



eCOMMONS

Loyola University Chicago
Loyola eCommons

Master's Theses

Theses and Dissertations

1981

The Forest Versus the Trees: The Relative Precedence of Global Versus Local Features in Visual Information Processing

Susan Gelmini
Loyola University Chicago

Follow this and additional works at: https://ecommons.luc.edu/luc_theses



Part of the [Psychology Commons](#)

Recommended Citation

Gelmini, Susan, "The Forest Versus the Trees: The Relative Precedence of Global Versus Local Features in Visual Information Processing" (1981). *Master's Theses*. 3206.

https://ecommons.luc.edu/luc_theses/3206

This Thesis is brought to you for free and open access by the Theses and Dissertations at Loyola eCommons. It has been accepted for inclusion in Master's Theses by an authorized administrator of Loyola eCommons. For more information, please contact ecommons@luc.edu.



This work is licensed under a [Creative Commons Attribution-Noncommercial-No Derivative Works 3.0 License](#).
Copyright © 1981 Susan Gelmini

THE FOREST VERSUS THE TREES: THE RELATIVE PRECEDENCE OF
GLOBAL VERSUS LOCAL FEATURES IN VISUAL
INFORMATION PROCESSING

by

Susan Gelmini

A Thesis Submitted to the Faculty of the Graduate School
of Loyola University of Chicago in Partial Fulfillment
of the Requirements for the Degree of
Master of Arts

January

1981

ACKNOWLEDGEMENTS

The author would like to thank Dr. Mark S. Mayzner the director of her thesis committee, for his helpful suggestions and advice throughout the development of her thesis. She would also like to thank committee members Dr. R.W. Bowen and Dr. D.L. Holmes. In addition, great appreciation is extended to Dr. Ira B. Appleman.

VITA

The author, Susan A. Gelmini is the daughter of Charles and Helen (Lafferty) Gelmini. She was born on June 28, 1956 in Connecticut.,

Her elementary education was obtained in the public school of Beacon Falls, Connecticut. She graduated from John Hersey High School in Arlington Heights, Illinois in June of 1973.

In September, 1973, she entered Regis College in Weston, Massachusetts, and in May of 1977 received the degree of Bachelor of Arts with a major in psychology. While attending Regis College she was made a member of Psi Chi, the national honor society for psychology in 1976. During that same year she was named an Undergraduate Fellow and Honorary Student Member of the New England Psychological Association.

In September, 1978, she entered graduate school at Loyola University of Chicago, where she was granted a research assistantship.

In 1979 she published a paper in the Bulletin of the Psychonomic Society entitled, "Angular estimation: An

exploratory study." She was second author of an abstract entitled, "The effects of interletter confusability on word and non-word recognition processes." This abstract appeared in that same bulletin the same year.

TABLE OF CONTENTS

	Page
ACKNOWLEDGEMENTS	ii
VITA	iii
LIST OF FIGURES	vi
INTRODUCTION	1
REVIEW OF THE RELEVANT LITERATURE	5
RATIONALE FOR THE CURRENT STUDY	22
EXPERIMENT 1	27
Method	27
Results	31
Discussion	32
EXPERIMENT 2	35
Method	35
Results	37
Discussion	40
EXPERIMENT 3	42
Method	42
Results	44
Discussion	45
EXPERIMENT 4	48
Method	48
Results	50
Discussion	50
GENERAL DISCUSSION	53
REFERENCES	61

LIST OF FIGURES

Figure	Page
1. Stimulus Set used by Navon (1977)	11
2. Mean Response Latencies as a Function of Consistency Level and Attentional Condition (Navon, 1977)	13
3. The Average Time to Respond "Yes" at Each Angular Display Size When a Large Letter was the Target, When Small Letters were the Targets, and to Respond "No" When Neither was the Target (Kinchla & Wolfe, 1979)	15
4. Latencies for Reporting Local and Global Aspects of Many Element and Few Element Stimuli, as a Function of the Level of Consistency of the Secondary Aspect (Martin, 1979)	18
5. Distorted Stimuli used by Hoffman (1980)	20
6. Stimuli used in Experiment 1	29
7. Mean Reaction Time as a Function of Attentional Instructions and Target Size (Experiment 1)	33
8. Examples of Stimuli used in Experiment 2	36
9. Mean Reaction Times for Correct Responses as a Function of Stimulus Ratios (Many or Few Local Elements), Local and Global Consistency (Consistent or Conflicting) and Attentional Instructions (Global or Local) (Experiment 2)	38
10. Mean Reaction Times for Correct Responses as a Function of Attentional Instructions and Stimulus Ratios (Experiment 2)	39

Figure	Page
11. Stimuli used in Experiment 3	43
12. Mean Reaction Times for Correct Responses as a Function of Consistency Level and Attentional Instructions (Experiment 3)	46
13. Stimuli used in Experiment 4	49
14. Mean Reaction Times for Correct Responses as a Function of Consistency Level and Attentional Instructions (Experiment 4)	51

INTRODUCTION

Virtually any scene or visual object can be broken down into a number of hierarchical sub-units. For example, a paragraph is made up of sentences, which are made up of words, which are made up of letters. A forest is made up of trees, which are made up of branches, which are made up of leaves. The functional utility of these sub-units with respect to visual perception has long been debated. Do these sub-units serve as powerful bits of information? If they do, in what manner? Is visual information processed bit by bit, feature by feature, each contributing equally? Is it perhaps the scene as a whole that offers the most information? An early theory has suggested that information is processed at a very low level, that it is the very basic sub-units that are crucial to recognition and understanding. Titchner (1910) and other Structuralists felt that perceptions were "selected groups of sensations," and that the perception of even complex events was made up of analyzable elements called sensations. This Structuralist position was in opposition to that held by the Gestalt psychologists (Chaplin & Krawiec, 1974), who believed that perceptual experiences arise as molar experiences which are not mere aggregations, but organized and meaningful wholes.

Representing a compromise between these two positions, it has often been suggested that the hierarchical sub-units of information function in an interactive manner. Rather than relying on very basic, low levels of information or a complex, high level of information, it has been argued that an interactive process occurs between the various hierarchical levels. It is doubtful that a scene is perceived as a whole, that all available information is processed simultaneously. There is evidence in fact that over time, more and more information is extracted from a scene (the longer it is looked at) (Yarbus, 1967). Nor does it seem probable that a scene is processed feature by feature in a purely additive sense. This approach would suggest that all features were weighted equally, that the whole is the sum of its parts, that a perception is the sum of its "sensations" as the Structuralists suggested. This would imply that there is no information transmitted across hierarchical levels, that no features are grouped, that all information is simply summed.

It seems probable that an interactive process occurs between the hierarchical levels of information or groups of features that a scene provides. This can be seen as perhaps the most efficient means of dealing with information. When presented with visual stimulation an observer's task is not just to account for a given input, but

to select which parts of the stimulus are worth attending to. Rumelhart (1977) discussed man's ability to focus on certain aspects of the world in order to increase the detail with which it is perceived. Neisser (1967) defines attention as an allotment of "analyzing mechanisms" to a limited region of the visual field. It is pointed out that to deal with an entire visual input at once is simply too large a task to be plausible. A simple feature by feature model of processing would provide too many units of information to deal with. By organizing information into, and selectively attending to hierarchical levels of information, a very efficient shorthand, or coded process is developed.

Given that hierarchical levels of information (groups of features) are utilized in perception, that one level of structure will feed information to an adjacent level of structure, what is the order in which this process occurs? Do very high levels of structure lend implications to lower levels of form, or is it the other way around? Do we start out with broad, general information and gradually focus and sharpen, or do we perhaps utilize specific low levels of information to build a broad general hypothesis or theory of information? In recognizing a forest do we first determine that we are looking at trees, or is it the recognition of the forest that then allows us to infer that trees are present?

This research will address these visual information processing issues with attention given to the features and/or hierarchical units of features a visual scene contains. These hierarchical sub-units and their proposed functional utility will be discussed. The relative influence of various levels of structure will be examined. A comparison of local, basic levels of structure to global, higher levels of structure in terms of their relative influence or precedence will be made.

REVIEW OF THE RELEVANT LITERATURE

It has traditionally been felt that it is the analysis of very low levels of structure that are essential for recognition of an object. Sets of features, feature detectors, or critical features are often identified. Gilmore, Hersh, Caramazza & Griffin (1979) state that feature or distinctive featural attributes are considered fundamental to perception and ongoing information processing operations. A model of information processing has been proposed by Estes (1972, 1974) in which the basic concept is a set of feature detectors and that the initial processing phase is a parallel feature extraction process. In his multicomponent theory of perception, Rumelhart (1970) has also suggested that the representations of letters in the alphabet in the perceptual and short term memory systems are generated by combining subsets of a master set of critical features in various ways. Similarly, in their model of the perception of geometric figures, Vitz and Todd (1971) discussed such critical features as the line segments making up the geometric form, the angles created by the intersection of the line segments, and the area the geometric form encloses. It was felt that the perception of an object or form is the result of the analysis of these features.

In what is perhaps the most representative of this featural component viewpoint, Neisser (1967) proposed a "constructive hypothesis". The low order featural components of a scene or object are seen as facilitators in terms of "building blocks" of information which provide for the identification of higher order forms. In other words, Neisser believes that perceptual processes begin with specific analyses and move to general ones. Thus, very detailed featural focusing provides hypotheses about the more general, global characteristics of an object. A perception is constructed by utilizing this lower order featural foundation and the implications it lends toward the higher order components. This viewpoint, or featural model allows for a passage of information between hierarchical levels. The direction of the information transmission would be from low levels to higher levels of information. It is implied that it is very low order forms that are the determinants of recognition and that higher order information is the result of lower levels of analyses.

In one study comparing methods for measuring inter-letter similarity between capital letters Holbrook (1975) found that feature analytic models of processing did not stand up very well, relative to template matching theories or subjective ratings of confusability. On the basis of the results it was felt that it cannot be reasonably assumed

that feature analysis theory has improved upon very simple theories or subjective ratings (in terms of predicting confusability or interletter similarity). This suggests that perhaps the feature analytic emphasis is not necessarily an accurate portrayal of the hierarchical information flow.

As studies such as those described above have continued to weaken the "specific to general" model of feature analysis, there has been a move away from these hypotheses, and it has been suggested that perhaps it is the higher order levels of structure or global features that provide for the initial recognition and identification of an object (from which the presence of lower level features can be inferred).

The hierarchical stages in the processing of visual information were studied by Hoffman(1975). It was suggested that any visual input is processed on several different levels and that there is an initial preattentive stage which seeks an overall or global organization of the input. It was further suggested that this stage is responsible for the perceptual foundation, or "constructs a program" to guide the operation of a subsequent stage.

This emphasis of higher order levels of structure is analogous to suggesting that it is the low spatial frequency cues that dominate perception. A normative visual image is made up of a mixture of spatial frequencies. High spatial

frequencies are seen with sharp edged, detailed stimuli and low frequencies with blurs or outlines of a stimulus (Kaufman, 1974). The overall form or outline of an object (global characteristic) consists of low spatial frequency cues. The idea of the precedence of higher order levels of structure was clearly described by Broadbent (1977) in an address to the American Psychological Association, and it seems to represent the recent trend in thinking. Broadbent suggested that higher order forms are processed first, followed by an analysis of progressively lower order forms.

