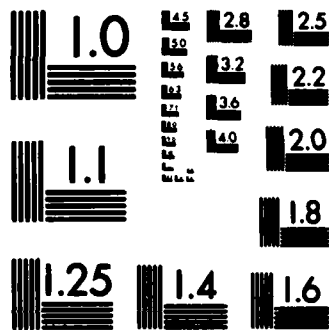AD-A172 254   VISUAL MOTION PERCEPTION AND VISUAL ATTENTIVE PROCESSES   1/1
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Visual Motion Perception and Visual Attentive Processes:

George Sperling, New York University

Final Progress Report, Year 5 (30 September 1984 to 29 September 1985).

Grant AFOSR 80-0279, Life Sciences Directorate

The main activities in the fifth year of this grant have been carrying out the experimental research set forth in the proposals (1980,1984), following up promising leads that developed in the course of this work, and preparing manuscripts for publication.

(1) Laboratory facility. All the necessary equipment and facilities were fully functional during the current grant year. Early in the year, there was a problem in maintaining required environmental temperatures in the present computer room; NYU provided a water-cooled air cooler and the requisite plumbing connections to the University's chilled water supply.

A major purchases was made of an Adage Image Processing system as authorized by AFOSR. The Adage system required more space and more electric power than was available in the present computer room. NYU provided an additional room to house the Adage (and the other computer equipment). The requisite electrical, plumbing, and interior renovations are underway. Program development for the Adage has been underway and the Adage is expected to be functional as soon as it can be installed.

(2) *Personnel.* The following have been retained to work on this project.

(a) George Sperling (principal investigator) Ph.D. in Experimental Psychology, Harvard, 1959. During the current year of funding, Sperling charged 0.25 of academic salary to this grant during the 9 month academic year. Sperling also worked full time for three months of the summer on this project.

(c) B. A. Dosher (consultant). B. A. Dosher, an associate professor at Columbia University, who spent last year working full time on this project, continues to make an important contribution as a consultant working one day per week with extra time during vacation periods and the summer. Her previous year's project on depth perception was completed, and the report was accepted for publication by Vision Research. She is continuing empirical and theoretical studies of the cues that aid in the recovery of 3D structure from dynamic 2D displays.

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19. ABSTRACT (Continue on reverse if necessary and identify by block number)

During the past five years, numerous publications have documented research findings in several distinct topics related to human sensory and perceptual performance. These topics include: bandwidth compression of images, models of motion detection, models of stereopsis, perception of depth, models of visual attention, and auditory memory. Details of these studies are too numerous for elaboration here.

20. DISTRIBUTION / AVAILABILITY OF ABSTRACT ☒ UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT. ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION UNCLASSIFIED

(d) Giselle Melendez worked full-time on this project to carry forward the administrative secretarial, clerical, and related tasks, aided by a various part-time assistants during the year: Carlos Santiago, Inna Bleck, Nancy Ho.

(d) Roman Yangarber (programmer). Our perennial undergraduate computer science student worked half-time during the year.

(e) Michael S. Landy was appointed assistant professor in the NYU Psychology Department at the beginning of the current year. Although he is not paid by this grant, he continues to work collaboratively with us in writing up previous joint research, advising us on computer related matters, and he is collaborating on structure-from-motion studies. Landy received his B.S. in computer science from Columbia University in 1974 and his Ph.D. in computer science from the University of Michigan in 1981.

(f) Barry J. Schwartz (consultant). Schwartz was an MIT undergraduate and received his Ph.D. in the PI's laboratory at NYU in 1983. He completed his part in the preparation for publication of his work on depth perception; it still requires a few days of time from the PI to complete this long manuscript.

(g) Adam Reeves (consultant). Reeves received his Ph.D. in Experimental Psychology from the City University of New York in 1978, was a post-doctoral fellow at Bell Laboratories, and until April 1982, a full-time researcher at the Institute of Ergonomics (Human Factors) at University of Dortmund. He is Assistant Professor of Psychology at Northeastern University. Reeves has been collaborating with the PI on a gating model of attention shifts. A manuscript submitted for publication to Psychological Review in the previous year was received back twice with requests for additional material. It is now "in press". Reeves made several visits to NYU do discuss revisions and the progress of computer simulations being carried out at Northeastern U.

