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1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE 7/25/95	3. REPORT TYPE AND DATES COVERED Final 6/1/92 - 5/31/95		
4. TITLE AND SUBTITLE (FY91 Assert) Interdisciplinary Training in Life Sciences		5. FUNDING NUMBERS FA9620-92-J-0260 61103D 3484/S4 AFOSR-TR-95 0527		
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9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) AFOSR/NL Attn: John Tangney, Ph.D. 110 Duncan Avenue, Suite B115 Bolling AFB DC 20332-0001			10. SPONSORING/MONITORING AGENCY REPORT NUMBER MD 911002-8330-360201	
11. SUPPLEMENTARY NOTES				
12a. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited.		12b. DISTRIBUTION CODE G		
13. ABSTRACT (Maximum 200 words) This grant supported interdisciplinary training (psychology, neuroscience and computer science) of a graduate student (Julie Epelboim), who earned a Ph.D. in Psychology by participating as a graduate Research Assistant on AFOSR Grants 91-0124 & F49620-94-1-0333, entitled "Coordinated action in 3-D Space". Epelboim's doctoral thesis: "Cognitive and Motor Coordination in Visuomotor Tasks", was successfully defended on July 17, 1995 (Ph.D.-degree will be conferred December 1995). The problems studied during AASERT training derived from objectives of the "parent" grants, namely, the test of alternative hypotheses about the control of gaze-shifts associated with arm motions, when an unrestrained, seated subject manipulated objects within arms's reach. Two different mechanistic models had been proposed, namely, (a) an "on-line" feedback model and (b) a "'single packet" model that based accurate gaze control on pre-planned patterns of coordinated movements of the head and eyes. Tests of these alternatives led to support for the first. The second problem studied the speed and accuracy of visually-guided hand movements and the correlation of these performance measures with binocular gaze-errors. Much more is now known about this problem thanks in no small measure to Epelboim's contributions. Epelboim's contributions earned her first authorship in a number of important publications.				
14. SUBJECT TERMS Training, neuroscience, cognitive science, psychology			15. NUMBER OF PAGES 5	
			16. PRICE CODE -	
17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT UL	

Objectives: This grant supported the interdisciplinary training (psychology, neuroscience and computer science) of an advanced graduate student (Julie Epelboim), who earned a Ph.D. in Psychology by participating initially as a graduate Research Assistant on AFOSR Grant 91-0124, entitled "Coordinated action in 3-D Space" and continuing on AFOSR Grant F49620-94-1-0333, entitled "Coordinated Action in 3-D Space II". Her doctoral thesis entitled: "Cognitive and Motor Coordination in Visuomotor Tasks" was successfully defended on July 17, 1995 and the Ph.D. degree will be awarded in December 1995. The problems she studied as part of her training were derived from the objectives of the "parent" grants to which the AASERT support was added. There were two main objectives in the parent grant.

First, it tested alternative hypotheses about the mechanism that controls the gaze-shifts associated with arm motions, when an unrestrained, seated subject manipulates objects within arms's reach. Two quite different mechanistic models had been proposed, namely, (a) an "on-line" feedback model and (b) a "single packet" model that bases accurate gaze control on pre-planned patterns of coordinated movements of the head and eyes. Experimental test of these alternatives led to support for the first alternative. Details can be found in an appended preprint by Epelboim *et al.* (in press) "When Push Comes to Shove: Compensation for passive Perturbations of the Head during natural Gaze-shifts."

The second thrust is to study the speed and accuracy of visually-guided hand movements and the correlation of these performance measures with binocular gaze-errors. In general terms, how well must you fixate a 3-D pattern of targets as you execute a visually-guided arm movement rapidly and accurately while moving naturally in 3-D space and performing a task that requires a sequence, rather than a single, visually-guided arm movement?

Little was known about these problems because, until recently, it had not been possible to measure binocular gaze-errors accurately as a subject manipulates nearby objects in 3-D space with the head and torso free to move naturally. Advancing knowledge in this rather technical research area requires developing expertise in the areas included in Epelboim's AASERT training program, which has been designed so as to contribute to the goals of the parent grant and at the same time prepare her for a productive career as a research scientist during the next 3 or 4 decades.

