1998

Categorical and coordinate spatial judgements in face recognition

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A Thesis Submitted in Partial Fulfilment of the
Requirements for the Award of
Bachelor of Arts (Psychology) Honours
Faculty of Health and Human Sciences, Edith Cowan University

October, 1998

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Abstract

The role of the cerebral hemispheres in processing spatial relationships is outlined in Kosslyn's (1987) theory that states that there are two separate subsystems for processing spatial relations: one located in the left hemisphere (LHem) that is more efficient at processing categorical information, and one in the right hemisphere (RHem) that is more efficient at processing coordinate information. To test Kosslyn's theory, this study manipulated two IVs in a within-subjects design, task: categorical and coordinate; and visual field (VF): left and right. Male and female face stimuli were presented in either the left visual field (LVF) to the (RHem) or the right visual field (RVF) to the (LHem). Forty-four, right-handed participants (13 males and 31 females) made 40 categorical and 48 coordinate judgements. Separate two-way repeated measures ANOVAs were performed on both judgement types in both VFs for the two DVs of mean response time (RT) and percentage correct. A significant interaction was predicted between VF and judgement type with a faster mean RT for the LFV/RHem on the coordinate than on the categorical judgements and a faster mean RT for the RVF/LHem on the categorical than on the coordinate judgements. However, although there were significant main effects for task on both RTs and percent correct, no other effects were found. These results do not provide support for Kosslyn's theory that categorical and coordinate spatial relations are processed differentially by each hemisphere.

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Submitted: November, 1998

Declaration

I certify that this thesis does not, to the best of my knowledge and belief:

(i) incorporate without acknowledgement any material previously submitted for a degree or diploma in any institution of higher education;

(ii) contain any material previously published or written by another person except where due reference is made in the text; or

(iii) contain any defamatory material.

Signed by ...(Jill Russell)

Date:...16 FEB 1999.......

Acknowledgements

I would like to acknowledge the support and assistance from a number of people without whose help this thesis would not have been submitted.

I wish to thank my supervisor, Dr. Paul Chang, for his time, patience and respect for my own process and I am grateful for his sound, responsive advice and help with equipment and computer know-how.

My thanks also to Brian Ducy from the Faculty of Business and Public Management for his help and instruction in passing on some of his knowledge about the Excel computer program.

Thankyou to my uni friends for their well-wishing enquiries along the way and for giving their time when they had little of it themselves.

A special thankyou to Doug, my fellow Honour student and husband, who consistently encouraged me.

And a big thankyou to my children, Melanie, Kelwyn and Jaron. Thankyou for unbegrudgingly accepting my university commitment and for warmly encouraging me to stay with it over the years.

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Introduction

The quest to find the location of functions of the brain was well under way by the early nineteenth century with the work of neuroanatomist Franz Joseph Gall. His was a phrenologic view and in order to understand the workings of the brain, he sought to uncover its fundamental building blocks, focussing on the functions of language, aggression, and emotion (Harrington, 1995). Modern cognitive neuroscience now recognises that distinct, functionally specialised regions exist in the brain. The specific operations of these distinct areas are coordinated and work together to produce behaviour such as reading and object recognition (Sergent, 1995). Scientific endeavour has revealed that such broad functional categories comprise many underlying functions or subprocesses, and as begun with Gall, the quest to localise them in the brain is continuing (Harrington, 1995).

Although at present the consensus is that both sides of the brain are equal in structure and chemical constituents (Galaburda, 1995), drawing from his laboratory studies on the anatomy of lateralisation of the two cerebral hemispheres, Galaburda concludes that they are not equal in either function or size of the location of the area concerned with a particular function. When comparing a function in one hemisphere with the same function in the other hemisphere, it is possible that a quantitative measure of the location of the area, can give rise to a qualitative difference in the hemispheric functions (Galaburda, 1995).

The present study explores one area of hemispheric functional difference - visuospatial judgement. Relevant studies are reviewed and their implications for the current study are noted in the introduction. The first major section in the introduction examines four perspectives for understanding the types of perceptual elements and cognitive operations involved in processing visuospatial information. Studies that have empirically investigated each specific perspective are reviewed. Intuitively, each perspective appears to converge on the other, however, as empirical research areas, they are to date, separate frames of reference. The main focus of this thesis is on one of those frames of reference, the perspective of Kosslyn (1987) that sought to elucidate "categorical" and "coordinate" visuospatial functions. An explanation of these terms is given presently, along with a review of studies testing Kosslyn's theory. Some of the studies included give empirical evidence of how related factors influence the outcomes of this research.

A proportion of the research into visuospatial functional laterality has been carried out involving commissurotomised (e.g. Sergent, 1991) and brain-injured patients (e.g. Hannay, Varney, & Benton, 1976; Kohn & Dennis, 1974; Laeng, 1994; Mehta & Newcombe, 1991; Mehta, Newcombe, & Damasio, 1987; Warrington & Rabin, 1970). Hannay et al.'s study demonstrates a right hemisphere (RHem) bias for visuospatial ability. Twenty-two patients without brain injury serving as controls, 22 with left hemisphere (LHem) and 21 patients with RHem lesions were involved. A tachistoscopically presented single dot and/or variously spaced pairs of dots, appeared on a screen with an exposure duration of 300 ms. This was followed by the appearance of a response card showing a set of numbers. The participant was asked to locate the position of either the single dot or the pair of simultaneously presented dots on the response card by giving the number(s) that corresponded to their position.

The results of this study showed that the control group and the LHem lesion group performed similarly, but the RHem lesion group made significantly more errors than the other groups. This indicated a deficit for dot location ability in the patients with RHem lesions, with the implication that the patients with their RHem intact (LHem lesion) could process object locations more efficiently in this hemisphere, although not exclusively.

The LHem was seen to be dominant for verbal processing and the RHem dominant for nonverbal processing, including visuospatial information (Sergent, 1985). However, a more recent view is that each hemisphere is efficient in processing different types of visuospatial cognitive tasks (Sergent), rather than the RHem being the exclusive domain of all visuospatial processing. Some studies, for example, that of Mehta and Newcombe (1991), show evidence of left hemispheric (LHem) lesion deficits in some spatial tasks, indicating that the LHem has equal if not superior ability to the RHem for particular visuospatial functions. The basis of this difference in visuospatial functioning is explained in detail through several frameworks that will be discussed in turn.

Perspectives of Visuospatial Processing and Hemispheric Laterality

Hellige (1993) distinguishes three dichotomous approaches to understanding the role of each hemisphere in visuospatial processing: coordinate versus categorical spatial relations; low versus high visuospatial frequencies; and global processing precedence over local processing. Another perspective, that of Marsolek (1995), will be discussed in comparison with Kosslyn's (1987) theory that describes categorical and coordinate spatial relations.

Categorical and coordinate spatial relations.

Kosslyn (1987) proposed that two separate neural subsystems were responsible for the processing of spatial judgements in strongly right-handed individuals. In order to negotiate objects in the world, people make both specific and generalised judgements regarding the location of those objects. According to Kosslyn's theory, the LHem was proposed to be more efficient at processing spatial information when the required output of this processing was a judgement of the relative location of an object. Originally based on evidence of the LHem's role in speech (Kolb & Wishaw, 1985) and the use of prepositional or categorical labels for information (Liberman, Cooper, Shankweiler, & Studdert-Kennedy, 1967), Kosslyn called these kinds of relative spatial judgements, categorical computations. For example, the terms "above", "below", "connected to", or "inside", describe locations of objects or their parts relative to other parts or objects and selection of this kind of spatial information from a visual scene gives rise to a categorical computation.

Conversely, Kosslyn (1987) argued that the RHem is more efficient in processing information that describes precise locations that require the cognitive measurement of distances between objects or points on those objects. These precise distance judgements he named coordinate computations. This assertion was based on reliable evidence that in patients with either RHem or LHem hemisphere lesions, those with RHem lesions performed worse on perceptual matching tasks that required comparison of finely discriminated distances (e.g., Hannay, Varney, & Benton, 1976; Warrington & Rabin, 1970).

