

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Left visual field</th>
<th>Right visual field</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>S1</td>
<td>S2</td>
</tr>
<tr>
<td>City-block model</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>-1353.8</td>
<td>-1209.4</td>
</tr>
<tr>
<td>3</td>
<td>-1123.8</td>
<td>-1197.2</td>
</tr>
<tr>
<td>4</td>
<td>-1382.2</td>
<td>-1218.0</td>
</tr>
<tr>
<td>Euclidean model</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>-1387.2</td>
<td>-1226.8</td>
</tr>
<tr>
<td>3</td>
<td>-1399.0</td>
<td>-1233.2</td>
</tr>
<tr>
<td>4</td>
<td>-1396.4</td>
<td>-1228.0</td>
</tr>
</tbody>
</table>

Note. S = subject. The underlined values indicate the best solutions.

AIC values for the former than the latter, it offers a poorer fit of the perceived dissimilarities than the Euclidean distance model. The main implication of this finding is that the component dimensions of the stimuli were not treated independently of one another but were combined in a nonadditive manner.

Best solution. One of the advantages of the spatial models is the possibility of displaying the results in the form of a spatial representation whose examination may provide further insight into the rules by which the dimensions are combined. The derived three-dimensional representations of Subjects 2 and 4 for each visual field are displayed in Figures 1 and 2, respectively. The spatial representations of Subject 1 were similar to those of Subjects 2 and 4, whereas the four-dimensional solution of Subject 3 cannot be displayed graphically. These representations show each face of the stimulus set as a point in a three-dimensional space whose coordinates can be identified as

![Subject 2](image)

*Figure 1: Derived three-dimension spatial representation of dissimilarities among faces for the left (LVF) and the right visual field (RVF) of Subject 2.*
the three-dimensions (facial features) that were manipulated. Examination of these spatial representations of the perceived dissimilarities reveals several interesting characteristics. First, it confirms that the hair was the more salient dimension because a difference in hair between two faces (Pairs 1–2, 3–4, 5–6, and 7–8) results in larger distance than a difference in either eyes or jaw. Second, and more important, a difference in the same dimension between two faces of the set does not result in equal distance between pairs that differ on this dimension. This is a clear indication of interactive processing of the component dimensions. Consider the same pairs as earlier of faces differing only in hair. If this dimension is treated independently of the two others, as implied in an analytic mode of operation, the distance separating the two faces of each pair should be identical because each two faces differ only in hair. As is apparent in the spatial representations of Figures 1 and 2, this is not the case: The distance resulting from hair difference varies depending on the value of the other dimensions. Thus, the perceived dissimilarity between faces differing only in hair is obviously a function of their difference along this dimension but also of the interaction between this dimension and the other dimensions. Clearly, the context in which a difference on one dimension is embedded influences how this difference is perceived, and this prevailed in the two visual fields of presentation. There is therefore evidence that the component dimensions were processed simultaneously in an interactive manner, and these characteristics are inherent properties of a gestalt mode of processing (e.g., Köhler, 1969). All three-dimensional solutions showed these characteristics. The four-dimensional solution of Subject 3 for LVF presentation described the three dimensions corresponding to the facial features that were manipulated, and a fourth dimension that could be tentatively interpreted as a feature-homogeneity dimension, depending on the masculine or feminine appearance of the facial features.

Comparison of visual-field performance:

The last question addressed in the analysis of data was concerned with the comparability of the two visual-fields' solutions for each subject. Whereas there was a clear difference between the best solution for LVF and RVF presentation in Subject 3, the results of Subjects 1, 2, and 4 yielded solutions of similar dimensionality in the two visual fields. Although this indicates similar basic processing for the two visual fields, it does not tell whether the spatial representations were qualitatively similar. Because the analysis of variance had shown a significant interaction of Visual Field × Types of Difference, one could expect that the visual fields' solutions were qualitatively different for each subject, as already found for Subject 3 and as an examination of Figures 1 and 2 could suggest for Subjects 2 and 4.

