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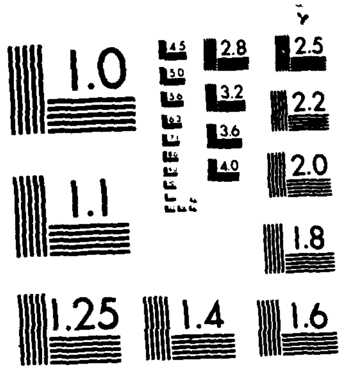


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The major effort in our laboratory was directed to investigate the ability of subjects to represent and use visual spatial location. One series of experiments was concerned with the effects of expectation of events(stimuli) at different spatial locations, on the performance of observers in different type of tasks. The results indicate that attentional effects(change in sensitivity) depend on the attentional instructions as well as on the complexity of the tasks. Another series of studies was carried out to assess the accuracy of perceived relative location as a function of visual vield eccentricity. The goal was to determine to what extend can human pattern recognition abilities be characterized as a translation invariant(after appropriate scaling) system. The results indicate that, although translation invariance does not hold, there are regularities in the data that give rise to interesting models of visual representation of distances. Another series of experiments was carried out to determine how people judge the direction of motion and how accurately they predict the final location of a moving target. The somewhat surprising results indicate

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# FINAL REPORT

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Grant no. AFOSR-84-03-08.

# FINAL REPORT

A comprehensive report of the activities and accomplishments over the funded period was included in a progress report submitted in the Spring of 1986. Since the funding period terminated shortly after, this final report will represent a summary of the activities reported earlier, amended by the results of the last six months. The major effort during the funded period had been setting up a laboratory for empirical research. The details of the laboratory facilities were described in the progress report and will not be discussed below.

## *Visual Persistence*

The goal of this study was to determine the persistence of briefly presented visual images. The experimental paradigm was based on the assumption that if the percept of an earlier flash is visible at the time a second flash is presented then an observer will see two objects simultaneously. The actual experimental task required human observers to judge simultaneous visibility of a number of sequentially displayed lines. The spatial position of these lines was such that most of the stimuli were perceived to be in apparent motion.

In this study, we were interested to determine whether previously obtained dependency of measured visual persistence on inter-stimulus distances would obtain in the new paradigm involving a linear instead of circular motion. The results confirmed the previous findings. In particular, visual persistence is reduced with increasing spatial proximity.

To examine the underlying mechanism of the spatial dependency, the results of the temporally offset stimuli were compared to simultaneously presented stimuli with varying intensity. We measured the relationship between the visibility of a stimulus and its spatial proximity to its neighbors. To the extent that this relationship is the same for simultaneously presented and for temporally offset stimuli, the same "gain control" mechanism may be implicated. The data from three experiments were analyzed and the results are described in a manuscript to be submitted to Vision Research. This work was done in collaboration with J. Farrell and G. Sperling.

*Spatial Attention*

Two research projects concerning visual spatial attention were carried out in our laboratory by C. Downing and S. Yantis. The objective of Steve Yantis' experiment was to determine the effect of attention on a difficult psychophysical task of vernier discrimination. On each trial, observers were shown up to four stimuli at different spatial locations. One of these was a vernier acuity target whose horizontal offset was to be judged. The remaining stimuli were distractors consisting of two vertical lines without horizontal offset. The observers were given varying amounts of information regarding the potential location of the target. Even though the task appears to be a difficult pattern recognition, our preliminary results indicate smaller effects of attention than was anticipated on the basis of other pattern discrimination studies. More data will be collected to confirm these results.

The two primary goals in Downing's experiment were 1) to examine the effects on attentional processes of spatial distance with all potential of retinal eccentricity; and 2) to determine whether and how attentional processes operate simultaneously at different levels of processing. She was especially interested to determine whether expectancy affects perceptual sensitivity or merely leads to changes in decision-making. Furthermore, it is unclear exactly how the effects of expectancy might be distributed over space and how this distribution might differ for different perceptual tasks. In order to examine these questions Downing asked her subjects to perform each of four perceptual tasks: luminance detection; brightness discrimination; orientation discrimination; and form discrimination. She manipulated the expectancy of target stimuli at different locations by providing a visual cue prior to each stimulus presentation and by presenting targets with different probabilities.

Expecting a stimulus at a particular location enhanced perceptual sensitivity for that location and also biased responses toward the expected stimulus type. Perceptual sensitivity fell off from that cued location according to a gradient over distance, such that the enhancement of sensitivity for stimuli at uncued locations decreased as they were farther from the cued location. There was no response bias for the uncued locations. The shape of the gradient of perceptual sensitivity was different for different perceptual tasks and for different stimulus configurations. For detection and brightness discrimination the gradient fell off less steeply than for orientation and form discrimination.

*Localization*

The following projects were initiated to investigate the perception of, and memory for, the location of objects. Accurate encoding and internal representation of spatial location are fundamental to our ability to recognize objects and to our interactions with objects in external space including locomotion through external space. We are particularly interested in how people form and use their expectations about spatial locations, and how they can utilize information from visual periphery.

*Location Judgments in the Visual Periphery*. H. Cunningham and I have been investigating the properties of vision in the peripheral visual fields. When an observer is required to align a movable stimulus ("cursor") vertically below or above another stimulus ("target") seen in the visual periphery (20-25 degrees eccentric), certain errors of alignment are made. These errors exhibit a bias that is consistent across subjects and suggests a distortion of visual space in the periphery. We are presently investigating whether the distortion in position judgments can be accounted for by a distortion in orientation judgments.