In gathering such evidence, Warrington and Rabin (1970) administered five tests, one of which comprised subtests of perceptual matching. The three perceptual matching subtests required precise measurement judgements on stimuli that were

presented simultaneously and again separately. Participants were required to make "same" and "different" judgements in matching dot position, the slope of a line and the size of a gap in contours. Across both simultaneous and successive presentations of stimuli, the RHem lesion group showed a significantly greater deficit in functioning on these precise measurement judgement tasks than the did the LHem lesion group. Such a result infers that the RHem must be more efficient for such processing in individuals with intact RHems if there is a demonstration of loss of capacity in RHem damaged individuals.

The patients in Warrington and Rabin's (1970) study were included as participants on the basis that they all had lesions verified by surgical reports and radiological investigations such as arteriograms, gamma scans and air encephalograms, and to that point, the existence of cerebral lesions were thoroughly satisfied across participants. It can be noted, however, that the cerebral lesions in either hemisphere were variously sited in either the temporal, parietal, occipital, frontal regions or in a combination of those regions. This may have been a confound to inferences drawn from the results because the different spatial tasks that Warrington and Rabin required the patients to perform may have demanded differential use of those sites. On the same test type and between the same hemisphere damaged participants, the site of the lesion within that hemisphere may have contributed to a deficit in functioning on that test. However, the same area of the lesioned brain may be normally adequate in an intact brain for competence but not essential to competency on the task.

Thus, the question arises, to what degree can results from studies involving commissurotomised, lobotomised and brain-damaged participants be generalised to the functioning of individuals with intact brains. It is worthwhile briefly noting the

advantages and disadvantages of studies whose participants have neurologically defective brains, before discussing further studies that provide converging evidence that supports Kosslyn's (1987) theory of two separate and lateralised subsystems of visuospatial processing.

Generalisability of evidence from brain-injury studies.

One way to determine in which hemisphere the processing of some competence occurs is the neuropsychological testing technique of "double dissociation". Given the competence in some cognitive skill of an individual with a damaged hemisphere, in addition to the finding of an absence of competency in another individual with damage to the exact area in the opposite hemisphere, the inference can be made that the location of the function must reside in the hemisphere that shows competency. However, this assumption of "positive competence" can be justifiably upheld only by the knowledge that (a) the process does not comprise subprocesses that could be located in either hemisphere, and (b) that the function that is inferred to be located within the damaged area is necessary to produce competency on a task, not merely sufficient.

Without this knowledge, hemispheric asymmetry may be evident but this does not necessarily equate with the conclusion that the process is unique to a particular hemisphere (Hellige, 1993). For instance, in a study involving 45 brain-damaged males and 22 nonbrain-damaged males as controls, Mehta, Newcombe and Damasio (1987) found a predominant RHem deficit on a visuoperceptual task that included in part, the answering of a question whether a face was perceived at all, followed by the gender categorisation of a face as a girl or boy, man or woman and old man or old woman. They also found a predominantly LHem deficit on visuospatial tasks involving the matching of line orientation and shape rotation.

As the participants in this study suffered various brain damage, could positive competence of either hemisphere be justifiably argued on the grounds that the processing of the experimental tasks do not comprise subprocesses that could be located in either hemisphere or that the function that is inferred to be located within the damaged area is necessary to produce competency on a task, not merely sufficient? Furthermore, it is possible that neurological and/or cognitive reorganisation can take place in individuals with brain-injury (Robertson & Lamb, 1991). Therefore, it seems more appropriate to test for asymmetries in intact brains and using brain-injured studies for confirming evidence.

Global processing precedence over local processing.

Another framework for explaining hemispheric differences in visuospatial processing is the global verses local paradigm. Navon (1977) argued that as perception is a dynamic process, it stands to reason that it would be more efficacious to initially visually obtain a coarse conception of the structure of a form, its global structure, than to initially focus on only a few details within the form, that is, the local features. As a consequence of the lack of studies that investigate the processing of global verses local information and the antecedent processing of global structure, Christman (1993) carried out two experiments involving different visual field presentation conditions and stimuli that represented global and local information. Hierarchical letter stimuli were used, that is, an arrangement of small letters (local information) forming a large letter (global information). A significant visual field effect was found in one experiment with global information taking precedence in the lower visual field rather than in the upper field and a non-significant trend towards the left visual field (LVF)/RHem for global processing.

In Christman's (1993) second experiment there was a significant LVF/RHem advantage for both response time (RT) and accuracy for global stimuli but no visual field differences for the local stimuli. As this experiment was a 4x7 within subjects repeated measures design (N = 18), there were very few observations per cell and the results indicating that precedent global processing occurs more efficiently in the RHem should be considered with reservation. Nevertheless, the hypothesis that global features are processed before local features was supported by evidence offered by Navon (1977) following a series of experiments. Hierarchical letter stimuli were used, as in Christman's (1993) study, and global differences between pairs of stimuli were detected more frequently than local differences. Furthermore, "global interference" occurred as a retardation of response to local information when both levels of information were presented. In other words, the local features were harder to process when global features were present at the same time. However, the difficulty of operationalising real world visual scenes and objects for laboratory settings detracts from the generalisability of the findings and should influence the evaluation of consequent conclusions (Navon, 1977).

In a study involving male university students who were asked to classify laterally presented hierarchical stimuli, Van Kleek (1989) failed to find any statistically significant evidence supporting the postulate that the LHem is specialised for local component processing and that the RHem is specialised for processing global components. Nevertheless, he argued that although the results of many studies, including both those with normal and with clinical participants, do not reach statistical significance, they do converge on a consistent pattern of laterality (e.g., Lamb, Robertson, & Knight, 1990; Van Kleek, 1989). Consequently, Van Kleek conducted a meta-analysis on data from eight previous studies in this area and

found statistically significant collective evidence that the LHem is more efficient at processing local information in hierarchical stimuli and that the RHem is more efficient at processing global information in hierarchical stimuli. This finding was conditional on the appropriate operationalisation of the structural differences within hierarchical stimuli.

Low verses high visuospatial frequencies.

In an attempt to integrate the multiplicity of influencing factors that may contribute to hemispheric differences in the perception, processing, and response output of visuospatial information, Sergent (1987) hypothesised that hemispheric processing efficiency is a function of the differential ability of each hemisphere to respond to the components of spatial frequency contained in presented visuospatial information. In a study designed to test this hypothesis, three face types of both male and females were presented. The first type, labelled "broad-pass", had unadulterated spatial frequencies within the range of zero to thirty-two cycles per degree (c/d) of visual angle. The second "low-pass" type, had unadulterated spatial frequencies within a reduced range of zero to two c/d, and the third "quantised" face type was made up of small blocks. Each small block contained an averaged spatial frequency pertaining to the area of the face that the block covered, so that relevant facial information was conveyed in lower frequencies, but higher irrelevant frequencies existed on the edges of the blocks.

The faces were presented laterally to young males under controlled luminance, for either of two duration times, 40 ms or 180 ms. Participants were to press separate keys after judging whether the stimuli faces were male or female. The results of the analysis of the RTs and error rates revealed that the hypothesis, that each hemisphere responds to the components of spatial frequency contained in

presented visuospatial information with differing efficiency, could not be entirely confirmed. However, it was apparent that lower frequencies advantaged the RHem more than the LHem whilst higher frequencies facilitated LHem efficiency more than the RHem in most of the results. There was a RHem advantage for each face type in the male/female categorisation task at the 40 ms stimulus exposure time and a LHem advantage for the broad-pass face with unrestricted high spatial frequency, only at 180 ms exposure.