Because data from each visual field represent independent samples, neither the AIC nor the chi-square statistics can be directly used to compare performance in the two visual fields. The data were therefore collapsed over visual fields for each subject and analyzed for a three-dimension solution. If the results from the two visual fields are not qualitatively different (or, in the context of maximum likelihood estimation, if the data come from the "same population"), the analysis should provide a better fit of the collapsed data than of the two visual fields considered separately. Thus, by comparing the AIC value for the collapsed solution with the sum of the AIC values for the two separate solutions, one may determine whether or not the solutions for each visual field are significantly different.
must be noted that this is a highly conservative test that considerably minimizes the risk of a Type 1 error, that of rejecting the null hypothesis while it is true. For one thing, doubling the number of observations by collapsing the data more than doubles the maximum likelihood if the data come from the same population. In addition, fitting two separate samples requires twice as many parameters as fitting the collapsed data, and this factor is taken into consideration in the respective AIC values. The results showed that for Subjects 1 and 2, the separate analyses of RVF and LVF data provided a better fit than did the analysis of the collapsed data: for Subject 1, the sum of separate AICs equals $-2828$, whereas the collapsed AIC equals $-2769$, $\chi^2(18) = 94.6, p < .001$; for Subject 2, the sum of separate AICs equals $-2301.2$, whereas the collapsed AIC equals $-2283.6$, $\chi^2(18) = 38.6, p < .01$. This suggests that for Subjects 1 and 2 the three-dimension Euclidean solutions obtained from LVF and RVF presentations were qualitatively different.

For Subject 4, however, the separate and the collapsed solutions did not differ significantly when using the conservative AIC statistic ($-2281$ and $-2282$ respectively), whereas the more liberal chi-square test, which is directly derived from the maximum likelihood, yielded a significant difference in favor of the separate solutions ($\chi^2(18) = 30.8, p < .05$). Nonetheless, parsimony advises the acceptance of the null hypothesis for Subject 4, suggesting no visual field difference. It is noteworthy that this subject had prior experience with the stimuli, and the absence of significant difference between the two visual fields may have resulted from overlearning. However, even if there was no difference in terms of processes, this subject displayed the RVF advantage in response latency. In addition, there is an interesting disparity between this subject's performance on centrally presented faces and that on laterally presented faces. Although the three-dimensional solution was the best for each visual field, his data were best approximated by a four-dimensional Euclidean solution when the faces were presented centrally (see Takane & Sergent, 1983, Figure 3). This suggests that the cooperative engagement of the two hemispheres in a face discrimination task may result in performance qualitatively different from that achieved when each hemisphere is stimulated separately.

**Discussion**

The present experiment was designed to examine how component dimensions of faces combine when the stimuli are initially projected to the RH or the LH and to test the analytic–holistic dichotomy of cerebral processing. By fitting latency measures of dissimilarity among a set of faces, we found that the data from each visual field of each subject were best approximated by the Euclidean distance model. Before discussing the implications of this finding, several aspects of the results need to be considered.

**Visual-Field Superiority in Face Processing**

The task was intended to be difficult so that a RVF advantage would emerge, and this pattern prevailed in different responses. Such an RVF superiority conforms with previous findings (Fairweather et al., 1982; Patterson & Bradshaw, 1975; Sergent, 1982a) obtained with faces differing in few features, and it is consistent with the view that the LH plays a critical role in difficult visuospatial processing when difficulty results from process limitation rather than state limitation (Haun, 1981; Sergent, 1983). Two aspects of these results deserve consideration. For one thing, the previous experiments with faces in which an RVF advantage had been found used either memorization of a target face or successive stimulus presentation. The present experiment involved simultaneous presentation of the stimuli, a procedure similar to that of Moscovitch, Scullion, and Christie (1976, Experiment 1), who reported no field difference. Moscovitch et al. (1976) suggested that such an absence of field difference reflected similar processes in the two hemispheres when information is represented in terms of brightness, contrast, and contour. They used Identikit faces differing from one another in all their dimensions, and it is likely that the less difficult nature of the comparison (as shown by latencies 132 ms shorter than in the present experiment) accounted for their finding. In the present study, the RVF advantage in different responses was obtained when
the faces differed in few features, but it was absent when they differed in all three manipulated features (Condition HEJ). It therefore seems that the difficulty of the discrimination is an important factor in determining the relative efficiency of the two hemispheres. It must be noted that this suggestion applies to discriminatory perceptual capacities, but it is not supported by the results of 2 subjects in same comparisons.