(h) Erich Weichselgartner (graduate research assistant, consultant). Weichselgartner continued to work briefly as a graduate research assistant before he received a Ph.D. from NYU in October, 1984. He accepted a research and teaching position at Regensburg University (his alma mater). He made two month-plus long visits back to NYU to finish manuscripts describing his earlier research here, and to present his findings at the Eastern Psychological Association. One ms describing work on visual persistence will be published in the December 1985 issue of the Journal of Experimental Psychology; another, with Adam Reeves and the PI, describing the work on the speed of attention shifting is being prepared for publication. Weichselgartner set up an experiment to test his improved method of measuring persistence. A bright undergraduate, Russ Swerdlow, will continue this research at NYU in Weichselgartner's absence.

(i) David H. Parish (graduate research assistant). Parish replaced the graduating Weichselgartner. He worked on three projects: (1) short-term recall of auditorily presented number strings; (2) comparisons of human and of optimum detectors for visual presented alphabetic characters; and he is beginning a project on the use of motion-derived information to reduced the channel capacity needed to carry dynamic visual images.

(j) Cathryn J. Downing (associate research scientist) Downing was a Phi Beta Kappa honors undergraduate at Yale and received her Ph D in Experimental Psychology from Stanford in 1985. She began work on this project in the last three weeks of the grant year. Her Ph D. thesis work dealt with the

spatial distribution of attention, and she will work with the PI on the attention projects of the proposal.

Charlie Chubb (associate research scientist). Chubb was a mathematics major as an undergraduate and received a Ph.D. in mathematical psychology under Jean-Claude Falmagne at NYU in 1985. Chubb began work in the last two months of the grant period, and will concentrate on the motion projects of the proposal. Both Chubb and Downing are accomplished programmers and already highly familiar with UNIX, the operating system in use at the laboratory. Downing's empirical and Chubb's mathematical abilities complement each other well; together, they make a powerful team and will make up for time period without a research associate.

(3) Experimental Research.

(a) Sensory-level phenomena in visual motion perception. Due to the inability to replace van Santen during this year, no mathematical work on sensory aspects of motion perception was carried out. One article giving an overview of previous work was prepared by the PI and is being published in Spatial Vision. A paper with van Santen was published that described the two-flash experiments and predictions, the relation of Reichardt models to general 3D Fourier models of motion, and the equivalence to the Reichardt model of two other (less-well worked out) theories of motion (Adelson and Bergen, Watson and Ahumada) that had previously been thought to be different.

(b) B. A. Dosher completed the study of the strength of stereopsis (the cue provided by the difference between the left- and right-eye images) measured with-and-against the strength of Schwartz's proximity luminance covariance (PLC) cue. The main results were: The strength of stereopis is enormous greater than PLC in static displays for all subjects. In moving displays that follow static displays, the previous static display governs the perception, at least initially, in the moving display. In moving displays without prior static preview, some subjects are governed only by stereopsis, others only by PLC and some by both. This very substantial difference in how different observers interpret that same display was quite surprising and was investigated further by a graduate student, Gloria Marks. A simple linear model, in which evidence for one perceived configuration or another is simply added, and the configuration with the greatest net strength is the one that is perceived (a "winner take all" model) offers an extremely efficient and accurate description of the data from an extensive cross-design experiment. The results are described in a manuscript that has been accepted for publication by Vision Research. A graduate student, Stephen A. Wurst, supported on an NYU teaching assistantship, assisted in this project.

(c) The structure-from-motion research described above asks the question: "Given that several perceptual 3D-configurations are computed, how is a decision reached as to the strongest?" This question is being approached in two ways. (1) Theoretically, Dosher and the PI have proved some interesting properties of orthographic and perspective projections relative to energy map descriptions. The conclusion is that the human visual system must be incorporating knowledge about perspective directly into the structure-from-motion computation contrary to the current theories of Ullman and others. (2) Dosher, Landy, and the PI are engaged in a continuing empirical study of how the number and arrangement of points in dynamic display contributes to the perception of rigidity and of other aspects of structure. Three-dimensional objects were

composed of random dots scattered on their surface or within their interior. These two kinds of objects were rotated and displayed (in 2D projection). Subjects judged displays for the amount of perceived "coherence" (unitary object versus separate objects), "rigidity", and "depth". The number of dots, perspective, type and size of object were varied. All three judgements increased with number of dots. Interestingly, interior points produced as much or more apparent depth as surface points, but did not effect other judgements. The data are quite complex; experimental and analytic work is continuing. Obviously, the observed complex interactions constrain models of the recovery of structure from motion; just how is not yet clear.