Furthermore, duration time of the stimulus presentation gave rise to different lateral efficiencies for each face type and a RHem advantage emerged for the lower spatial frequency ranges exemplified in the low-pass and the quantised face types. Overall, Sergent's (1987) results pointed to more unexpected and unsolved anomalies despite her attempt to conceptually simplify the entanglement of factors involved in determining what conditions bring about reliable predictions of hemispheric laterality for visuospatial processing. Nevertheless, a meta-analysis of experiments conducted by Christman (1989) revealed that 45 of the 79 studies analysed, produced evidence of interactions between visual field (and thus hemisphere) and perceptual characteristics indicating effects in either direction of the spatial frequencies that were contained in visual stimuli. Christman argued that on the basis of his meta-analysis, the spatial frequency content of a visual stimulus has been found to determine which hemisphere performs more efficiently in the processing of that stimulus, thus Christman redirected attention to the involvement of spatial frequencies in hemispheric laterality.

<u>Abstract visual-form system verses specific visual-form system.</u>

Like Kosslyn (1987), Marsolek (1995) argued that two subsystems exist for processing visual forms. One he termed the abstract visual-form (AVF) system, and

the other, the specific visual-form (SVF) system. The AVF system computes different instances and gives an output that is generalised in nature, and this system, Marsolek hypothesised, operates more efficiently in the LHem. As an analogy of this system at work, Marsolek described a situation where one is looking around for a writing instrument with which to jot down a phone message. The search is an attempt to identify a pen or pencil but not a particular one. The pen, pencil or whatever is found that writes, belongs to the general category of "writing instrument". The SVF system on the other hand, is connected with the storage of highly specific information, which preserves detail that is used to distinguish different instances of the same form.

A similar relationship exists between Kosslyn's (1987) categorical and coordinate visuospatial subsystems and Marsolek's (1995) AVF and SVF subsystems. In both the proposed AVF and categorical subsystems, information is abstracted from the visual scene or form to give a generalised outcome from the locations of features presented. This outcome can be compared with a store of other prototypical forms which facilitates the categorisation of the distinct forms or instances presented, based on the abstracted information drawn from them. In contrast, in the SVF and coordinate subsystems, information regarding the precise location of features of a form is processed to give a specific outcome that can be compared with other stored specific instances thus facilitating the discernment of differences.

Using prototype visual forms as test stimuli, Marsolek (1995) conducted three experiments. The aim was to test the postulate that two visual-form processing subsystems exist and that the AVF has a propensity to better functioning in the LHem. The stimuli were presented for 183 ms after central fixation, to either the left

or right visual field and at 2.75 cm from the centre of a computer screen. The dependent variables were RT and correct classifications, with visual form and visual field as independent variables. The results of the similarly designed second and third experiments replicated those of the first experiment that supported the hypothesis that relatively invariant abstracted features are processed by the AVF in recognising types of form and that the LHem does this processing more efficiently than the RHem.

Marsolek's (1995) experiment follows up on previous investigation into form-specific verses abstract processing. Marsolek, Kosslyn and Squire (1992) carried out an experiment to assess whether there was a proclivity towards RHem processing in the manner of the form-specific (or SVF) system. That is, whether the SVF system can process differences in detail between instances of the same form, better in the RHem. They found that there was a more effective operation of the SVF in the RHem than in the LHem. However, the researchers surmise that the SVF system may have broader application to visual forms other than form-specific representations of words without concluding that the different systems (i.e. the AVF and the SVF) are necessarily located in opposite hemispheres. The AVF/SVF subsystem framework that Marsolek (1995) experimented within has not been applied to other forms of visual stimuli such as faces or those less abstract and relevant to everyday experience. Thus, it is currently limited in explanatory power relative to differential hemispheric processing for other visuospatial computations.

Kosslyn et al.'s (1989) Study

Kosslyn et al. (1989) describe everyday advantages and disadvantages of having distinct cognitive operations for two types of spatial relationships: categorical relations, depicting relative placement in space; and coordinate relations between

objects of precisely measured distances between objects. Coordinate judgements provide information where categorical judgements do not, illustrating their distinctiveness. For example, when reaching up for one's freshly made hot cup of coffee from a relaxed and well cushioned position on the floor, it is not enough to know the cup is on the table, but how far from the edge and whether you can reach the distance accurately to grasp it properly.

Likewise, when recognising a face at a short focal distance, the perceived existence of eyes, nose and mouth, is not enough information for recognition. Metric details are needed to discern the uniqueness of the facial features (Kosslyn, 1987). Conversely, categorical processing is required, for example, to assure oneself that a bath mat is available for use by the perception that the mat is "on" the floor and not "in" the bathroom cabinet before taking a shower. It is not necessary to perceive the precise dimensions of the mat or how many millimetres it lies from the edge of the shower recess, for assurance that the mat is on the floor. It is this qualitative difference that motivated Kosslyn et al. (1987) to pursue evidence to verify or refute the existence of two separate processing subsystems responsible for computing these two kinds of information. In addition, previous evidence from studies finding a LHem advantage for linguistic categorical processing and a RHem advantage for navigational tasks, directed the methodology of Kosslyn et al.'s inquiry towards visual half-field presentation of lateralised stimuli.

The 24 participants in Kosslyn et al's (1989) first experiment in a series of four that examined the distinction between categorical and coordinate spatial information processing, were university students with normal or corrected-to-normal eyesight. Stimuli were outlined shapes, closed, curved free-form, with an attendant dot placed either on the outline or outside the shape (see Appendix A for

representative diagrams typical of the stimuli). One of two questions were asked of the participants in each of the two task groups in relation to the position of the dots relative to the line-drawn shapes that Kosslyn et al. called "blobs".

For the categorical task group, 12 participants were asked to judge whether the dot was "on" or "off" the outline of the blob and in the coordinate task, the remaining 12 participants were asked whether the dot was "near", within 2mm of the blob's outline, or "far", further than 2mm from the blob's outline. The stimuli were presented tachistoscopically on a white background following the five second appearance of a five millimetre fixation point in the centre of the screen at the beginning of each trial. After six or more practice trials, 40 trials for each task group were given, comprising 10 trials containing randomly selected stimuli from each set of "on" and "off", and "near" and "far" dot positions (20) all repeated once (40).

Participants' foreheads were stabilised against an eyepiece at an unspecified standard distance from the screen. Half of the stimuli were presented to each visual field, two degrees from the central fixation point. A millisecond timer was activated by the presentation of the stimulus and two telegraph keys labelled "on" or "off " and "near" and "far" according to the task, deactivated the timer on the participant's response. Key responses made with each index finger were counterbalanced within participants in each task group.

Errors were removed from the data before analysis, although what criteria determined an error was not reported except in experiment three. Here it was stated that trials on which errors had occurred were removed along with outliers that were determined by calculating which RTs were twice the mean of the remaining RTs in each cell. With task, visual field, gender and response hand as independent variables between groups, an interaction between task and visual field was found to be

significant. Only the RTs on the coordinate task for the LVF/RHem were significantly faster, the RTs on the categorical task being marginally faster in the LHem. However, in selecting out the RTs for stimuli that appeared in both tasks and examining them, it was found that the categorical judgement RTs were significantly faster when stimuli were presented to the right visual field (RVF) than the LVF, and coordinate judgement RTs were faster when stimuli were presented to the LVF than to the RVF. This result supported Kosslyn et al.'s (1989) conjecture that there were two distinct subprocesses for categorical and coordinate judgements.

In order to test the generalisability of these results to different sorts of stimuli, and to a different categorical relation of left/right, Kosslyn et al. (1989) used a plus and a minus sign in a second experiment and presented them beside one another (see Appendix A for sample stimuli). The question was asked of the participants in the categorical task group whether the plus sign was to the left of the minus sign and the coordinate task group was asked whether one sign was placed within a precise distance from the other. Once again, analysis of simple effects underlying the significant interaction between task and visual field revealed a statistically significant advantage for the RHem on the coordinate task but only a marginal advantage for the LHem on the categorical task.