*Eccentricity Scaling*. In order to determine how an observer represents location information from periphery it is necessary to determine the availability of that information. In conjunction with the project described above we have investigated the ability of observers to make vertical vernier acuity judgments as a function of eccentricity and vertical separation. We are in the process of determining to what extent this function can be described by a simple dilatation (scaling) transformation.

*Vernier Discrimination after Saccades*. The eye movement control system requires accurate estimates of spatial locations of visual targets in order to produce accurate saccades. There is some evidence that saccade trajectories are influenced by non-target visual stimuli which are near the target, but studies reporting such effects are open to certain criticisms. When an observer is required to perform a precise visual judgment, under speed constraints, concerning a peripherally presented stimulus, the spatial accuracy of the oculomotor control system is pushed to its limits. A preliminary experiment, conducted under my supervision by Rebecca Moore, suggests that the saccade control system exhibits speed-accuracy tradeoff under certain conditions, and that non-target distractors are particularly powerful when speed requirements are imposed.

*Search*. Another way that spatial location is important occurs when a person searches for a signal in a visually noisy environment. Prior knowledge of probable target locations should be an important factor in determining a search pattern. On the other hand, other factors such as difficulty (or cost) or movement, must also enter into search path planning. Suppose an observer is given a probability distribution of a single target occurrence at different locations. How does the observer arrive at his strategy, and how close is this strategy to optimal? The goal of this project is to determine the extent to which perceptual and motor limitations, and probability information, influence this process. That is, what is the tradeoff between probability and cost of movement? At the present time, we are using a *manual scan* paradigm, varying probabilities and the *motor* costs of moving a cursor around the display screen. This research has obvious immediate implications for the design of computer-aided graphics and menu-based computer operations. But it also is serving as a prototype for studying the cognitive processes that go into making strategic choices.

*Orientation, Spatial location and Prediction of Motion*

Another way to study the problem of localization and its relation to the perception of orientation is based on human ability to extrapolate trajectories. Consider an observer confronted with an object moving along a straight line. His task is to make predictions about the location of the object at some future time. The position of that object at any given time provides only poorly constrained information as to where the object was at some past moment or where it will be at some future moment. Extrapolation of the trajectory must involve some ability to perceive and remember the past positions of the object and to construct a representation of the trajectory from this information.

An experiment has been performed that examined the performance in extrapolating a linear trajectory. Dot trajectories were varied using adaptive staircase design and the observer made a two-alternative forced choice response concerning whether the dot would pass to right or left of a probe location. Performance was surprisingly good and was consistent with a linear-regression model of trajectory extrapolation modified by temporal decay of information.

The performance on this task is directly comparable to a similar, static, task where the trajectory of the object is represented by a stationary, continuous line. Any decrement in performance on the motion extrapolation task relative to the static one must be due to the limits in ability to assess orientation by integrating location information over time or integrating motion detectors. This follows from the fact that orientation information is not present directly in any one frame of the moving stimulus and must be inferred by the observer. In order to interpret our results, the ability to extrapolate linear motion must be compared to orientation judgments. We, therefore, began a series of experiments to determine observers' ability to extrapolate stationary lines. In that situation the observer has the orientation information available directly in the stimulus.

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# FINAL REPORT: ADDENDUM

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Grant no. AFOSR-84-03-08.

## ABSTRACT

The major effort in our laboratory was directed to investigate the ability of subjects to represent and use visual spatial location. One series of experiments was concerned with the effects of expectation of events (stimuli) at different spatial locations, on the performance of observers in different type of tasks. The results indicate that attentional effects (change in sensitivity) depend on the attentional instructions as well as on the complexity of the tasks. Another series of studies was carried out to assess the accuracy of perceived relative location as a function of visual field eccentricity. The goal was to determine to what extent can human pattern recognition abilities be characterized as a translation invariant (after appropriate scaling) system. The results indicate that, although translation invariance does not hold, there are regularities in the data that give rise to interesting models of visual representation of distances. Another series of experiments was carried out to determine how people judge the direction of motion and how accurately they predict the final location of a moving target. The somewhat surprising results indicate that the judgement of moving targets yield similar accuracy as those with static stimuli. The implication is that such judgements are performed at a highe· level of stimulus representation. The last group of experiments investigated transformations of the mapping between visual and motor spaces. Movement under transformed mapping can be modeled as a solution of simple differential equations incorporating the properties of the transformation.

## Manuscripts in Preparation

Pavel, M., Cunningham, H. and Stone, V. Prediction of Linear Motion. To be submitted to Vision Research. Portions presented at ARVO, 1985.

Farrell, J.E., Pavel, M., and Sperling, G. The Visible Persistence of Stimuli in Stroboscopic Motion.

Downing, C. J. Expectancy and Visual-Spatial Attention: Effects on Perceptual Quality and Decision Making. Submitted to J. Exp. Psych.: Human Perception and Performance.

Cunningham, H. and Pavel, M. The Effects of Eccentricity and Gap Size in a Vernier Acuity Task. In preparation for VISION RESEARCH. Portions presented at ARVO, 1986.

Cunningham, H. Motor Performance under Transformed Visual-Motor Mappings.

Cunningham, H. and Vardi, I. A Differential Equation Model of Motor Performance Under Transformed Visual-Motor Mappings. Presented at Interdisciplinary Conference, Jackson Hole, 1987.

Pavel, M. and Cunningham, H. Signal Processing Methods Applied to the Analysis of Movement Trajectories.

Cunningham, H. and Pavel, M. Characterizing Movements in Time and Space.

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