In his study of the visual recognition of isolated lower case letters, Bouma (1971) described the envelope of a letter. This is defined as the smallest possible enclosing polygon without indentations of a given configuration. This envelope, or global outline of a stimulus, which is considered to be an important cue with respect to recognition, represents a low spatial frequency cue.

In what is again a representative discussion, Lupker (1979) discusses visual perception in terms of a focusing process. In response to traditional feature analytic models of perception the recognition of letters and specific features thought to make up those letters such as - or / were studied. A simple backward visual masking paradigm was used and the stimuli and responses were recorded. Confusion matrices were generated. Few predictions in accord-

ance with featural models were upheld, in that errors almost always involved stimuli having more perceptual data than the presented stimulus (if stimuli were analyzed as a featural model would predict, errors would reflect omissions of "critical features"; with an analysis of the presented low level featural cues no new information should be added). Perception was viewed as a process in which an initial array of perceptual data is focused over time. When data is initially available it is conceived of as a blurred image and over time becomes more and more defined, until, with sufficient time, the local features become clear.

This focusing process model allows for a passage of information between hierarchical levels in the opposite direction of that allowed by the featural model. The direction of the information transmission would be from high levels to lower levels of information. Within this model it is implied that it is the higher order forms that are the determinants of recognition and that the knowledge of lower order forms is contingent upon this recognition process.

In an article which has since served as a catalyst for a large amount of research, the precedence of global features in visual perception was discussed (Navon, 1977). It was again proposed that perception proceeds from a global analysis to more and more specific, local analyses. Navon felt, in fact, that his findings demonstrated the "inevit-

ability of global processing". A series of experiments in which the global and local features of stimuli were manipulated were carried out. His most impressive finding was obtained in an experiment in which he used stimuli composed of letters made up of smaller letters, as shown in Figure 1. These stimuli, as originally suggested by Kinchla (1974), were used such that the identified properties of the global and local features could be equated (the set of identified global features - the large letter, was identical to the set of identified local features - the small letters).

Subjects were shown the above stimuli under two different conditions. In the global directed condition the subject was asked to indicate whether the global character (large letter) was an H or an S. In the local directed condition the subject was asked to indicate whether the local characters (the small letters making up the large one) were Hs or Ss. The results indicated that the global pattern was responded to faster than the local characters, and more importantly, subjects were able to voluntarily attend to the global pattern without being affected by the local features, but they were not able to attend to the local features without being affected by the global characteristic (under the global directed condition it made no difference whether the two levels of structure were consistent or conflicting; under the local directed condition consistent stimuli were

GLOBAL DIRECTED CONDITION

H	H	S	S	0	0
H	H	S	S	0	0
H	H	S	S	0	0
H H H H H H		S S S S S S		0 0 0 0 0 0	
H	H	S	S	0	0
H	H	S	S	0	0
H	H	S	S	0	0

	H H H H		S S S S		0 0 0 0
H	H	S	S	0	0
H		S		0	
	H H H H		S S S S		0 0 0 0
	H		S		0
H	H	S	S	0	0
	H H H H		S S S S		0 0 0 0

LOCAL DIRECTED CONDITION

H	H	H H H H	H H H H H H
H	H	H	H
H	H	H	H
H H H H H H		H H H H	H
H	H		H
H	H	H	H
H	H	H H H H	H H H H H H
S	S	S S S S	S S S S S S
S	S	S	S
S	S	S	S
S S S S S S		S S S S	S
S	S		S
S	S	S	S
S	S	S S S S	S S S S S S

Figure 1. Stimulus set used by Navon (1977).

responded to more rapidly than were conflicting stimuli). Navon's results are shown in Figure 2.

That global attributes were processed more quickly in Navon's study is perhaps not surprising. There is evidence (Lupp, Hauske & Wolfe, 1976) that subjects respond rapidly to low spatial frequencies and progressively more slowly to higher frequencies, which in itself would predict Navon's findings. There is also considerable evidence that single letters are easier to perceive than letters flanked by other letters (Townsend, Taylor & Brown, 1971; Wolford & Hollingsworth, 1974). This phenomenon is called a lateral masking effect and would appear in Navon's stimulus set only on the local level, which also may have made letters within the local condition more difficult to perceive. What is surprising, however, is the finding that the local features did not interfere with the processing of the global letters, while the global features did interfere with the processing of the local letters. It was this finding that led Navon to conclude that processing on the global level was inevitable; it seemed that subjects had to process the large (global) letter first in both conditions.

In response to Navon's results, Kinchla & Wolfe (1979) again addressed the problem of the order of visual processing. The stimuli used were similar to those used by Navon, however, the overall size of the stimuli was varied

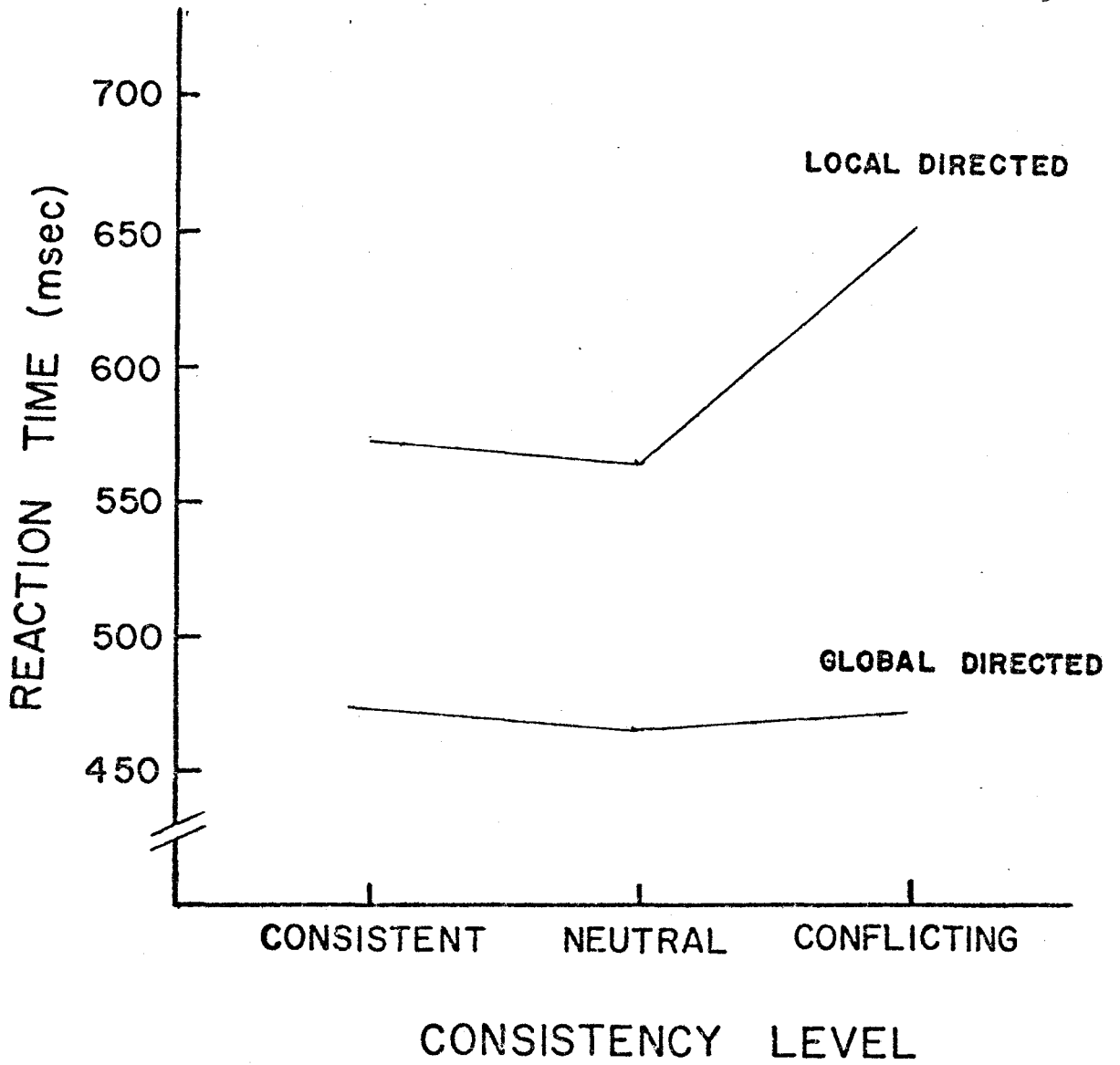


Figure 2. Mean response latencies as a function of consistency level and attentional condition (Navon, 1977).

over a much larger range of visual angle. Navon presented stimuli at a visual angle of approximately $3^{\circ}12'$; Kinchla and Wolfe presented stimuli in which the height of the large letter subtended, with equal probability on each trial, 4.8° , 6.7° , 8.0° , 10.3° , or 22.1° visual angle. Subjects heard a target letter defined and were then shown a stimulus letter. Their task was to respond "yes" if the target letter corresponded to either the large letter or the small letter in the stimulus letter and "no" if it did not. It was found that "no" responses generally took longer than "yes" responses and that there was a crossover interaction between the speed of a "yes" response to large and small targets and the visual angle of the display, as shown in Figure 3.

At smaller visual angles the large letter evoked the fastest "yes", while at the larger visual angles the small letters did. These results suggested neither an invariant global to local process (which Navon had proposed as inevitable), nor a local to global process (as a feature analytic model would predict). Rather than a top-down, global to local process or a bottom-up, local to global process, a sort of "middle-out" process was proposed. It was suggested that forms at some intermediate level of structure having an optimal size or spatial frequency might be processed first (this does not necessarily imply a middle level of structure, it may well be that it is a global or local form