The third experiment tested yet another categorical relation, that of above/below and using stimuli (see Appendix A for sample stimuli) from Hellige and Michimata's (1989) similar study. A dot placed above or below a short line provided information that could facilitate categorical and coordinate processing as in Kosslyn et al.'s previous experiments. The duration time of stimuli when presented on the computer screen was 150 ms following a blank screen and central fixation for 500

ms. The participants were asked to speak aloud their one-word responses, that is, "up" or "down" for the categorical task and "in" or "out" for the coordinate task.

To test for learning effects in this experiment, trials were administered in eight blocks, and analysis of the RTs showed a considerable decrease after the first block generally, but a marked drop in RTs from the first to the second block in the coordinate task for RVF/LHem presentation. Importantly, further analysis revealed that although the RHem was advantaged in processing coordinate task stimuli that were initially presented in the contralateral visual field, the apparent advantage disappeared as the LHem increased in efficiency with practice. There were no similar learning effects in the processing of categorical information for the Rhem. It appeared that the LHem was learning new categories for coordinate information over the blocks of trials.

It is interesting to note that Bruyer, Scailquin and Coibon (1997) did not convincingly replicate this learning effect in their second experiment of a series of five, testing for dissociation of categorical and coordinate relations processing. The binary nature of the response requirement for the coordinate task in Kosslyn et al.'s (1989) third experiment may have biased the participants' toward categorising "near" and "far" distance measurements. In the second experiment, Bruyer et al. attempted to reduce this possible tendency by introducing more than two response choices. In addition, Bruyer et al.'s first experiment required a manual response rather than a vocal one, although it was identical to Kosslyn et al.'s third experiment in other respects. A hemispheric dissociation of categorical and coordinate relations did appear in their second experiment albeit in a diminished form and regardless of the modification to the nature and range of stimuli computations.

Finally, the fourth experiment in Kosslyn et al.'s (1989) study was carried out with the same tasks of their first experiment using only male participants and Oldfield's (1971) Edinburgh Handedness Inventory that determined a laterality quotient (LQ), indexing the degree of strength of right-handedness. These changes were an attempt to reduce individual differences. The results were that only the high LQ group (i.e., the strongly right-handed participants) showed a significant difference in RTs between left and right visual field presentations with the RTs being faster for the coordinate task when stimuli were presented to the RHem and faster for the categorical task when stimuli were presented to the LHem. No hemispheric difference was found for the low LQ group. However, a speed/accuracy trade-off was observed in the low LQ group when accuracy and RT were analysed, because responses were either slower and more accurate or faster and less accurate, and this prevented further meaningful interpretation.

Kosslyn et al. (1989) concluded that whilst their hypothesis was confirmed by the collective evidence from the experiments, the occurrence of learning effects over the blocks of trials in experiment three, meant that RTs were only faster for the coordinate task when stimuli were presented to the RHem while the participants had not been able to practice the task effectively. Following on from this point, they stated that just because a task contains certain information that allows for processing of a particular type, there is no assurance that other processing strategies will not be used to meet the requirement of the task's solution (see Ernest, 1997). Thus, it is plausible that the LHem could adopt, given practice, a categorical process for efficiently (i.e., fast and accurately) computing coordinate information such as that presented in the stimuli in Kosslyn et al's study. Two questions were raised consequent to the outcome of experiment three - whether a repeated, specific

distance measurement can be categorised, and what other types of spatial relations can be processed as categorical relations?

As a cautionary note, Kosslyn et al. (1989) explain their failure to adequately replicate the results of experiment two when due to a failure of the tachistoscope originally used, a computer was substituted. However, they found the second experiment results reliable with the use of back projected slides and the results of experiment three reliable when they used low glare, black on white stimuli, and high resolution on the computer. The outcomes of those changes point to the importance of methodological parameters in experiments investigating visuospatial processing, and empirical literature contains some reports of studies investigating their effects in this area. Methodological parameters will be reviewed following a brief look at factors giving rise to individual differences such as gender and handedness that Kosslyn et al. (1989) and others addressed in their studies of categorical and coordinate relations.

The Effects of Sex, Handedness and Age

It is possible that variations in the population are reflected in one sample more than another, incidentally, when testing for the same effects (Kosslyn et al., 1989). Controlling for all possible individual differences is problematic, however, controlling for some researched differences that may give rise to failure of consistency in results is possible. Some of these assessable differences are the sex[1] of the participant, handedness and age.

[1] As the term "gender" refers generally to the social factors involved in an individual's sexual identity, the term "sex" will used when it is important to distinguish a participant on the basis of biological and/or neurological brain structure rather than a socially relevant sexual identity that the term "gender" denotes.

Handedness and the sex and handedness interaction.

Jones (1980) researched the effects of sex and handedness on a categorisation task that required the participants to make a decision whether the tachistoscopically presented faces were male or female. Left-handed participants who had close relatives with left-handedness, Hécaen and Sauget (1971) suggested be termed familial sinistrals (i.e. left-handers) and those without close relatives with left-handedness, they termed nonfamilial sinistrals. Hécaen and Sauget concluded that dextrals (i.e. right-handers) and nonfamilial sinistrals have an inherited propensity to left-brainedness for speech production, whereas familial sinistrals, who have not inherited a propensity to dextrality, have a tendency toward right-brainedness for speech production.

In accord with Hécaen and Sauget's evidence, Jones (1980) hypothesised that the speech processing hemisphere (i.e. the left) should be more efficient at categorising faces according to their gender in familial dextrals and nonfamilial sinistral males, and that the RHem should be more efficient at categorising faces by gender in familial sinistral males. He also hypothesised that there should be no visual field advantage for familial female sinistrals. The results of his experiment showed that males tended to be more strongly lateralised than females. Laeng and Peters (1995) right-handed participant group replicated Kosslyn et al.'s findings of laterality in categorical and coordinate functions whereas the left-handed group showed no laterality. Harshman, Hampson and Berenbaum (1983) also found that sex-related differences in verbal and visuospatial behaviour varied as a function of handedness.

Handedness and sex were also studied in relation to individual differences in hemispheric asymmetry by Hellige et al. (1994). As part of a multitask study, these

researchers tested hemispheric asymmetry for two spatial tasks that reproduced the stimuli used by Hellige and Michimata (1989) and Kosslyn et al. (1989). A horizontal line with a dot variously positioned above or below the line, and presented in either the left, right or central visual field served as stimuli for both a categorical and a coordinate function task. The motivation behind this experiment was that previous studies had found only small effects in visual field by task interactions, the RHem advantage for coordinate task could disappear with practice as shown in Kosslyn et al.'s third experiment in their study, and also that LHem advantages for the categorical task have most often not reached statistical significance (Hellige et al.).

The introduction of handedness and sex as factors in Hellige et al.'s (1994) experiment was intended to separate the effects of right and left handers and males and females. However, for dextrals, the results indicated no effect for the participants' sex and no significant effect for left or right visual field presentations, although there was a significant effect for bilateral presentations. Once again, for the dextrals, a trend toward a LHem advantage for the categorical task did not approach statistical significance. In contrast, there was a significant advantage for the RHem over the LHem in the coordinate task. For sinistrals, there were also no effects for the participant's sex or familial sinistrality but a significant advantage for the RHem emerged on the coordinate task and different asymmetries for right and left handedness on the categorical task (Hellige, 1993).