The second aspect concerns the nature of the stimuli. Most experiments with unfamiliar faces reporting an RVF advantage involved the presentation of schematic or line-drawing faces, and this raises questions as to what characteristics of the stimuli contribute to such an advantage. The schematic nature of these faces does not seem sufficient to account for an RVF advantage because fairly dissimilar schematic faces can yield an LVF advantage (Fairweather et al., 1982; Patterson & Bradshaw, 1975). The distinctive characteristic of the facial features composing schematic or line-drawing faces and those that could facilitate an analytic mode of processing cannot explain the RVF advantage because in the present experiment the component dimensions were not processed in an independent manner. Although the aforementioned factors may have partly contributed to the pattern of results, it seems that the use of schematic and line-drawing faces simply provides the possibility of constructing a set of fairly similar faces (thus difficult to discriminate), a condition that is not as easily achieved with photographs of real faces.

One should not therefore attribute the RVF advantage in the present experiment to the use of line-drawing faces as such but to the high similarity between the faces that the LH may be more efficient at discriminating than is the RH. The results may thus provide further evidence that the task requirements, in terms of the stimulus characteristics that need to be processed to achieve efficient performance, significantly contribute to the relative superiority of one hemisphere over the other (see Hellige, Corwin, & Jonsson, 1984). Why the RVF advantage was more robust in discriminatory than in matching operations in the present experiment (see also Fairweather et al., 1982) remains unclear and requires further investigation.

Nature of the Underlying Processes

The present results suggest that faces initially projected to either hemisphere are compared on the basis of their overall similarity and that the component dimensions interact with each other. Whether such a process reflects the typical mode of operation of each hemisphere must be examined by considering the particular procedure of the experiment and certain aspects of the results.

Preliminary considerations. The experiment was conducted with relatively brief exposure duration and small retinal eccentricity, two factors that reduce visual acuity. It is then possible that the Euclidean solution obtained for both visual fields of presentation resulted from these procedural conditions. For example, Lockhead (1972) suggested that any stimulus is initially processed as a “blob,” or integrally, and that analytic or separable processing is implemented subsequently if the task requires it. It is thus conceivable that the brief exposure may have prevented an analytic processing from being implemented. There are at least three reasons why this argument should not be of concern in the present study. First, even if this were the case, it would nonetheless indicate that a holistic operation was taking place after presentation in the LVF or in the RVF. Second, most research with normal and commissurotomized subjects that served as a basis for the suggestion that the LH operates analytically (see Bradshaw & Nettleton, 1981) used procedural conditions similar to those prevailing in the present experiment. Third, even at brief exposure, one can obtain evidence of independent and separable processing of stimulus dimensions. For example, Sergent and Takane (1984) centrally presented for 50 ms parallelograms varying in size and tilt (see Attneave, 1950) and found that latency measures of dissimilarity between these stimuli were best approximated by the city-block model, thus indicating that component dimensions can be combined additively with such a brief exposure duration. In addition, Takane and Sergent (1983) found that the Euclidean model provided the best fit of RT measures of dissimilarity among faces centrally presented for 1 s, suggesting that longer ex-
posure duration does not necessarily imply that analytic processing will be implemented.

There is therefore no reason to believe that the present finding was entirely determined by the procedural conditions. However, whether multidimensional stimuli such as faces are processed analytically or holistically depends on the particular experimental task. One could easily, for example, attend selectively to each feature of a face presented for an unlimited time and count the number of common features between two faces, a procedure that typically involves an analytic mode of processing. As noted by Garner (1978), both component and configural properties of a stimulus can be used depending on the task, but in the present experimental conditions in which speeded dissimilarity judgment was required the component dimensions of the faces were not treated analytically. The facts that the Euclidean model provided the best fit of the data and that interactions between features were evident in the spatial representations of the results suggest a mode of processing based on simultaneous and interactive treatment of the facial features. Such a mode of operation is typical of holistic processing, and, in the context of Garner's formulations, refers to a processing of faces in terms of their configural properties that emerge from the interrelationships among their component dimensions.

**Hemispheric processing asymmetry.** The analytic–holistic processing dichotomy predicted that different combinatorial rules would mediate the dissimilarity judgments on faces presented in the LVF and the RVF, but the results did not conform with this prediction. For each subject, the dominance metric, the feature-matching, and the city-block models, all implying independence of components, yielded poorer approximation of the data than did the Euclidean model, which entails interactions among components. In addition, as shown in Figures 1 and 2 for both visual fields, the particular value taken by a dimension influenced how another dimension was perceived, which confirms a lack of independence of the components of a face. The dominance-metric model yielded the poorest fit of the data, suggesting that a serial self-terminating mode of comparison does not adequately describe the operations underlying this discrimination task. Models implying a parallel mode of processing came closer to describing the nature of the operations, but the independence of the component attributes postulated by the feature-matching and the city-block models was not consistent with some of the characteristics of the rules by which dimensions were combined in LVF and RVF presentations.