(d) The reaction-time for shifting visual attention (Weichselgartner). Weichselgartner, Reeves, and the PI finished the manuscript and sent it for publication. In the course preparing the ms, careful analyses were made of other recent studies that purported to find evidence for continuous vs discreet theories of attention movement. Such serious methodological and analytic flaws were uncovered that we conclude that none of the previous evidence has any pertinence to this matter. Our conclusion is that attention shifts at a rate independent of the spatial distance traversed, i.e., in quantized jumps. This is because an independent measure of detection time obtained via a concurrent motor response task, shows that distance-related attentive effects also appear in the motor task and are therefore properly assigned to the detection process, not to the velocity of attention. Also, visual obstacles placed in the path of moving attention have no affect whatsoever on the attention shift. Thus, attention does not sweep, it jumps.

(e) Two attention glimpses. (Weichselgartner) This research represents a monumental effort by Weichselgartner. (A brief summary of the work was presented in last year's progress report.) A full manuscript describing this work, Weichselgartner's Ph.D. thesis, is appended to the present report. Weichselgartner and the PI will attempt a long-distance collaboration to prepare this work for publication in the coming year.

(f) Continuous measurement of visible persistence (Weichselgartner). A manuscript describing the work was prepared, submitted for publication, revised, and will appear in the Journal of Experimental Psychology. The method used so far requires the subject to decide whether an auditory click occurred before or after two adjacent, dynamically varying patches of light matched in intensity. An alternative method in which the subject decides which of the two patches is brighter at the instant of the click has certain theoretical advantages, is easier to describe, but seems not to be easier for the subject. During a visit to the laboratory in August, Weichselgartner prepared a experiment to further investigate this method. During the coming year, R. Swerdlow, an undergraduate science major at NYU, will attempt to run this experiment with assistance of R. Yangarber (programmer).

(g) David Parish completed an empirical study of auditory memory for digits, pseudodigits, letters, and pseudoletters. He investigated two questions: (1) To what extent digits and letters were recalled better than pseudodigits and pseudoletters that were phonemically identical; (2) to what extent recall of pseudocharacters could be improved by practice and by particular training methods. He found that pseudocharacters (pseudoletters or pseudodigits) suffered about 1.5 items in recall of short lists relative to letters or digits. This effect of "familiarity" of the real letters and digits in short-term memory is over and above any effect of acoustic confusability, which also is another important

determiner of memory. Indeed, by selecting a set of letters that were optimally discriminable acoustically, Parish found, for the first time, that a set of letters could be recalled almost as well as a set of digits. Previously, letters had always been less well recalled than digits. The various training methods he used, however, did not diminish the difference between pseudodigits and digits. This inability to improve performance with pseudodigits replicates the PI's earlier observation made with much less training and practice. The resistance of pseudodigits to improvement is quite remarkable because the tests for improved recall were quite sensitive. This suggests that there is a strong practical reason to choose familiar items in recall tasks --their recall advantage will persist even after extended practice of the new items.

A long manuscript on the bandwidth limitations in visual communication of American Sign Language was completed and accepted for publication by Computer Vision, Graphics and Image Processing. This was joint work with Michael S. Landy, M. Pavel and Y. Cohen. The original work was supported by the NSF without any USAF participation; the preparation of the manuscript was, in part, supported by the USAF and is acknowledged in the publication. This work demonstrates that by suitable visual codes, ASL can be communicated at bandwidths and bit-rates comparable to those used to communicate acoustic speech. Whereas previously it had been thought that a picture was worth a thousand words (4,000,000 Hz for TV, 3,000 Hz for telephone), the ratio has come down to nearly 1 to 1. Furthermore, the work compares many of the the known (and some new) methods of image compression and of code compression with a dependent variable (intelligibility) that is more useful than previous measures of image quality.

(h) Theoretical work on attention. (i) With Adam Reeves, consultant, The manuscript describing the "Gating Model of Attention" was revised and accepted for publication in Psychology Review. Theoretical work with Reeves on the simulation of gating attention models continued.

(j) With B. A. Dosher, Consultant. The long chapter on *Stratergy and Optimization in Human Information Processing* required some time consuming revisions and proofing in the course of preparing it for publication in the Handbook of Perception and Performance. It is planned to further develop this subject matter into a stand-alone research/reference book.

(5) (a) Manuscripts published and submitted for publication during grant period, 1984-85.

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