In a study designed to determine if there was an interaction between handedness, saccadic latency (i.e. the time it takes for the eye to make a movement left or rightward) and hemispheric specialisation, Pirozzolo and Rayner (1980) involved sinistrals and dextrals (*N*=16). An eye movement recorder registered

saccadic latencies when either a three letter word or an asterisk were presented to either visual field. A significant interaction between visual field and handedness revealed that dextrals had lower saccadic latencies to the RVF, but there was no significant asymmetry for the sinistrals. Pirozzolo and Rayner's conclusion was that for dextrals, the LHem was more efficient than the RHem in executing the visuo-motor task given that participants were only required to look to the stimuli from fixation (there were no differences for stimuli type) and also that sinistrals were a more problematic and variable group. Pirozzolo and Rayner did not include sex or age as independent variables in their study.

Age.

Hoyer and Rybash (1992) investigated possible hemispheric differences in the processing of categorical and coordinate spatial relations with age of participants as an independent variable. One of two groups included 32 young adults between 18 and 21 years (M = 19.2) and the other group included 32 older adults between 56 and 81 years (M = 68.8). All participants were female and dextral. The same tasks and stimuli set as Hellige and Michimata (1989) and Kosslyn et al.'s (1989) third experiment were used. However, Hoyer and Rybash also added a new set of stimuli for the categorical and coordinate tasks that consisted of a line of three varying lengths with two square dots appearing either above or below the line. This set was included because these stimuli required the participants to make metric judgements without the possibility of categorising the judgement. The distance separating the dots varied according to length of line they accompanied, with only two possible dot separation distances for each of the three line lengths.

The line-and-dot stimulus were presented for 150 ms centrally and to left and right visual fields at 3° from a central fixation diamond that preceded the stimuli. For

each task, 36 trials in 3 blocks were administered to each participant. RTs were recorded and those less than 100 ms and more than 2000 ms were counted as incorrect responses and deleted from the data set as outliers.

Analyses of the data indicated that all participants responded faster in both tasks when stimuli were presented to the LVF/RHem rather than the RVF/LHem. RTs were faster to the original set of stimuli than the new dot-and-line set only in the coordinate task for the older participants, in the interaction for stimuli set by task by age. An interaction between trial block, visual field and task revealed a RHem advantage on the coordinate task for block one but not for blocks two and three. Kosslyn et al.'s (1989) third experiment produced a similar finding in the coordinate task over blocks.

In addition, Hoyer and Rybash (1992) failed to find a significant LHem advantage for the categorical task or age related findings that may have suggested a difference in hemispheric functioning between the two tasks. Bruyer et al. (1997) echoed Hoyer and Rybash's results with regard to age effects, only suggesting that on coordinate functions the elderly do not perform as well. Although the age range of both young and old groups was comparable between the two studies, Bruyer et al. included equal numbers of males and females, whereas Hoyer and Rybash's participants were all female but in both studies, age played less a role in hemispheric laterality than sex and handedness.

<u>Methodological Parameters</u>

Cerebral asymmetry patterns and the level of visual acuity have been found to be influenced by blurring, decreased luminance, decreased exposure duration, peripheral stimuli or increased retinal eccentricity, increased stimulus size, and stimuli with computer reduced high frequencies (Christman, 1989; Hardyck, 1986;

Hellige, 1993; Sergent, 1987; Sergent & Bindra, 1981). Such factors can have the effect of diminishing LHem efficiency in processing stimuli unless, as a possible exception, other higher level cognitive demands are being made (Hellige). Cowin and Hellige's (1994) study examined the effects of blurred stimuli presented for 150 ms in categorical and coordinate tasks, and the results indicated no significant effects for blurring. Nevertheless, RTs indicated a RHem advantage for the coordinate task and no hemispheric advantage in the categorical task. These results were echoed in Sergent's (1991) fourth experiment with a stimulus exposure time of 100 ms and reduced luminance.

Sergent (1991) carried out four experiments in examination of Kosslyn's (1987) theory. The first experiment used different stimuli than Kosslyn et al. (1989) consisting of a circle containing dots at various positions from the central point, and the stimuli in the second experiment were the same as those used by Hellige and Michimata (1989) and Kosslyn et al. Commissurotomised participants took part in the third experiment that used the same stimuli, and in the fourth experiment, the luminance level of the same stimuli was very much reduced although other factors in this experiment replicated those of the second. The first three experiments failed to produce supporting evidence for Kosslyn's theory stating that the two hemispheres process categorical and coordinate visuospatial information differently (Sergent, 1991).

However, the fourth experiment rendered partially supporting evidence in that there was a significant task by visual field interaction. Underlying the interaction was a RHem advantage in the coordinate task but no hemispheric differences in the categorical task. Thus, support for part of Kosslyn's (1987)

hypothesis that the RHem is more efficient at coordinate functions was achieved, but only under degraded viewing conditions (Sergent, 1991).

Reduced exposure time, another of the methodological factors that have been shown to determine the conditions under which hemispheric lateralities appear, has been reported to enhance RHem functioning for both categorical and coordinate spatial relations. Jones (1980), who presented stimuli for 200 ms, a relatively long exposure, found LHem functional efficiency superior to the RHem in the categorical task where participants were asked if a face was male or female. Sergent (1982b) also laterally presented faces at exposures of 40, 120 and 200 ms, to male participants for them to categorise faces on the basis of gender. RHem efficiency remained stable from the 40 ms exposure to the 200 ms exposure, and the shorter stimuli duration yielded a greater RHem advantage than for the LHem. However, the efficiency of the LHem did improve in the 200 ms exposure condition compared with the 40 ms condition, surpassing the efficiency of the RHem at this exposure. These differential effects were not tested at such duration times for a coordinate task in this experiment.

Importantly, it was Sergent's (1982b) conclusion that the longer the duration, the more that distinctive and relevant featural information becomes available to be processed. The stimuli in most studies are given at less than 200 ms duration because above this exposure, there is uncertainty whether eye movements may be made that disrupt the unilateral viewing that half-field studies are designed to achieve (Hardyck, 1986). An increase or decrease in duration time can effect the balance between the amount of visual information that is made available for processing and the amount that is required to efficiently perform the task (Sergent, 1982b).

Other Studies Investigating Categorical and Coordinate Subprocesses

Several studies have reported empirical evidence in support for Kosslyn's (1987) theory at least in part (e.g., Bruyer, Scailquin, & Coibon, 1997; Cowin & Hellige, 1994; Kosslyn, Koenig, Cave, Tang, & Gabrelli, 1989; Laeng, 1994; Laeng & Peters, 1995; and Rybash & Hoyer, 1992). Laeng found that in patients with stroke-damaged left and right hemispheres, deficits in ability to judge categorical and coordinate relations corresponded to the LHem advantage for categorical and a RHem advantage for coordinate tasks. Hellige and Michimata (1989) found more efficient RHem responses for discriminating different stimuli when presented with "same/different" choices of stimuli. All the studies reviewed used stimuli consisting of lines, line-and-dots or drawings in their coordinate tasks. However, despite the findings of these studies supporting Kosslyn's (1987) theory, the use of such abstract stimuli raises caution in assuming their generalisability to cognitive processes outside the laboratory.

Michimata (1997) employed a less abstract stimuli in a recent within-subjects study to test for hemispheric efficiency in processing categorical and coordinate spatial relations of both visual perception and imagery as predicted by Kosslyn (1987). A diagrammatic clock-face was used and differences of angle formed by the hands of the analog clock in each presentation provided coordinate information in the coordinate task. The participant was asked if in each case the angle was "more" or "less" than 60°. In the categorical task participants were asked whether the pair of clock hands were "above" or "below" the midway line of the clock face. The stimuli were presented for laterally for 150 ms in duration and RTs and errors were measured. Thus, another type of stimulus was used to test Kosslyn's (1987) theory, and one with more relevance to everyday life. As with previous studies, (e.g. Cowin

& Hellige, 1994; Hellige and Michimata, 1989; Kosslyn et al., 1989; Rybash & Hoyer, 1992; Sergent, 1991) a weak and statistically nonsignificant LHem advantage was apparent for the categorical task in the visual perception analysis and a significant RHem advantage in the coordinate task.