The Euclidean model provided the best fit of the data for each visual field, and the Euclidean solutions for the two visual fields in Subjects 1, 2, and 3 were significantly different. The implications of these results for models of hemispheric processing must then be examined in the context of the RVF superiority and of the interaction between visual field and type of difference between faces, as shown by the analysis of variance. Although these results suggest hemispheric processing asymmetries and holistic operations on faces projected to the LH, they may not unequivocally indicate that both hemispheres processed faces in terms of their configuration. In fact, it is possible that faces were compared only in the LH and that visual field asymmetries were due to differences between hemispheres in initial encoding operations or to degradation and transformation of information as it was transferred from the RH to LH for comparison. This would explain why a Euclidean solution provided the best fit of the data for both visual fields while accounting for the qualitative difference between the solutions for the two fields. Because information may spread throughout the brain even after unilateral presentation, it is conceivable that finding that the same combinatorial rule prevailed in the two visual fields resulted from a comparison process performed only in the LH. There are, however, some aspects of the results that may not entirely support this interpretation.

If hemispheric differences were present only at the initial encoding level and if only one hemisphere was mediating the comparison, one should expect a main effect of visual field but no Visual Field × Type of Difference interaction, which indicates an asymmetry at the comparison level: Whether two faces differ in eyes or in three features cannot influence the encoding process because all faces are essentially of similar complexity and should be encoded at approximately the same rate within each hemisphere. It also seems that an interpretation in terms of interhemispheric transfer...
of information may not be consistent with the finding of an interaction between visual field and type of difference. The information being transferred is that about a pair of faces, and the type of differences between two faces should not affect transfer time because the comparison has not yet taken place. In addition, if information must be relayed from the RH to the LH for comparison, performance in LVF presentations could not be as fast as performance in RVF presentations, but it was in the HEJ condition. Moreover, the solutions of Subject 3 for the two visual fields were of different dimensionality, suggesting that, at least for this subject, comparison of faces presented in the LVF and the RVF was not mediated by the same processor.

It is nonetheless possible that some transformation of the input was involved during transfer from the RH to the LH, which would have made the comparison less efficient for LVF presentations than when information was directly projected to the LH, but this account would still not explain the equal efficiency for both fields of presentation in the HEJ condition. Although an interpretation in terms of information transfer cannot be ruled out, it is not entirely consistent with the results. Furthermore, one may wonder why the RH, whose competence at processing faces, even nonreal faces (e.g., Tzavaras et al., 1970), is well documented, would forfeit this capacity and send information to the LH. It may then be that visual-field asymmetries reflected some differences in the efficiency with which each hemisphere performed the discrimination. The fact that the same similarity-relations model yielded the best solution for each visual field of each subject may then suggest that essentially similar processes were performed in the two hemispheres. On the other hand, the finding of qualitatively different spatial representations of the perceived dissimilarities in the two visual fields of Subjects 1, 2, and 3 points to differences between the two hemispheres.

If similar processes characterize the operations performed by each hemisphere, one possible source of this qualitative difference may be the nature of the representations that can be constructed in the two hemispheres and that may differ in terms of correlates of the physical characteristics of the stimulus. As Sergent (1982b) speculated, the cerebral hemispheres may be preferentially sensitive to particular spatial-frequency outputs, which could facilitate local processing in the LH and global processing in the RH, but both hemispheres would nonetheless be capable of analytic and holistic operations.