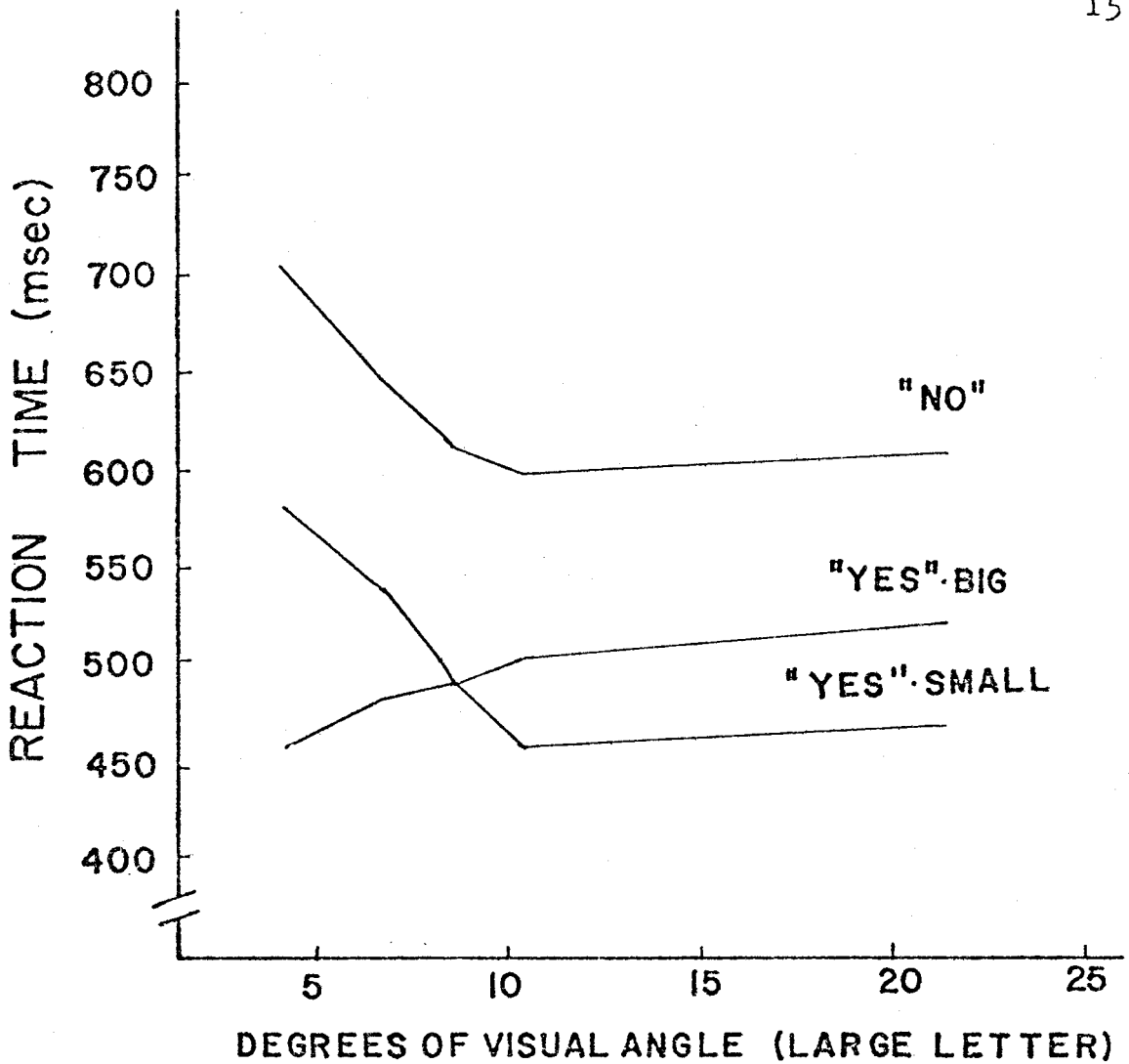


Figure 3. The average time to respond "yes" at each angular display size when a large letter was the target, when small letters were the targets, and to respond "no" when neither was the target (Kinchla & Wolfe, 1979).

that is processed first; what are of central importance to this idea are the concepts of optimal size and spatial frequency) with subsequent processing of both higher and lower levels of form.

Another series of studies was conducted by Martin (1979), again in direct response to Navon's findings. Martin used stimuli similar to those used by Navon, letters made up of smaller letters. As in Navon's study, stimuli were presented in one of four possible quadrants of the stimulus field, immediately adjacent to the field's central and vertical axes. The global shape subtended 2.8° to the left or right of the center point of the field and 4.1° above or below it. Her research addressed two assumptions - the first was that global processing precedes local processing and the second was that when two conflicting types of information are processed, perception of a secondary (more slowly available) type is impaired by the primary type.

In Martin's main experiment subjects were shown a global letter composed of several smaller, local letters. The sparsity of each stimulus was varied by having each global aspect be comprised of either many or few local ones, such that the local to global size ratio was varied. The task of the subject was to identify either the global or local letters (as instructed) as rapidly as possible.

A two way interaction between sparsity and attentional

instruction was found. Depending upon the conditions either the global aspects or the local aspects of the stimuli were responded to more rapidly, as shown in Figure 4. Although global processing was significantly faster than local processing for stimuli with many local elements, it was significantly slower than local processing for stimuli with few local elements. The results of her series of four experiments consistently demonstrated a global processing priority only for many-element stimuli, a local processing priority appeared for few-element stimuli.

Hoffman (1980) conducted a series of studies in which he also investigated the processing of levels of structure. He utilized a paradigm that combined elements of Navon's (1977) interference paradigm and Kinchla and Wolfe's (1979) target search task. Each of his trials began with the presentation of a memory set of one, two, or four letters. A stimulus pattern was then presented consisting of a large letter made up of small letters. A letter was considered positive if it was a member of the memory set and negative if it was not. The experiment was divided into a "large only" condition in which the target letter might appear at the global level, a "small only" condition in which the target letter might appear at the local level, and a "both" condition in which the target letter might appear at either

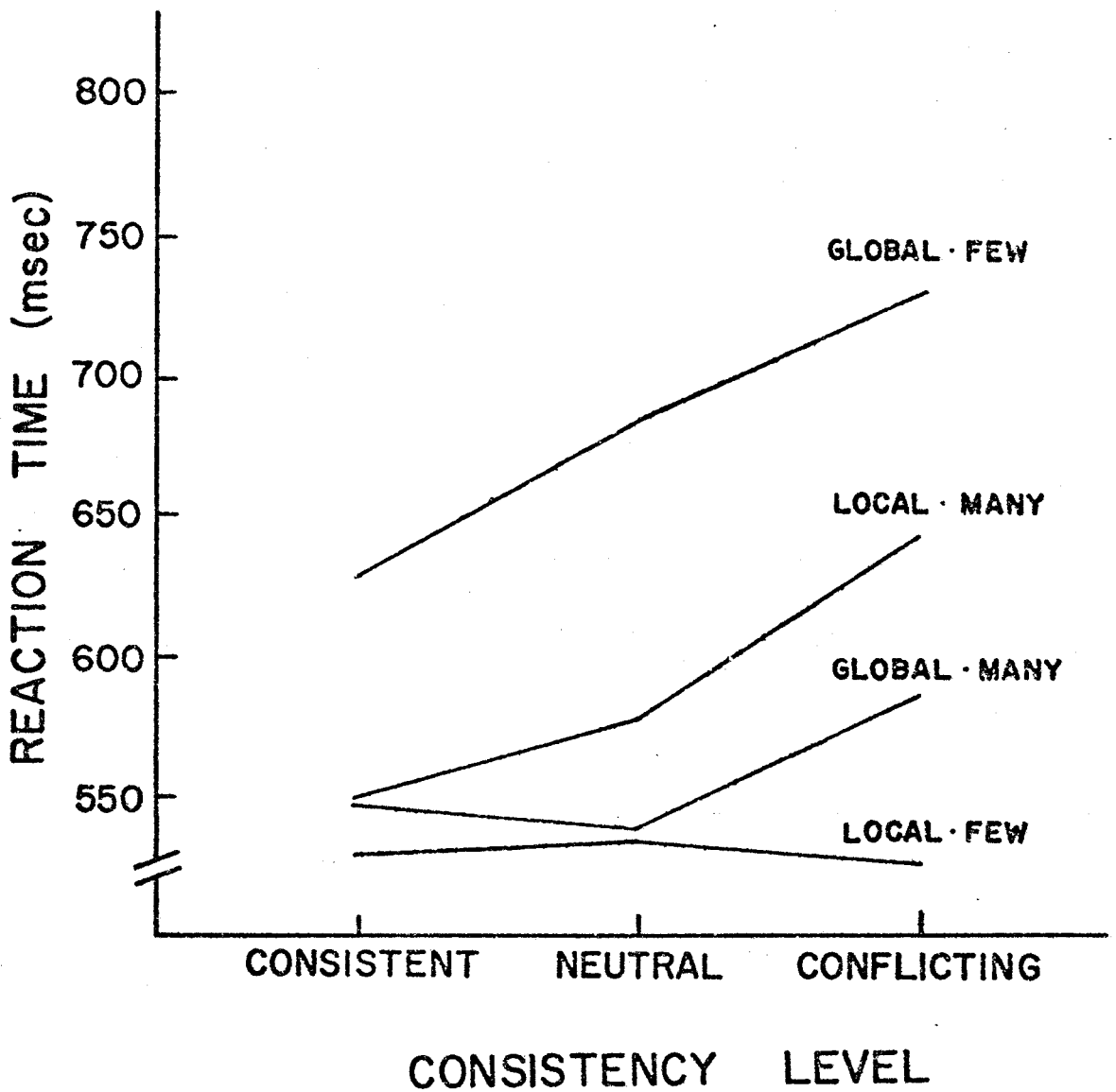


Figure 4. Latencies for reporting local and global aspects of many element and few element stimuli, as a function of the level of consistency of the secondary aspect (Martin, 1979).

level. In an experiment in which stimuli were the letters L, X, T, Y, H, N, F, and Z, it was found that in the focused attention conditions subjects were unable to attend to only the instructed dimension. Reaction times were faster when the two dimensions (large and small letters) were in agreement than when they conflicted, and that the magnitude of the interference provided by the to-be-ignored dimension was approximately the same in both the global and local directed conditions. In the divided attention, or "both" condition reaction time was the same for targets located at either the global or local level, and it was generally slower than for the corresponding focused attention condition.

In a second experiment the quality of information at the local and/or global levels was distorted. This was done by changing the position of a randomly chosen element of a letter (at the appropriate global or local level) from its correct position to a new randomly chosen position within the letter matrix. An example of Hoffman's stimuli is shown in Figure 5. When the small letter was distorted, a global precedence pattern was obtained. Subjects could not ignore the large letter when told to attend only to the small and the identity of the small letter was irrelevant when subjects were attending to the large letter. It is important to note that these results are in accordance with those that