Meaningful stimuli like the clock in Michimata's (1997) study and the face stimuli for categorisation (e.g. Jones, 1980; Sergent, 1982a; Sergent, 1982b; Sergent, 1985) contrast in complexity and relevance to everyday functioning with the totally abstract and simple visual representations that have been used in studies testing for hemispheric differences in categorical and coordinate functions. Sergent and Corballis (1989) used male and female human faces presented under controlled luminance and at different orientations from the upright, including full inversion. When participants were asked to make a categorical judgement (whether the face was male or female), they found a LHem advantage for the categorical task. However, the difference in perception imposed by the orientation of the face introduced yet another level of complexity to the discernment of visual field effects.

The Current Study

The current study will use upright male and female faces as task stimuli because they are more relevant to cognitive processes used in day to day life than the more abstract stimuli like those used by Kosslyn et al. (1989) and others. Faces clearly possess information that may be processed as categorical (e.g., gender, age) and have been used previously in categorical tasks. In addition, faces also contain coordinate spatial relations (e.g., angle of jaw, distance between eyes). This attribute allows for metric judgements of difference to be made between the features of same and different faces. The use of faces as stimuli for the coordinate task also has another advantage. The question was raised consequent to Kosslyn et al.'s third

experiment, whether coordinate judgements on simple stimuli could be categorised. As the information contained in faces is complex, not of a binary nature, and each new face holds a different set of information, it is highly unlikely that face stimuli should promote categorising effects in the coordinate task.

To ensure viewing of stimuli in either visual field, a fixation point will be presented to cue bioptic vision to the centre on the computer screen before presentation of stimuli. A chin rest will support the participants' head, horizontally and vertically, standardising both viewing distance and centred viewing so that the eccentricity of the stimuli is maintained. The participants will be right-handed and then further assessed to ensure strong right-handedness in light of studies whose evidence suggests a different laterality pattern in left-handed participants (Laeng & Peters, 1995).

The participants in the current study will be mixed so as to provide data for possible future analysis and individuals with intact brains are used as a more representative sample of the population of normally functioning individuals. An exposure time for the stimuli of 200 ms has been selected as this duration time has not been so often reported for intact-brain participants and yet it is still below the saccadic threshold above which the eyes can make a movement to counteract unilateral viewing.

Based on Kosslyn's (1987) theory, it is anticipated that when stimuli requiring a categorical judgement, in this case categorisation of faces on the basis of gender, are presented to the RVF, faster RTs than those when faces presented to the LVF will indicate left hemisphere ease for categorical judgements. Conversely, when faces requiring a coordinate judgement on feature variations are presented to the LVF, faster RTs than those appearing in the RVF will indicate right hemisphere

ease for coordinate judgements. These findings would support Kosslyn's (1987) contention that not only do both hemispheres process visuospatial information, but also that one hemisphere is more efficient than the other for a specific type of spatial judgement, the left for categorical and the right for coordinate judgement types in right-handed individuals. It is hypothesised that for coordinate judgements, RTs will be faster and more accurate when faces are presented in the LVF than in the RVF and that RTs for categorical judgements will be faster and more accurate when faces are presented in the RVF.

Method

Participants

Forty-four right-handed psychology undergraduate university students with normal or corrected-to-normal eyesight participated in this study. The volunteers were invited to participate without any incentive other than to have the opportunity to discuss with the experimenter their academic goals and queries. There were 13 males and 31 females between the ages of 18 and 50 years. All participants completed a consent form (see Appendix B) that addressed confidentiality issues and contained general information about the study.

Apparatus and Materials

An Apple Power Mac 7200 computer presented photographic quality face stimuli to the participants. A chinrest was used and Oldfield's (1971) Edinburgh Handedness Inventory (see Appendix C) to ascertain direction and strength of right-handedness. The inventory asks which hand is used for 10 activities and from the strength of the hand preference indicated, a Laterality Quotient (LQ) is calculated.

Stimuli

The stimuli that appeared on the 15 inch computer screen for the categorical task were colour photographs of the face and hair only, of five adult males and five females, all Caucasian and unknown to the participants in the current study. There were no beards, moustaches or jewellery adorning the faces. In an order randomised by the computer, each face was presented four times, two to the LVF and two to the RVF. The set was repeated once totalling 40 trials. The photographs were presented in either visual field on a white background, the centre of each subtending

approximately 2.5° of visual angle. The central fixation point was marked by a 5mm by 5mm black plus sign.

The set of 12 faces for the coordinate task were of different individuals from those in the categorical task, but equal in respect to their size and field location and none of the faces used in either task were of individuals known to the participants. Each face was presented four times, twice with an identical face presented following to each visual field, and twice with a modified face following to each visual field. Thus, 24 "same" face and 24 "different" face stimulus pairs totalled 48 trials.

Those face pairs that were different, were the face of the same individual, but one of the pair was either a caricature (i.e., modified featural proportions to extend distortion) or an anticaricaturised face (i.e., modified featural proportions to attain normalised proportions). Computerised photographic images of caricatures and anticaricatures were generated from original (veridical) photographs in three stages. First, an equal number of points (208) on each face defined and delineated the facial features, forming a grid. By averaging the metric distances between features across all the faces photographed, a norm face representation was produced.

Then the difference between any two selected points on a veridical face and the same two on the norm face was *reduced* by 36% and the process repeated on other sets of points. The veridical image was then modified to match these new dimensions producing a stimulus face closer to the norm face, that is, an anticaricature. Alternatively, the difference between any two selected points on a veridical face and the same two on the norm face was *increased* by 36%, producing a stimulus face further removed from the norm and the veridical face, resulting in a caricature. Finally, once stimuli faces were produced, the colour pixel values within mapped areas on their respective veridical images were replicated in the

corresponding areas on the newly created stimulus faces. Pairs of modified faces were then selected by their level of dissimilarity thus ensuring a perceptible difference in the two faces presented in the "different" condition.

Procedure

Each participant was instructed to fill out Oldfield's (1971) Edinburgh Handedness Inventory. When each participant was seated approximately 40cm from the screen, the chin rest, seat position and seat height and were adjusted to bring the line of vision centred to the level of the fixation point. At the beginning of both tasks, instructions (see Appendix D and E for standardised instructions) appeared on the screen and the experimenter read them to the participant explaining what was required of the participant, with a request for the participant to respond as quickly and as accurately as possible. The participant tapped on the table a few times with the appropriate index finger as the experimenter called out "male" and "female" for the categorical task, or "same" and "different" for the coordinate task. This prepared the participant and assured the experimenter that the participant understood the task requirement and response procedure. The participant reread the instructions on the screen and self-started the trials by pressing any key on the computer keyboard. There was a one-way viewing window through which the experimenter monitored the procedure and the moment of task completion.

Each trial in the categorical task consisted of 2500 ms central fixation followed by a male or a female face for 200 ms to the LVF or RVF. The participant was required to indicate via a keypress whether the face flashed onto the screen was male or female, and the screen remained blank until their response instigated the next trial. At the completion of the first task, there was a one minute break and then instructions were given for the second task.

The coordinate task began with a blank screen for 2000 ms, followed by a 5000 ms presentation of a male or female face in the central visual field; fixation for 2500 ms; a 200 ms presentation to the LVF or the RVF of either a "same" or a "different" face. The task of the participant was to indicate via a keypress if the face flashed laterally was the same face as that presented previously in the centre of the screen. At the completion of the second task, the participants were thanked, given debriefing information about the experiment with a reminder of the contact numbers for possible future enquiries and then offered the refreshments.