Deciding on the nature of the processes. Despite the finding of configural processing in the two visual fields, RT measures did not conform with the usual criterion of a holistic operation whereby latencies should not be influenced by manipulations of stimulus components. The only study on faces conforming with such a criterion was reported by E. E. Smith and Nielsen (1970), who found that increasing the number of relevant dimensions from three to five did not influence RTs to same responses, and they suggested that comparisons were performed on the basis of “template matching.” This suggestion is questionable, however, because, even if relevant dimensions were varied from three to five in E. E. Smith and Nielsen’s (1970) experiment, the actual number of dimensions was kept constant at five, and there is no guarantee that subjects processed only the relevant dimensions. Reaction time variations with the manipulation of dimensions are in fact consistent with a holistic mode of processing if one considers the respective contribution of each dimension to the configuration. That is, each facial feature represents a contributing factor to the configuration, and, depending on its objective or subjective salience, its modification affects more or less the original configuration of the face. As noted by Lockhead (1972), “blobs” that are distant from each other in a representational space are discriminated more rapidly than those that are near each other. Thus, finding that RTs decrease with an increase in the number of differences between faces does not unequivocally suggest a self-terminating analytic mode of processing and may also indicate a configural operation by which adding differences between faces enhances their configural disparity. The significant linear trend obtained for both visual fields may then have limited value in determining the nature of the processing involved in each hemisphere. Had the analysis of data been restricted to the conventional analysis of variance and the linear trend analysis, the conclusion would have been that the two hemispheres sy-
erated in a self-terminating analytic manner. As shown subsequently, the dominance metric model provided the worst fit of the data in nearly all cases, and this suggests that the analysis of variance may have little power in providing information to determine the processes underlying performance.

The foregoing discussion indicates that the conclusion drawn by Sergent (1982a) that the LH compares faces in a top-to-bottom serial mode, although consistent with the results of the analysis of variance, suffers from the limitations of such an analysis. An alternative, and probably more appropriate, interpretation would be that in Sergent’s (1982a) experiment the contribution of the facial features to the configuration depended on their top-to-bottom location within the face for RVF presentations, whereas it was more dependent on their objective salience for LVF presentations. Because only a small portion of all possible different pairs were used in Sergent’s (1982a) study, the data cannot be subjected to a model-fitting procedure as in the present investigation. In addition, because in the present experiment objective feature salience corresponded approximately to the top-to-bottom location of the features within the face, the aforementioned interpretation must await further investigation to ascertain its validity. Nonetheless, the results of the present study indicate that information gathered from analysis of variance of the data is of limited value to determine the nature of the processes underlying performance.

Conclusion

The present findings cast some doubts on the validity of the analytic–holistic dichotomy as an explanatory model of hemispheric processing specialization, although it would be premature to rule it out definitively: The serial nature of speech production, mediated almost exclusively by the LH, is strong evidence of analytic processing capacities not possessed by the RH. More research is needed to determine whether the two hemispheres operate similarly in all perceptual processes, and it would be especially necessary to examine whether the RH is capable of subserving analytic processing, using, for example, stimuli such as geometric forms whose dimensions are typically separable and analyzable (Attneave, 1950; Hyman & Well, 1967). It is nonetheless questionable whether this dichotomy can still be used to account for findings of asymmetrical performance by the two hemispheres in visual tasks. Bradshaw and Nettleton (1981), confronted with an accumulation of contradictory findings, pointed out that “since hemisphere differences are relative and not absolute, the right hemisphere should therefore be capable of some analytic processing” (p. 84). An implication of this statement, and of the present results, is that no interpretation in terms of this dichotomy can be made in the absence of objective criteria to identify the nature of the underlying processes.

Much evidence presented so far in support of the analytic–holistic dichotomy was derived from performance on tasks that could be equally well described as involving an analytic or a holistic operation, and the results were the determining factor in deciding in favor of one or the other (see Marshall, 1981). The arbitrary nature of this approach can be illustrated with the present results: The more pronounced RVF advantage when faces differed in one dimension than in three dimensions (see Table 1) could be attributed to an LH analytic mode of operation, which is better suited when there are few differences between the stimuli; conversely, the difference in response latency between the visual fields was minimal in conditions HJ and HEJ, and this could be attributed to the RH holistic processing capacities, which were more appropriate when the faces differed in their external features or contour. Thus, the findings can be easily “recuperated” in favor of the analytic–holistic dichotomy. Indeed Sergent (1982a) used this type of reasoning to account for her data, yet this is a superficial and misleading explanation of the results, one that does not directly address the nature of the processes underlying performance. Although the aforementioned observations may point to a differential sensitivity of the hemispheres to the local and global attributes of the faces, they provide no cue per se as to the operations involved. Only with specifically and objectively defined criteria to evaluate performance can we reach an understanding of the processes respectively subserved by the two hemispheres.
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Received October 13, 1983
Revision received March 12, 1984