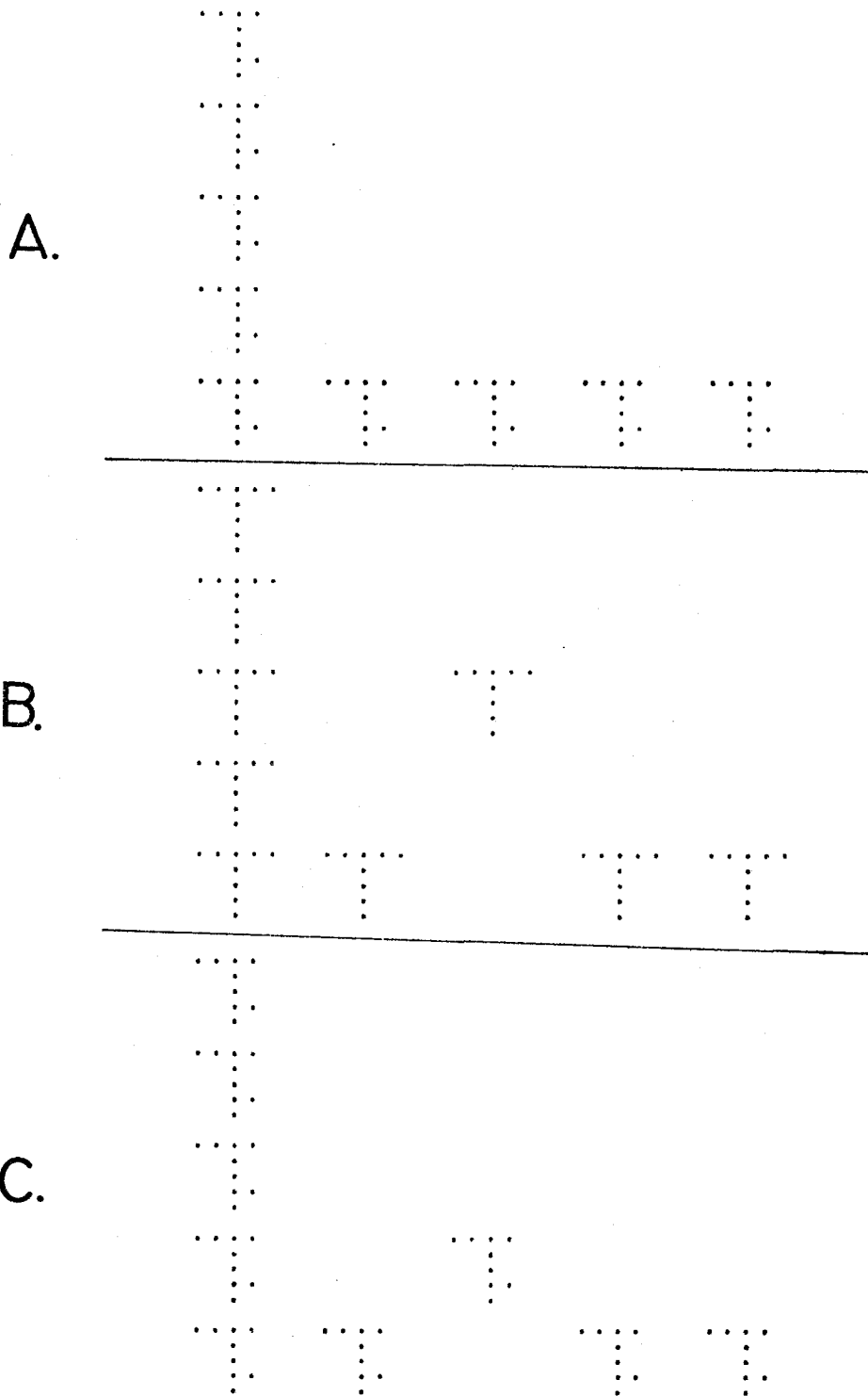


Figure 5. Distorted stimuli used by Hoffman (1980).
 A. Distortion on the local level.
 B. Distortion on the global level.
 C. Distortion on both levels.

would be predicted by Navon's (1977) precedence model. When the large letter was distorted however, a corresponding local precedence pattern was obtained. It was assumed that both the large letters and the small letters were proceeding through a pattern recognition process simultaneously. It was felt that the relative quality of information at each level determines the speed of recognition.

RATIONALE FOR THE CURRENT STUDY

Discussions involving the order of visual processing seem to have undergone a rather consistent change in the last few years. There has been a shift away from the very traditional viewpoint that it is the low levels of structure or "critical features" that are essential to recognition, toward an increased emphasis on more global, higher order levels of structure. Rather than constructive theories of recognition, focusing models have recently been proposed.

Compelling evidence for a global oriented, higher order levels of processing model has been offered with the work done by Navon (1977). His work demonstrated what he termed "the inevitability of global processing". His results seemed to indicate that visual information processing always proceeds from a general, global level to a more focused, local level. It appeared that global characteristics can be recognized without the knowledge of local characteristics, but that information about local characteristics is dependent upon initial processing of the related global characteristics. Although Navon's findings show a clear emphasis on global processing, and a full shift in thinking about the order of visual processing seems appropriate, it appears that the main value of his work may be that it served as a catalyst which generated a new series of studies. Subsequent

studies have demonstrated that global processing may not be that inevitable after all.

In direct response to Navon's work Kinchla and Wolfe (1979) looked at the order of visual processing as a function of the overall size of the visual stimulus. When using stimuli similar in size to those used by Navon, global characteristics (letters) were processed more quickly than local letters. When the size was increased however, local letters were processed more quickly. Martin (1979) varied the size ratio of the global to local characters and again found that global characteristics took precedence, or were processed more quickly, only under certain conditions. Global processing was significantly faster than local processing for stimuli with many local elements, however local processing was faster (took precedence) for stimuli with few local elements. Hoffman (1980) also demonstrated this reversal of precedence. In an experiment in which he distorted either the local characteristics, or the global characteristics, or the characteristics on both levels, he found that the level of processing that took "precedence" was contingent upon the level of distortion. A global precedence pattern was obtained when the local characteristics of the stimuli were distorted, but a local precedence pattern was obtained when the global characteristics were distorted.

In light of recent evidence it appeared that the

assumptions involved with the order of visual processing needed to be further investigated. It was not felt that global processing either "took precedence" or was "inevitable". It was felt that neither a global precedence model nor a local precedence model ("critical features") was appropriate. A series of studies was conducted in an attempt to define an appropriate model with respect to the order of visual processing and to clarify some important variables relevant to that model. Within this series subjects were asked to look at a figure made up of smaller figures and identify either the large figure (the global component) or the small figures (the local components). Stimuli were similar to those used by Navon in that the same figures were used to represent both the lower order and the higher order features. Four experiments were conducted and are presented below.

Experiment 1 combined the essential features of both Navon's and Kinchla & Wolfe's studies. Kinchla and Wolfe have shown that the overall size of the target stimulus is an important variable with respect to global or local precedence. The differential interference effect of the global versus local forms reported by Navon was not dealt with in their study, however. Because subjects were merely asked to indicate if a given target was present in a given stimulus array (at either the global or local level) there was no op-

portunity to tap the potential interference of global or local characters with respect to the opposing global or local characters. As in Navon's study, the subjects in this study were asked to respond to either the global or local components of a stimulus and these components were randomly varied, such that the components on the two levels were either consistent or conflicting. As in Kinchla and Wolfe's study, the overall size of the target stimulus was randomly varied.

Experiment 2 reassessed the importance of the global to local size ratio. As in Martin's study the size of the global component was held constant while the size of the local components was varied. In this way the size ratio was varied such that a target stimulus either consisted of many local elements (a "dense" target) or few local elements (a "sparse" target). In this study, stimuli were much larger than those used by Martin and were centered at a fixation point, rather than appearing in one of four quadrants.

Experiments 3 and 4 were conducted in an attempt to gain further insight into the differential interference effects imposed by the opposing level of information (depending upon the attention condition, either the local or the global level). All stimuli were the same size and located either to the right or to the left of the fixation point. The stimulus set was varied to see if some conflic-

ting components might introduce more interference than others. Experiment 3 used the letters O and C at the relevant level (the level to which subjects were instructed to respond), on the irrelevant level the letters O, C, and L were used, such that the combinations produced were either consistent (O-O or C-C), conflicting-confusable (O-C or C-O), or conflicting-non-confusable (O-L or C-L).

It has been shown that there is a very large difference in recognition performance despite a small difference in actual geometry between letters and non-letters (Mayzner & Habineck, 1975). Experiment 4 utilized the same paradigm as Experiment 3, but introduced a non-letter at the conflicting level. The letters E and H were used at the relevant level and the characters E, H, and H^{\flat} were used at the irrelevant level. The combinations these characters produced were consistent (E-E or H-H), conflicting-letter (E-H or H-E) and conflicting-non-letter (E- H^{\flat} or H- H^{\flat}).

It was hoped that the results of these four studies would together provide the insight necessary for the development of an appropriate levels of processing model of visual information processing.

EXPERIMENT 1

Method

Subjects. Ten undergraduate students at Loyola University of Chicago enrolled in general psychology were used as subjects. All subjects had normal or corrected-to-normal vision.

Apparatus. Stimuli were presented to the subjects on a Scientific Prototype tachistoscope, Model N-1000. A dove prism was mounted to the tachistoscope such that the visual field was rotated 90° . This was done in order to maximize the height of the rectangular viewing field. Subjects initiated each trial by pushing a button which was positioned on a table in front of them.

The tachistoscopic presentations were in a dimly lighted room. Subjects viewed the tachistoscope monocularly through their right eye and wore an eye patch over their left eye. Subjects viewed the screen through an eye piece and rested their heads on a chinrest in order to minimize movement and to insure that a constant distance of 104.14 cm. between the display screen and the observer was maintained at all times.

Subjects responded to the presented stimuli by pushing a button which was positioned on a table in front of them (the same button as mentioned above). This button was con-

nected to an Earling Counter Timer Frequency Meter which was interfaced to the tachistoscope and served to measure reaction time. All responses were recorded by the experimenter.

Stimuli. All stimuli were constructed of black lines on a white background arranged according to various spatial parameters. Test stimuli were letters made up of smaller letters as described earlier and as shown in Figure 6. The letters E, H, and S were used both as higher order and as lower order features such that there were nine stimuli in all. These letters were chosen because they are the letters that were used in the Kinchla and Wolfe study. The stimuli were presented at visual angles of 2.09° and 6.26° . For the small sized stimuli local letters subtended 0.35° visual angle and for the large sized stimuli the local letters subtended 1.045° visual angle. All stimuli were constructed from a possible four column by five row array of letters. All stimulus arrays were centered on the tachistoscope screen, were preceded by a fixation point which was one point in the center of the screen, and were followed by a random noise mask.

Procedure. The following procedure was utilized. The subject sat in a dimly lighted room and viewed the tachistoscope screen through his right eye. On each trial the

E	E	H	H	S	S
E	E	H	H	S	S
E E E E		H H H H		S S S S	
E	E	H	H	S	S
E	E	H	H	S	S

E E E E	H H H H	S S S S
E	H	S
E E E E	H H H H	S S S S
E	H	S
E E E E	H H H H	S S S S

E E E E	H H H H	S S S S
E	H	S
E E	H H	S S
E	H	S
E E E E	H H H H	S S S S

Figure 6. Stimuli used in Experiment 1.

fixation point was presented for 500 msec. followed by a variable foreperiod. The foreperiod was randomly varied between 1000 and 2000 msec., as was recommended by Woodworth and Schlosberg (1954). Immediately following the foreperiod one of the nine stimuli at one of the two visual angles was randomly presented for 50 msec.. A random noise mask immediately followed the target stimulus and remained on the screen for 500 msec.. A total of 216 trials were presented to each subject, representing 12 repetitions of each stimulus by size condition. The task of the subject was to respond to either the large letter or the small letters which made up that letter, as directed by the experimenter.