Counterbalancing

The order of task presentation was counterbalanced with the first 22 participants performing the categorical judgement task first and the remaining 22 performing the coordinate judgement task first. For the two-alternative forced-choice keypress responses, the use of left and right keys on the keyboard were counterbalanced within each task. For the categorical task, 22 participants pressed the forward-slash key for "male" with their right index finger and the left index finger pressed the "z" key for "female", whereas the reverse pattern applied to the remaining 22 participants. In the coordinate task 22 participants used their right index finger on the forward-slash key for "different" and their left for "same" on the "z" key whereas the reverse pattern applied to the remaining 22 participants. The use of caricatures or anticaricature faces were also counterbalanced in the coordinate task so that when all these factors were counterbalanced, every consecutive group of five participants received a different combination of all counterbalanced factors.

Results

Two within-subjects repeated measures ANOVAs were conducted on RTs of 2000 ms and below for RT and percentage correct responses. The normality of distributions was considered satisfactory. The RT data yielded a significant main effect for task F (1,43) = 317.77, p = .000, calculated on correct responses. Participants took longer to respond on the coordinate task (M = 999.07, SD = 339.27) than the categorical task (M = 438.16, SD = 139.99). There were no significant effects for visual field or the interaction between task and visual field. Similarly, the analysis of percentages correct yielded a significant effect for task, F (1, 43) = 102.29, p = .000, but not for visual field or the task by visual field interaction. The mean percentage correct was higher for the categorical task (95.66%, SD = 6.34) than the coordinate task (80.74%, SD = 10.81) indicating that participants made more errors on the coordinate task than the categorical task. Comparative means for all cells are shown in Table 1.

Table 1

Mean Response Times in Milliseconds of Cells in Task and Visual Field Interaction

Task	Visual Field	*M*	*SD*
Categorical	Left	438.94	93.59
	Right	433.39	107.51
Coordinate	Left	962.93	216.96
	Right	947.97	217.25

Discussion

The results of the analysis did not confirm Kosslyn's (1987) theory which states that the hemispheres process categorical and coordinate information differentially, the RHem being faster and more accurate at processing information of a coordinate nature than the LHem, and the LHem processing categorical information faster and more accurately than the RHem. A means comparison for the main effect of task indicated that the two tasks varied in degree of difficulty with the mean RT for the coordinate task (999.07 ms) being much slower than the mean RT for the categorical task (438.16 ms) suggesting that the coordinate task was more difficult to compute. However, as there was a main effect for task when the data for percentage correct were analysed, the similarity of effects for percentage correct and RTs suggests that there was no trade-off between speed and accuracy. Although statistically significant, the task effects give no indication of the laterality that was hypothesised in this experiment or that of Kosslyn (1987) who proposed that such laterality in the processing of categorical and coordinate spatial relations would indicate separate processing systems (similar in function to those proposed by Marsolek, 1995).

Analysis of hemispheric performance in the coordinate task showed a trend in the right direction albeit a much attenuated indication of RHem efficiency, with a nonsignificant difference of 14.97 ms between the means of the RHem and the LHem. Although the results of this experiment did not support Kosslyn's (1987) theory, other studies with exposure durations of 200 ms, as was the case in the current study, have replicated Kosslyn et al.'s (1989) results, in part. Sergent (1982b), for example, presenting faces at 200 ms exposures to the male participants for a categorical task, found that the efficiency of the LHem in the 200 ms condition

significantly (statistically) surpassed that of the RHem at this exposure. Sergent also found that both hemispheres have the capacity to categorise faces on the basis of gender.

In addition, Jones (1980) found confirming results for a LHem advantage in a categorical computation that classified faces presented for 200 ms according to their gender. In that study, the LHem was more efficient than the RHem in right-handed familial and left-handed nonfamilial males, who tended to be more strongly lateralised than females, and the RHem was more efficient than the LHem in left-handed familial males and no visual field advantage for familial female left-handers. Both Jones and Sergent (1982b) tested laterality with stimulus exposure of 200 ms in a categorical relations task only.

The researchers who found significant laterality effects in both tasks, had presented stimuli for less than 200 ms. For example, Bruyer et al. (1997) found a hemispheric dissociation of categorical and coordinate relations when their stimuli were presented at 150 ms. Laeng and Peters (1995) right-handed participant group replicated Kosslyn et al.'s (1989) findings of laterality in categorical and coordinate functions with 150 ms stimuli exposures whereas the left-handed group showed no laterality.

In contrast, the existence of a RHem advantage on coordinate tasks without any laterality effects on the categorical tasks was found in several studies at stimulus exposure times of less than 200 ms. Hellige and Michimata (1989) found more efficient RHem responses for discriminating different stimuli when presented with "same/different" choices of stimuli at 150 ms. Also, with 150 ms presentation exposure, Hellige et al. (1994) found a significant advantage for the RHem over the

LHem in the coordinate task and only a trend that did not approach statistical significance toward a LHem advantage for the categorical task right-handers.

Similarly, in Michimata's (1997) study, an attenuated nonsignificant LHem advantage was apparent for the categorical task and a significant RHem advantage in the coordinate task when stimuli were presented laterally for 150 ms. Cowin and Hellige's (1994) study that examined the effects of blurred stimuli in categorical and coordinate tasks indicated no significant effects for blurring but a RHem advantage for the coordinate task and no hemispheric advantage in the categorical task, regardless of blurring. These results were echoed in Sergent's (1991) fourth experiment with a stimulus exposure time of 100 ms and reduced luminance.

So, while some studies have shown a convincing hemispheric dissociation for processing categorical and coordinate information at less than 200 ms stimulus duration, others have not been able to replicate these results for both tasks (Cowin & Hellige, 1994; Hellige & Michimata, 1989; Hellige et al., 1994; Michimata, 1997; Sergent, 1991). Yet others (Jones, 1980; Sergent, 1982b) have found LHem efficiency for testing only categorical tasks only at 200 ms stimulus exposure. Therefore, the current results may indicate that dissociated functioning of each hemisphere in processing categorical and coordinate relations is dependent on specific criteria in a broad range of methodological parameters. These parameters include the sex and handedness of the individual, viewing conditions such as luminance, stimuli structure and complexity such as whether the balance of global and local information or spatial frequencies that the stimuli contain (Hardyck, 1986; Hellige & Sergent, 1986).

Failure to find supporting evidence for Kosslyn's (1987) theory of differential hemispheric processing of categorical and coordinate spatial information in the

current study may have been due to a false assumption that the face stimuli and task requirement used in the coordinate task operationalised a purely coordinate spatial information processing function. Although such results were not predicted, it is not too surprising that a LHem advantage did not surface for the categorical task given the checkered history of results from the testing of this function (e.g., Kosslyn et al., 1989, Experiment 1; Michimata, 1997).

However, face stimuli were used in this task rather than lines and dots, and given that many studies have found a RHem advantage for coordinate task processing (e.g., Hellige & Michimata, 1989; Kosslyn et al., 1989; Sergent, 1991; Rybash & Hoyer, 1992) and that this study did not, then perhaps the face stimuli in the present study contained various information criteria that allowed for different processing strategies of either hemisphere to meet the task requirement of "same" or "different". For example, some of the stimuli presented secondly in the "different" trials of the coordinate task contained featural differences that constituted local feature changes that were found to be more quickly processed by the LHem (Van Kleek, 1989), in accord with the global/local feature processing perspective. These types of changes may have allowed for a LHem global feature detection precedence over the RHem.

Furthermore, at the exposure duration of 200 ms in this experiment, and assuming that the coordinate task did operationalise coordinate processing, more spatial frequencies would have been available than at a lesser duration, a condition that favours functioning of the LHem (Sergent, 1982b). If this was the case, then LHem RTs would have been faster than RHem RTs. The current results bear out this prediction, as although a LHem advantage was not statistically significant, there was

incremental evidence in the mean RT from the coordinate task in this direction (see Table 1).