At the start of each session the subject was shown a drawing of the stimuli to be used and it was explained that he would be asked to respond to either the large letter or the set of small letters for each array, as instructed. Each testing session was divided into four blocks of 54 trials each, such that for two blocks the subject was asked to respond to the large letter and for two blocks he was asked to respond to the small letters. The instructional set for each block was counterbalanced across subjects. At the start of the trials and the first time the instructional set was shifted the following instructions were read to the subjects:

To begin each trial push this button. You will then see a dark point in the center of the screen. That will disappear and the screen will remain blank for a brief interval. You will then see a letter made up of smaller letters on the screen for a short time. Following this, the screen will be filled with many different letters in many different positions. All you need concern yourself with is the letter made up of smaller letters. For this first group of trials all you need concern yourself with are the small letters (is the large letter), by that I mean the letters that are making up the large letter (the overall shape or outline of a letter). You can ignore the large letter, or overall shape or outline of a letter (the small letters, or letters that are making up the larger outline of a letter). I will later ask you to look at the large letter (the small letters). Your task is to determine whether those small letters (that large letter) are Es, Hs or Ss (is an E, H or S). When you feel you know which letters they are (it is), push the button a second time and say the letter out loud. You are to respond as quickly as possible, but remember, accuracy is the most important factor here. Don't feel you have to rush, or that you have to answer within a certain time span. Don't push the button and then decide what letter you thought you saw. Try not to respond until you are certain. This is a self paced task. You initiate each trial, so go at your own speed. After each trial, please wait until I say "ready" before you begin the next one.

The first 18 trials within each instruction condition were considered practice trials and were not scored. Following each block the experimenter introduced the instructional set for the subsequent block.

Results

An analysis of variance with repeated measures yielded a significant interaction between the instructional set and the target size ($F(1,9)=8.825, p<.05$). Figure 7

shows the mean reaction time as a function of instructional set and target size across subjects. When subjects were instructed to attend to the global components of the stimuli they responded to the small targets more quickly than to the large targets. When subjects were instructed to attend to the local components they were able to respond more quickly to the large targets.

Significant main effects were found for neither the target size, nor the instructional set, nor the consistency factor. No other interactions were found to be significant.

Discussion

No main effects were significant. In the Kinchla and Wolfe study, size as a main effect was significant. It may have been because size was varied over a much wider range of visual angle than in the present study. That neither the instructional set (the attention condition) nor the consistency factor (whether the global and local components of the target were consistent or conflicting) was significant was surprising in light of Navon's results. Contrary to Navon's data, it appeared to make no difference whether stimuli were consistent or conflicting, there was no evidence of an interference effect. It also appeared to make no difference whether subjects were asked to attend to the global components of the target or to the

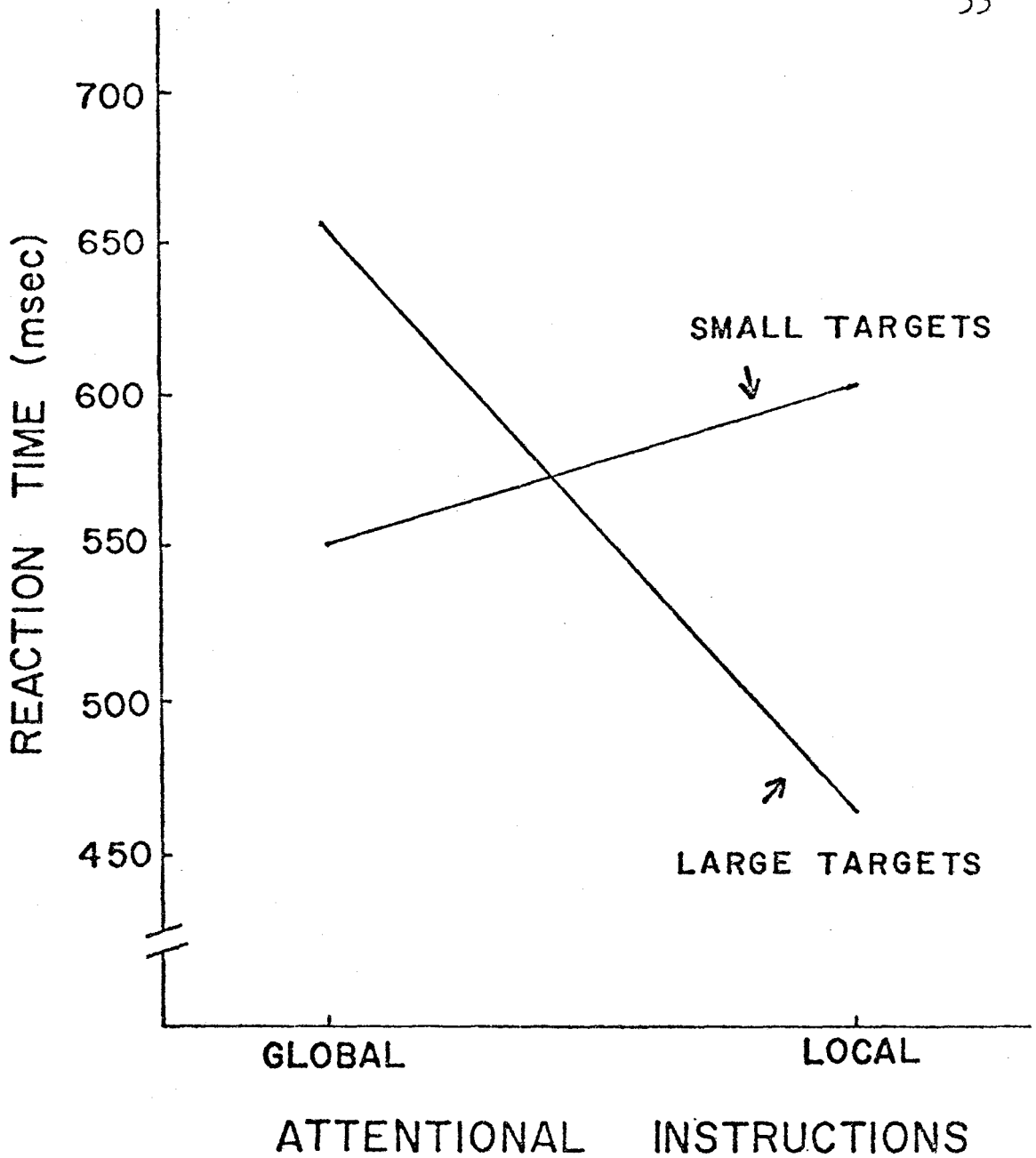
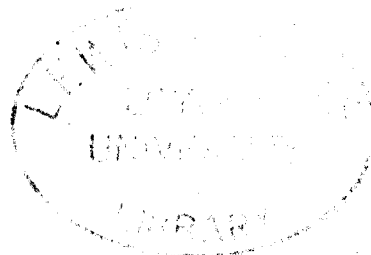


Figure 7. Mean reaction time as a function of attentional instructions and target size (Experiment 1).



local components - subjects responded to either set of components at an equal rate. None of these results strengthen a global precedence model.

The interaction between target size and instructional set also serves to weaken a global precedence model. The results of this study indicated that the global components of a stimulus are important sometimes; the relative importance or "precedence" of global versus local components seemed to be contingent upon the target size variable.

EXPERIMENT 2

Method

Subjects. Ten different undergraduate students enrolled in general psychology at Loyola University of Chicago were used as subjects, again, all had normal or corrected-to-normal vision.

Apparatus. All apparatus was the same as was used in Experiment 1.

Stimuli. All stimuli were again constructed of black lines on a white background, arranged according to various spatial parameters. Test stimuli were again the letters E, H and S. Each letter served as both a global character and as local characters. Stimuli were always presented at a visual angle of 4.18° . Local letters subtended either 0.35° or 1.045° visual angle. Stimuli which utilized the small sized local letters were constructed from a possible seven column by nine row matrix of letters, stimuli which utilized the larger sized local letters were constructed from a possible four column by five row matrix, such that the global to local component size ratio was varied. Examples of stimuli used in this experiment are shown in Figure 8. All stimulus arrays were centered

E E E E H H H H S S S S³⁶
 E H S
 E E E E H H H H S S S S
 E H S
 E E E E H H H H S S S S

E E E E E E E H H H H H H H S S S S S S S
 E H S
 E H S
 E H S
 E E E E E E E H H H H H H H S S S S S S S
 E H S
 E H S
 E H S
 E E E E E E E H H H H H H H S S S S S S S

Figure 8. Examples of stimuli used in Experiment 2.

on the tachistoscope screen, were preceded by a fixation point, and were followed by a random noise mask.

Procedure. The experiment proceeded in exactly the same manner as did Experiment 1.

Results

Mean reaction times for correct responses as a function of stimulus ratios (many or few local elements), local and global consistency levels (consistent or conflicting), and instructional set (local or global) are shown in Figure 9.

An analysis of variance for repeated measures showed that reaction times were faster for consistent targets than for conflicting targets ($F(1,9)=16.658$, $p < .01$). Main effects for instructional set and stimulus ratio were not significant. A crossover interaction was found between stimulus ratio and instructional set, ($F(1,9)=9.995$, $p < .05$), as shown in Figure 10. A three way interaction was found between instructional set, consistency, and stimulus ratio. An analysis of simple effects showed that all two way interactions, at all levels of the third variable were significant (except for the instructional set by consistency level interaction, with respect to "few" local letters). An analysis of simple,

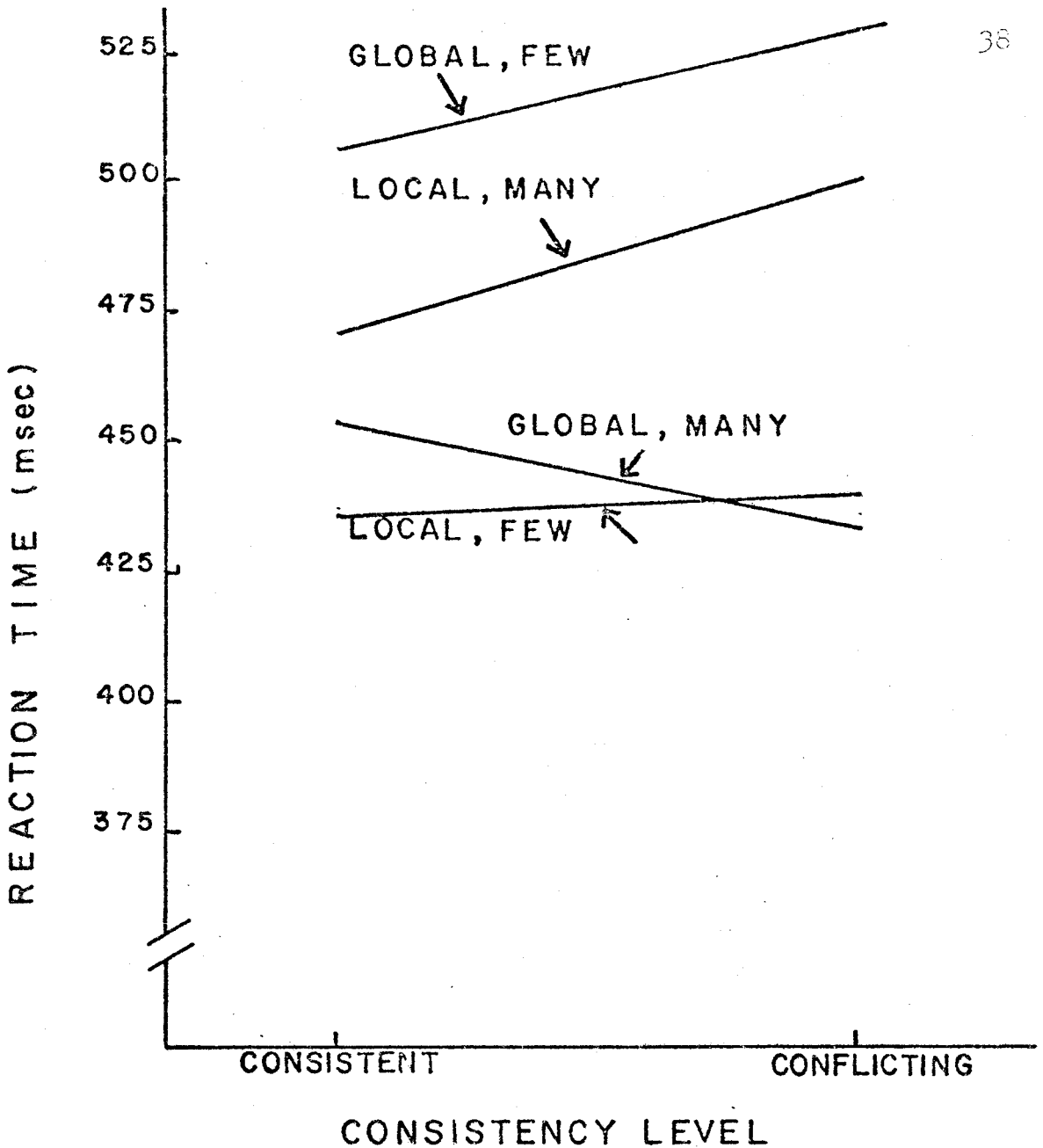


Figure 9. Mean reaction times for correct responses as a function of stimulus ratios (many or few local elements), local and global consistency (consistent or conflicting), and attentional instructions (local or global) (Experiment 2).

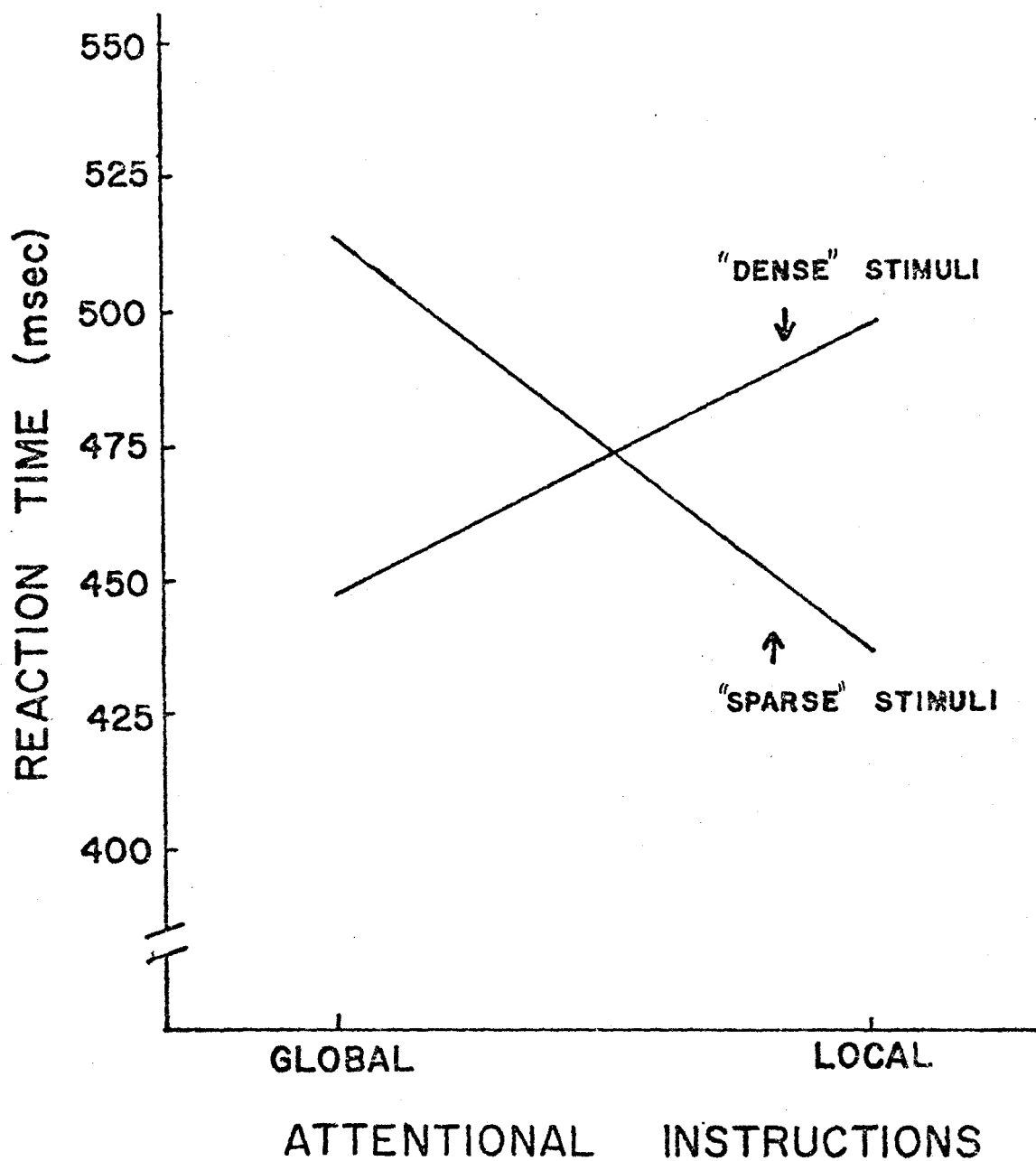


Figure 10. Mean reaction times for correct responses as a function of attentional instructions and stimulus ratios (Experiment 2).

simple effects showed that the ratio variable was the most consistently significant (that is, the ratio variable was significant at all levels of consistency and instructional set).

Discussion

The results of this experiment showed that consistent targets were responded to more quickly than conflicting targets. This would indicate that subjects were not able to attend to either the global or local level of information without interference from the opposing level. These results are not in accordance with a global precedence model. A global precedence model would infer that global letters would interfere with the processing of local letters, but that local letters would not interfere with the processing of global letters. An equal-precedence effect seems to be occurring in this case.

The crossover interaction between instructional set and stimulus ratio exhibits a "reversal of precedence" effect in accordance with the results of Hoffman (1980), Kinchla and Wolfe (1979) and Martin (1979). Targets which had many local elements (dense) were responded to more quickly than targets with few local elements (sparse) when subjects were instructed to attend to the global components of a stimulus. When subjects were asked to respond to the

local components however, a reversal occurred. Targets which had few local elements were responded to more quickly than targets which had many local elements. Depending upon the size of the local elements of the target (more accurately, the size ratio of global to local elements), either global or local elements "took precedence".

The three way interaction between ratio, consistency, and instructional set is difficult to interpret. An analysis of simple effects seemed to indicate that it was the stimulus ratio variable which was important. It appeared that the size ratio was interacting with the different levels and different combinations of levels of instructional set and consistency. This would imply that there is a complex relationship between variables, and that each level of each variable serves to affect all other variables.

EXPERIMENT 3

Method

Subjects. Ten different undergraduate students enrolled in general psychology at Loyola University of Chicago volunteered as subjects. All had normal or corrected-to-normal vision.

Apparatus. The apparatus was the same as was used in Experiments 1 and 2.

Stimuli. All stimuli were again constructed of black lines on a white background, arranged according to various spatial parameters. The letters O, C, and L were used. On the relevant level (either global or local, the level to which the subjects were instructed to attend), the letters O and C were used. On the irrelevant level (either local or global, the level which was not given in the attention condition) the letters O, C, and L were used. Combinations of the relevant and irrelevant levels produced stimuli which were either consistent (O-O or C-C), conflicting-confusable (O-C or C-O), or conflicting-non-confusable (O-L or C-L). Stimuli are shown in Figure 11.

Stimuli were constructed from a matrix of five columns by seven rows. Local letters subtended 0.35° visual angle. The entire target subtended a visual angle of 3.138° .

GLOBAL DIRECTED CONDITION

0 0 0	C C C	L L L
0 0	C C	L L
0 0	C C	L L
0 0	C C	L L
0 0	C C	L L
0 0	C C	L L
0 0 0	C C C	L L L
0 0 0	C C C	L L L
0 0	C C	L L
0	C	L
0	C	L
0	C	L
0 0	C C	L L
0 0 0	C C C	L L L

LOCAL DIRECTED CONDITION

0 0 0	0 0 0	0
0 0	0 0	0
0 0	0 0	0
0 0	0 0	0
0 0	0 0	0
0 0	0 0	0
0 0 0	0 0 0	0 0 0 0 0
C C C	C C C	C
C C	C C	C
C C	C C	C
C C	C C	C
C C	C C	C
C C C	C C C	C C C C C

Figure 11. Stimuli used in Experiment 3.

All trials were preceded by a fixation point in the center of the screen and were followed by a random noise mask. Stimuli were positioned such that they were immediately to the left or immediately to the right of the fixation point.

Procedure. The procedure was virtually the same as for Experiments 1 and 2. On each trial a fixation point was presented for 500 msec. followed by a foreperiod which varied between 1000 and 2000 msec.. Immediately following the foreperiod a stimulus target was presented to the subject for 75 msec.. A total of 192 trials were presented to each subject. Each testing session was divided into four blocks of 48 trials each, such that for two blocks the subject was asked to respond to the large letter and for two blocks he was asked to respond to the small letters. The instructions read to the subjects were virtually the same as in Experiments 1 and 2, adjusted to be relevant to this study.

The first 24 trials within each instruction condition were considered practice trials and were not scored.

Results

Mean reaction times for correct responses as a

function of consistency level (consistent, conflicting-confusable, or conflicting-non-confusable) and instructional set (global or local) are shown in Figure 12.

An analysis of variance for repeated measures yielded significant main effects and a significant interaction effect. There was a significant difference between response times when subjects were asked to attend to the global or to the local components of the stimuli, ($F(1,9) = 6.947, p < .05$), and between response times at the three consistency levels, ($F(2,18) = 13.2, p < .01$). The interaction between consistency level and instructional set was also significant, ($F(2,18) = 4.52, p .05$). It appeared that consistent stimuli were always the easiest to respond to. Within the local condition, conflicting-non-confusable stimuli were responded to more quickly than conflicting-confusable stimuli; within the global condition conflicting-confusable stimuli were responded to more quickly than were conflicting-non-confusable stimuli.