Neither exposure time nor stimuli type appear to wholly or convincingly account for the lack of visual field differences and thus lack of hemispheric processing dissimilarity, in the categorical task. Previous studies have not always obtained significant LHem advantage effects over a range of stimuli and at exposure durations of less than 200 ms (e.g., Sergent, 1987) but Sergent's findings indicated that in a gender categorisation task, the face type with regard to structure and spatial frequency was more predictive of visual field asymmetry than the exposure duration. Consequently, the null results of this study are difficult to explain on those bases.

However, a possible confound in the experimental procedure could have been that participants were not sufficiently admonished to refrain from the temptation to anticipate into which visual field the stimuli was about be presented. Instructions did direct participants to centrally fixate upon the plus sign whenever it appeared. On checking the randomisation of visual field presentation, it was found to be more than adequate and even if it had been possible for any participant to correctly "anticipate" the location of a stimulus before it appeared, it is not clear whether any participant would have shifted to foveal vision or remained centrally fixated to perceive the stimuli peripherally. If, in the case of correct anticipation, the participant's eyes did shift to the location of the stimuli in either task, then both hemispheres would have received information that was intended for only one hemisphere. Then both hemispheres would have contributed to the processing of stimuli for each visual field presentation, possibly masking any laterality effects.

Future Studies

In comparison with studies carried out prior to the present time, this study shows no visual field effects at 200 ms stimuli exposure under normal viewing conditions with regularly tested visual field eccentricity in right-handed, participants. Different stimuli were used for the coordinate task than have been used in previous studies and so it is not yet clear what contribution these make to the outcome. In order to refine methodological parameters but keeping the same stimuli, another experiment could be carried out involving right-handed participants with three levels of stimuli exposure time including 60, 130 and 200 ms. Face stimuli could be screened carefully to exclude or at least reduce the possibility of a global/local feature or spatial frequency disparity between them. The importance of remaining centrally fixated would be stressed in instructions to the participants especially in the 200 ms condition, to reduce the possibility of bioptic viewing. Luminance would be recorded and gender would become a between-subjects factor.

Conclusion

It is plausible that laterality differences in hemispheric processing for categorical and coordinate tasks do exist in conditions with 200 ms stimuli exposures. However, in laterality studies involving normal (i.e., not brain-injured) participants and that have stimuli exposure durations that approach the saccadic latency threshold thereby allowing maximum stimuli information to be perceived, methodological parameters that prevent the participants' use of processing strategies other than categorical and coordinate functions, are difficult to put in place (Hellige & Sergent,1986).

Furthermore, previous studies that showed a RHem advantage for coordinate judgements had reduced either luminance, exposure time and/or optimal levels of

other viewing conditions (e.g., Sergent, 1991). As viewing conditions in the current study were not degraded, it may in part explain why no RHem advantage emerged. In addition, those studies that reported a dissociation between hemispheric processing on the two tasks did so with simple stimuli, often in replications of the experiments of Kosslyn et al. (1989) and Hellige and Michimata (1989). Given this fact and the results of the present study, whether one hemisphere is more specialised for the processing of categorical or coordinate information, may be dependent on an interaction of stimuli complexity, exposure duration and many other factors that can be manipulated to diminish optimal viewing conditions. Although the range of sometimes contradictory results from disparate combinations of methodological parameters makes it unlikely that two separate unilateral subsystems operate in the processing of all categorical and coordinate spatial relations (Sergent, 1991), the conflicting evidence cannot be dismissed. Thus more information needs to be gleaned from further studies in this area.

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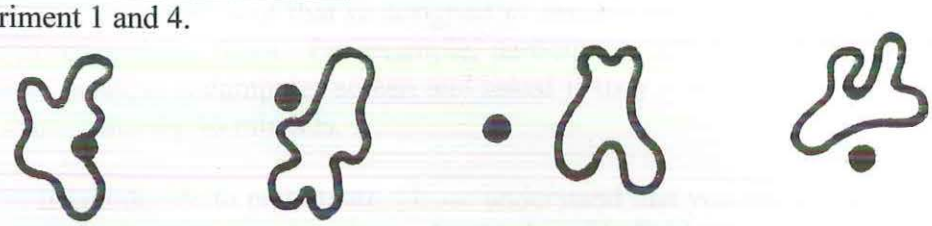
Appendix A

Sample Stimuli

<u>Representative stimuli of the type used in Kosslyn et al.'s (1989) study for both categorical and coordinate tasks.</u>

Experiment 1 and 4.



Experiment 2.

Experiment 3.

<u>Representative stimuli of the type used in the current study.</u>

Categorical Task
a) female face
b) male face

a) 

b) 

Coordinate Task
a) caricature
b) anticaricature

a) 

b) 

Appendix B

Information and Consent Form

As part of the fourth year Psychology (Honours) student program I am conducting an experiment that is designed to involve the left and right sides of the brain in recognising faces. For example, participants will be shown two similar or identical faces on a computer screen and asked if they match. The experiment will take approximately 40 minutes.

If you decide to participate, please understand that you are free to withdraw at any time. In the process of analysis, the results of individuals will be averaged over the group and any individual information will become anonymous data. A report of the study that will discuss the averaged results and their relevance to face recognition may be published, however, no-one who participates will be identifiable. Feel free to contact myself, Jill Russell (ph: [redacted] or my supervisor, Dr Paul Chang, of the School of Psychology, Edith Cowan University, Joondalup WA 6027 (ph: 94005555) if you have any queries regarding this experiment.

Thankyou for your assistance.

Yours sincerely,

....

Jill Russell

Consent Form

I give my consent to participate in this study and I understand that

- my results will not be identifiable
- any individual information remains confidential
- the experiment will take approximately 40 minutes
- I may withdraw at any time
- this experiment tests for the involvement of the left and right side of the brain in recognising faces

....

Participant Date

Appendix C

Copy of Edinburgh Handedness Inventory

R.C.Oldfield

Medical Research Council Speech & Communication Unit

EDINBURGH HANDEDNESS INVENTORY

Surname............................. Given Names...................................

Date of Birth......................... Sex............

Please indicate your preferences in the use of hands in the following activities *by putting + in the appropriate column.* Where the preference is so strong that you would never try to use the other hand unless absolutely forced to, *put* + +. If in any case you are really indifferent *put + in both columns.*

Some of the activities require both hands. In these cases the part of the task, or object, for which hand preference is wanted is indicated in brackets.

Please try to answer all the questions, and only leave a blank if you have no experience at all of the object or task.

		LEFT	RIGHT
1	Writing		
2	Drawing		
3	Throwing		
4	Scissors		
5	Toothbrush		
6	Knife (without fork)		
7	Spoon		
8	Broom (upper hand)		
9	Striking Match (match)		
10	Opening box (lid)		
i	Which foot do you prefer to kick with?		
ii	Which eye do you use when using only one?		

L.Q.		Leave these spaces blank	DECILE	

March 1970

Appendix D

Coordinate Task Instructions
Computer Monitor Display

At the beginning of each trial, a person's face will appear in the middle of the screen for 5 seconds and then disappear.

Please look at the face and try to remember it.

Then, a "+" sign will appear in the middle of the screen. Be sure to focus on the "+" sign whenever it is on the screen.

After a while, either the same face that you saw in the middle of the screen will be briefly presented to the left or right of the "+" sign, or a slightly different version of the face will be briefly presented to the left or right of the "+" sign.

If you think that the face presented briefly was exactly the SAME as the one presented in the middle of the screen, then press the "/" key.

If you think that the face presented briefly was slightly DIFFERENT to the one presented in the middle of the screen, then press the "Z" key.

Please respond as quickly and as accurately as you can.
If you are ready, then please press any key to begin.

Appendix E

Categorical Task Instructions
Computer Monitor Display

At the beginning of each trial, a "+" sign will appear in the centre of the screen.

After a while, a face will be presented briefly to the left or right of the "+".

If you think that the face presented briefly was a MALE, then press the "/" key.

If you think that the face presented briefly was a FEMALE, then press the "Z" key.

Please respond as quickly as you can.

If you are ready, then please press any key to begin.