Discussion

The results of this experiment all seemed to indicate significant differences. Subjects responded to global stimuli more quickly than to local stimuli. This result is in accordance with a global precedence model. It was also found that subjects responded the most qui-

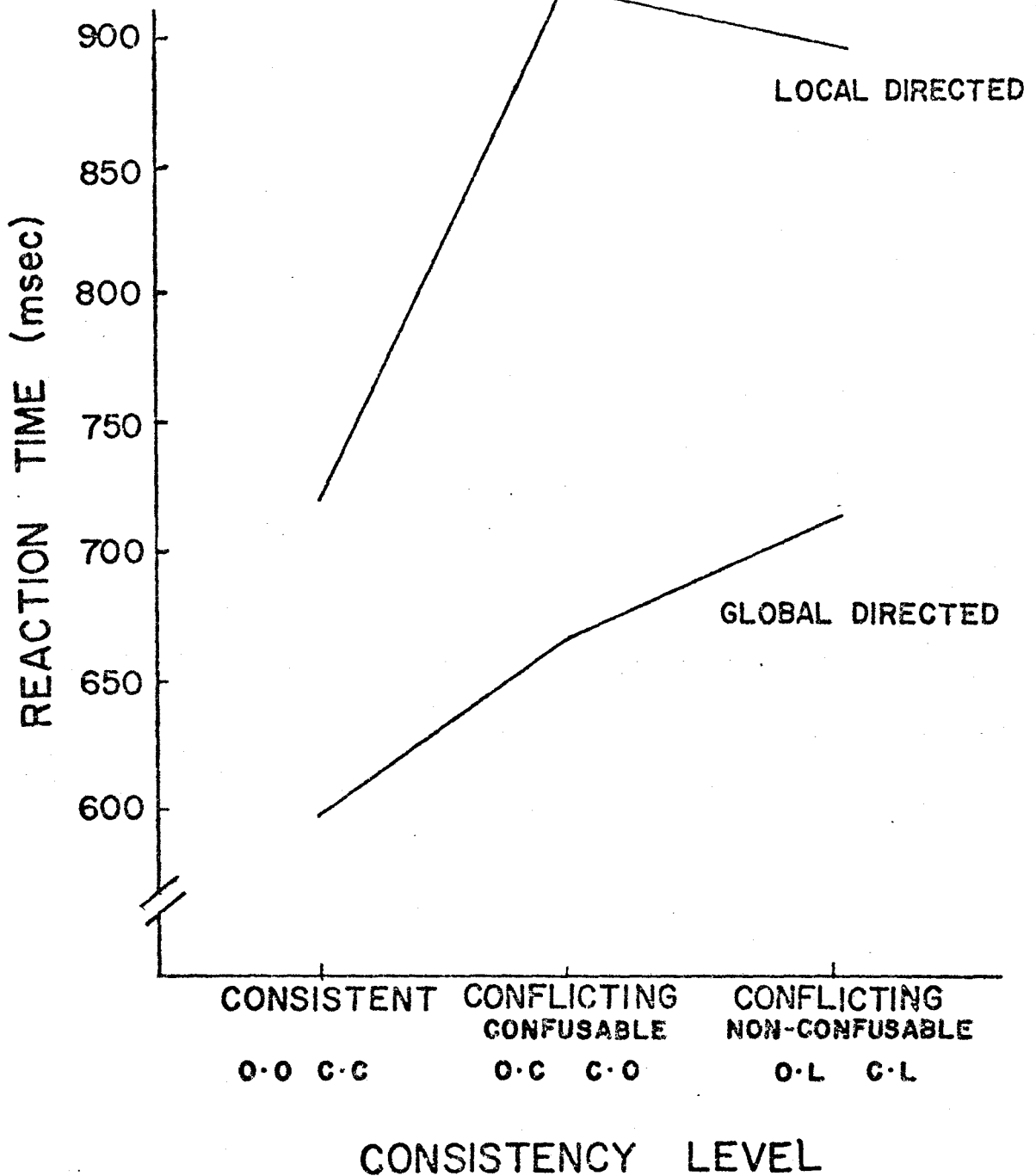


Figure 12. Mean reaction times for correct responses as a function of consistency level and attentional instructions (Experiment 3).

ckly to consistent stimuli (stimuli with the same characters on both the global and local levels) and more slowly to conflicting stimuli, as was found in Experiment 2.

There was an interaction between instructional set and consistency level. At the global level of attention conflicting-confusable stimuli were responded to more quickly than conflicting-non-confusable stimuli. At the local level the reverse was true. It was hoped that by manipulating the conflicting stimuli new information might be gained with respect to differential interference effects. In light of this interaction effect however, it was not felt that enough information was available to form any strong conclusions. Further manipulation of the conflicting characters seems necessary.

EXPERIMENT 4

Method

Subjects. Ten different undergraduate students enrolled in general psychology at Loyola University of Chicago served as subjects. All had normal or corrected-to-normal vision.

Apparatus. The apparatus was the same as was used in Experiments 1, 2, and 3.

Stimuli. All stimuli were again constructed of black lines on a white background, arranged according to various spatial parameters. The characters E, H, and $\text{E}^{\#}$ were used. On the relevant level the characters E and H were used. On the irrelevant level all three of the above characters were used. Combinations of the relevant and irrelevant levels produced stimuli that were consistent (E-E or H-H), conflicting-letter (E-H or H-E), and conflicting-non-letter (E- $\text{E}^{\#}$ or H- $\text{E}^{\#}$). Stimuli are shown in Figure 13. Stimuli were the same size and were positioned in the same manner as in Experiment 3.

Procedure. The procedure was the same as for Experiment 3. Instructions were adjusted such that they were relevant to this study.

GLOBAL DIRECTED CONDITION

E E E E E	H H H H H	E E E E E
E	H	E
E	H	E
E E E E E	H H H H H	L D E E E
E	H	E
E	H	E
E E E E E	H H H H H	E E E E E
E	H	E
E	H	E
E E E E E	H H H H H	E E E E E
E	H	E
E	H	E
E	H	E

LOCAL DIRECTED CONDITION

E E E E E	E	E	E	E
E	E	E	E	E
E	E	E	E	E
E E E E E	E E E E E	E E E E E	E E E E E	E E E E E
E	E	E	E	E
E	E	E	E	E
E E E E E	E	E	E E E E E	E E E E E
H H H H H	H	H	H	H
H	H	H	H	H
H	H	H	H	H
H H H H H	H H H H H	H H H H H	H H H H H	H H H H H
H	H	H	H	H
H	H	H	H	H
H H H H H	H	H	H H H H H	H H H H H

Figure 13. Stimuli used in Experiment 4.

Results

All main effects and the interaction effect were again significant in this study. Figure 14 shows the mean reaction time for correct responses as a function of consistency level and instructional set.

Subjects responded much more quickly within the global attention condition than within the local attention condition, ($F(1,9)=22.485$, $p < .01$). Consistent stimuli were responded to the most rapidly, followed by conflicting-non-letter and conflicting-letter, ($F(2,18)=18.371$, $p < .01$). There was a significant interaction effect between consistency level and instructional set, ($F(2,18)=15.582$, $p < .01$).

Discussion

The results of this study were the most closely in line with those results found by Navon of all the results from this series of four experiments. Global letters were responded to more quickly than local letters. Consistent targets were responded to more quickly than conflicting targets (indicating an interference effect). The interaction between consistency and instructional set seemed to indicate that at the global level there was no interference from the local level, but at the local level

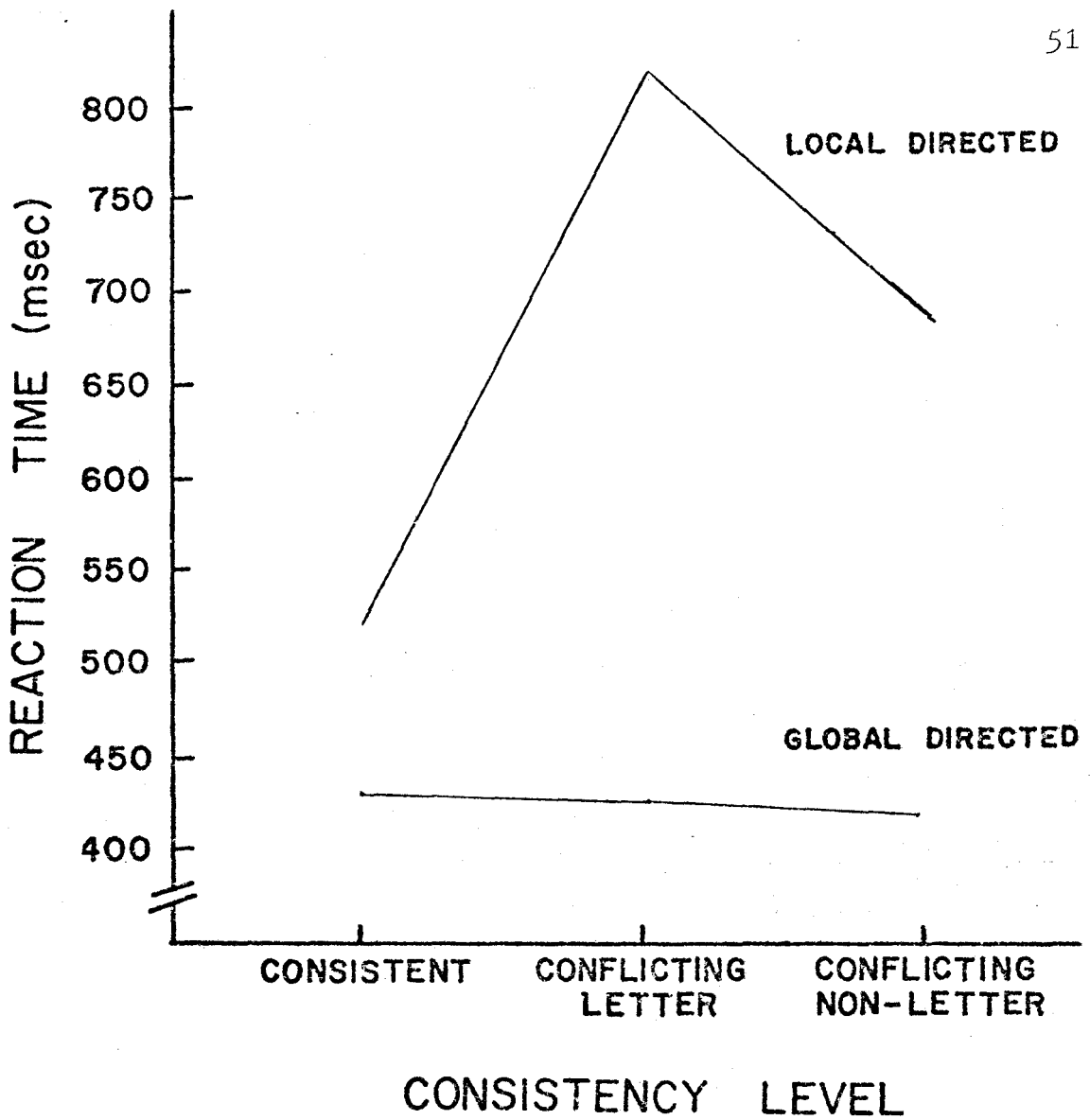


Figure 14. Mean reaction times for correct responses as a function of consistency level and attentional instructions (Experiment 4).

there was a large degree of interference from the global level. The results from this study alone would serve to strongly confirm a global precedence model of the order of visual processing. The results in light of the results of the previous three studies seem to indicate something quite different. This will be further discussed in the following section.

It was again felt that there was not enough information available to pursue the idea of differential interference effects (with respect to the different types of conflicting stimuli) and that this should be looked at in greater detail in a future study before discussing possible implications.

GENERAL DISCUSSION

Of major interest to the investigator was the way in which the results of this series of studies formed a new bulk of information with respect to the order of visual processing. Each study, taken alone either served to support or weaken a global precedence model of processing. When taken together however, they lend insight into a new way of looking at this type of information processing.

In Experiment 1 stimuli were presented to subjects at a central location. They were one of two possible sizes and either consistent or conflicting (with respect to the local and global levels of information). Subjects were asked to attend to either the local or global level of information. It was found that neither the instructions, the size of the targets, nor the consistency level produced significant differences, but that there was a significant crossover interaction between size and instructional set. This finding was not surprising. On the local level, large stimuli were responded to more quickly than were small stimuli, on the global level, small stimuli were responded to more quickly.

Experiment 2 again presented stimuli at a central location. Stimuli were either consistent or conflicting

and were of one of two size ratios (the global size was held constant, the local size was varied). Subjects were again instructed to attend to either the global or local components of the targets. There was a significant difference between consistency conditions (consistent stimuli were responded to more rapidly than conflicting stimuli), a significant interaction between instructional set and ratio (under the global condition dense stimuli were responded to more rapidly than sparse stimuli, under the local condition the reverse was true), and a significant three way interaction between instructional set, ratio, and consistency level.

In Experiments 3 and 4, no aspect of the stimulus size was varied, therefore the location of the stimuli was randomly varied such that the targets appeared either immediately to the left or immediately to the right of the fixation point. This was done in order to prevent subjects from focusing on a small portion of the tachistoscope screen to identify the presented targets (when stimulus size was varied this strategy would not be successful).

Experiment 3 varied the stimulus set relative to the previous experiments. Subjects were asked to respond to the stimuli under one of two attention conditions

(global or local). Stimuli were either consistent or conflicting. The instructional set was significant, and the interaction between consistency and instructions was significant.

Experiment 4 was run in much the same way as Experiment 3. A new set of stimuli was introduced, but the variables were analagous to those in Experiment 3. The results were also analagous: the instructional set, the consistency level, and their interaction all produced significant differences.

Upon the analysis of the results of these four studies it became evident that the results of Experiments 3 and 4 more closely paralleled the results of studies confirming a global precedence model of processing than did the results of Experiments 1 and 2. This was somewhat surprising because the conditions of Experiments 1 and 2 were more similar to the conditions of other global precedence studies than were the conditions of Experiments 3 and 4. Upon closer scrutiny it appeared that about the only thing similar to previous global precedence studies in Experiments 3 and 4 and dissimilar in Experiments 1 and 2 was target location. Targets in Experiments 1 and 2 were centrally located, targets in Experiments 3 and 4 were located in one of two positions, and targets

in Navon's study were located in one of four possible quadrants.

On an intuitive level, target location may not seem to be a very relevant variable. However, the results of these studies suggest that it is a very significant determinant of the relevance of all other variables within a levels of processing study. When targets are centrally located, the center of the target falls on the fovea, regardless of the target size. When there is more than one possible location in which the target might be centered, the larger the target, the further the center the target is from foveal vision! It has been found that if you look directly at an object you see its fine details much more clearly (with foveal vision) than if an object falls on a peripheral location (Cornsweet, 1970). The target which is centered at the fixation point will also be centered on the subject's fovea, the target which falls in a location adjacent to the fixation point will fall on an area of the subject's eye that is peripheral to the fovea (the larger the stimulus, the more peripheral its center).

This factor of stimulus location will influence visual processing in two ways. First, the more central the target, the easier it is to perceive the local, detailed components of the stimulus (as the target becomes

more peripheral, the local components become more difficult to perceive than the global components - the acuity loss is not equal on both levels). It is easy to understand, therefore, why global targets might be responded to more quickly than local targets when they are in a peripheral location, but at the same speed when they are at a central location (as was evidenced in Experiments 3 and 4 versus Experiments 1 and 2). Secondly, it can be seen that as targets move farther and farther away from a central location they become more and more difficult to perceive overall (this increased difficulty is also a function of the increase of target size at a central location, but to a lesser degree). That is, as targets move away from a central fixation point, the "task difficulty" increases.

"Task difficulty" can be seen as a determinant of the relevance of all other variables. Within an easy task, one that has a low level of task difficulty, other variables do not seem to be very important. When a subject is asked to identify a target that is very clear to him, other factors such as opposing levels of information probably don't interfere too much. Within a task that has a high level of difficulty however, other variables seem crucial. Within an easy task, subjects can attend to that task and make the desired response, within a more difficult

task subjects seem to attend to other sources of information (as provided by other variables) in search of hints, as if they use all the help they can get. When subjects are asked to perform an easy task (such as identify a centrally located target) conflicting levels of information do not seem to interfere. When they are asked to perform a more difficult task (such as identify a peripherally located target) conflicting levels of information produce a great deal of interference.

It seems that the clearer, the easier, the task, the less relevance the task variables seem to take on; the more obscure, the more difficult the task, the more crucial the task variables are. Task difficulty can be defined in many ways, distance from the fovea is only one. It can also be defined in terms of overall target size, the size of the local target elements relative to the size of the global target elements, or the degree of target distortion.

It is felt that task difficulty is a valuable conceptualization with respect to a model of the levels of processing. Within an easy task it seems probable that global and/or local stimulus features are successfully processed (as determined by attentional instructions). Within a task that is high in difficulty however, it does not seem that a given level of information takes prece-

dence in any simple or consistent manner. It appears that the greater the task difficulty, the greater the probability that the precedence level is a function of all involved variables. Just which level takes precedence seems to be determined by how the task difficulty affects the stimuli. Stimuli which are obscure (difficult) on a local level will probably elicit global precedence performance. Stimuli which are obscure (difficult) on a global level will probably elicit local precedence performance.

A local-global precedence trade-off can be seen in experiments which manipulate the level of obscurity. On a low level, task difficulty was manipulated in Experiment 1 with respect to target size and in Experiment 2 with respect to target size ratio (a global-local trade-off was shown). On a much stronger level task difficulty was manipulated with respect to target location in Experiments 3 and 4. When targets are not centrally located, detailed analysis is difficult. Targets which were peripherally located provided for superior global analysis, and global precedence performance was exhibited. Hoffman's (1979) experiments in which he systematically varied the distortion of different levels of information within his targets (and thus systematically manipulated task difficulty) provide an excellent example of a precedence trade-off

as a function of task difficulty. When local levels of information were distorted (made "difficult") subjects exhibited a global precedence pattern. When global levels were distorted (made "difficult") a local precedence pattern was exhibited.

In summary, it is not believed that the complex process of perception by a human observer can be broken down into levels of processing or an order of processing in any simple or systematic manner. It is felt that a process as complex as this must be discussed in a much more general, descriptive way.

A conceptualization such as task difficulty provides a way in which to discuss the combined effects of various involved variables. The influence of many different variables can be generalized in terms of how they affect an information processing task. The overall difficulty (or obscurity) of a task, as determined by any number of variables seems to dictate the "precedence" of given levels of information. The less "difficult" a level of information is to perceive, the more it stands out from other levels of information (regardless of what those levels are) and thus, the greater the probability that it will take "precedence".

REFERENCES

- Bouma, H. Visual recognition of isolated lower case letters. Vision Research, 1971, 11, 459-474.
- Broadbent, D.E. The hidden preattentive process. American Psychologist, 1977, 32, 109-118.
- Chaplin, J.P. & Krawiec, T.S. Systems and theories of psychology. New York: Holt, Rinehart & Winston, Inc., 1974.
- Cornsweet, T.N. Visual perception. New York: Academic Press, 1970.
- Estes, W.K. Interactions of signal and background variables in visual processing. Perception and Psychophysics, 1972, 12, 278-286.
- Estes, W.K. Redundancy of noise elements and signals in visual detection of letters. Perception and Psychophysics, 1974, 16, 53-60.
- Gilmore, G.C., Hersh, H., Caramazza, A. & Griffin, J. Multi-dimensional letter similarity derived from recognition errors. Perception and Psychophysics, 1979, 25, 425-431.
- Hoffman, J.E. Hierarchical stages in the processing of visual information. Perception and Psychophysics, 1975, 18, 348-354.
- Hoffman, J.E. Interaction between global and local levels of form. Journal of Experimental Psychology: Human Perception and Performance, 1980, 6, 222-234.
- Holbrook, M.B. A comparison of methods for measuring the interletter similarity between capital letters. Perception and Psychophysics, 1975, 17, 532-536.
- Kaufman, L. Sight and mind: An introduction to visual perception. New York: Oxford University Press, 1974.
- Kinchla, R.A. Detecting target elements in multidimensional arrays: A confusability model. Perception and Psychophysics, 1974, 15, 149-158.

- Kinchla, R.A. & Wolfe, J.M. The order of visual processing: "Top-down," "bottom-up," or "middle-out". Perception and Psychophysics, 1979, 25, 225-231.
- Lupker, S.J. On the nature of perceptual information during letter perception. Perception and Psychophysics, 1979, 25, 303-312.
- Lupp, L.U., Hauske, G. & Wolf, W. Perceptual latencies to sinusoidal gratings. Vision Research, 1976, 16, 969-972.
- Mayzner, M.S. & Habineck, J.K. Visual information processing of letters and non-letters. Paper presented at the meeting of the Psychonomic Society, Denver, Colorado, November, 1975.
- Martin, M. Local and global processing: The role of sparsity. Memory and Cognition, 1979, 7, 476-484.
- Navon, D. Forest before the trees: The precedence of global features in visual perception. Cognitive Psychology, 1977, 9, 353-383.
- Neisser, U. Cognitive psychology. New York: Appleton-Century-Crofts, 1967.
- Rumelhart, D.E. A multicomponent theory of perception of briefly exposed visual displays. Journal of Mathematical Psychology, 1970, 7, 191-218.
- Rumelhart, D.E. Introduction to human information processing. New York: John Wiley and Sons, 1977.
- Titchner, E.B. A textbook of psychology. New York: Macmillan, 1910.
- Townsend, J.T., Taylor, S.G. & Brown, D.R. Lateral masking for letters with unlimited viewing time. Perception and Psychophysics, 1971, 10, 375-378.
- Vitz, P. & Todd, T.Z. A model of the perception of simple geometric figures. Psychological Review, 1971, 78, 207-228.
- Wolford, G. & Hollingsworth, S. Retinal location and string position as important variables in visual information processing. Perception and Psychophysics, 1974, 16, 437-442.

Woodworth, R.S. & Schlosberg, H. Experimental psychology
(Rev. ed.). New York: Holt, Rinehart & Winston,
1954.

Yarbus, A.L. Eye movements and vision. New York: Ple-
num, 1967.

APPROVAL SHEET

The thesis submitted by Susan Gelmini has been read and approved by the following committee:

Dr. M.S. Mayzner, Director
Professor, Psychology, Loyola

Dr. R.W. Bowen
Assistant Professor, Psychology, Loyola

Dr. D.L. Holmes
Assistant Professor, Psychology, Loyola

The final copies have been examined by the director of the thesis and the signature which appears below verifies the fact that any necessary changes have been incorporated and that the thesis is now given final approval by the Committee with reference to consent and form.

The thesis is therefore accepted in partial fulfillment of the requirements for the degree of Master of Arts.

Oct 2, 1980
Date

Mal. L. Mayzner
Director's Signature