More is now known about the coordination of head, eye and arm movements thanks in no small measure to Epelboim's contribution to this aspect of the parent grant (see the appended preprint : Epelboim *et al.*, in press, "The Function of Visual Search and Memory in Sequential Looking Tasks").

Summary of Activities as an AASERT student:

(1) Epelboim, collaborating closely with Kowler (a co-PI on the parent grant), published a series of experiments, showing quite clearly that the low velocity oculomotor control subsystem (slow control) is not position sensitive and seems, therefore to be responsible for minimizing drift velocity exclusively (contrary to claims that have been made).

This work satisfied Epelboim's "masters or research competency" requirement and, in conjunction with her completion of all required course-work, advanced her to our "doctoral program". A manuscript describing this work was accepted by Vision Research in July of 1992 and appeared in the February 1993 issue of this prestigious journal where it filled 19 pages in a journal in which the modal article length is only 8 pages. Only 11 of the 200 full length papers published in Vision

Research during 1992 and 1993 were longer. So, this was not a minor contribution to the field and it served to establish Ms. Epelboim as a very promising addition to the human oculomotor specialty.

(2) Epelboim, Booth & Steinman continued working on the reading research reported at the 1992 ARVO Meeting and described in the 1992 Technical Annual Report of the parent grant. Working in this area served to give Epelboim in-depth training on an important, traditional area in cognitive science, one of the goals of this AASSERT grant. A very long (31 pages) paper covering this very provocative work was published in Vision Research. This paper encouraged Rayner & Pollatsek to attempt a critique that was accepted by this journal after revision. In their critique, they tried to find fault with our main conclusion, viz., that word recognition, rather than spaces between words, was the important guide for programming reading eye movements. The Rayner & Pollatsek critique and the Epelboim, Booth & Steinman reply are now in press in Vision Research. I expect this exchange, when coupled with our original and subsequent papers, will do a great deal to establish Epelboim's reputation as an unusually important young investigator. Two more papers on reading have been published in the Proceedings of the Cognitive Science Society and a third is currently being prepared for submission to Vision Research.

(3) Epelboim joined the laboratory with exceptional under- and post-graduate training in computer science, having received her B.S. with a joint major in Psychology/Computer Science at Carnegie-Mellon U. and having then worked for a year at the Computer Sciences Corp. as a programmer, specializing in expert systems. Her specialized training thus far under the AASSERT grant has, therefore been largely self-directed. It took the form of her developing an extensive library of eye/head/arm movement programs used to control experiments and collect data with our unique eye/head recording instrument (the MRFM) and also an elaborate program which runs in the SUN OpenWindow's environment we use to visualize and analyze recordings made on experiments central to the mission of the parent grant.

Epelboim has also taken a bit of advanced Computer Science course-work as an AASSERT student to meet her interdisciplinary requirement (i.e., courses in Connectionist Models and AI), but her main advanced computer science training to date has been via the development of advanced programming skills specifically related to projects of the parent grant where she will find her the research project that will provide the basis for her doctoral research in psychology.

(4) Epelboim's background in neuroscience was more limited than her background in computer science and psychology and her training in this part of her interdisciplinary AASSERT program has consisted so far of completing the 2 semester (8 credit) graduate course in the Fundamentals of Neuroscience offered by our Neuroscience Center, mainly under the auspices of our Department of Zoology. She received the grade of "A" for both semesters.

(5) Epelboim also passed her comprehensive exams for admission to "Doctoral Candidacy" during her first year on the AASERT grant. This exam includes a series of 15 public lectures on topics in her formal specialty area (Sensory and Perceptual Processes) with her examining committee attending or listening to tapes of all lectures and a subsequent oral examination. Her examining committee was quite complementary.

(6) Epelboim defended her thesis entitled "Cognitive and Motor Coordination in Visuomotor Tasks" on July 17, 1995. The first chapter of this thesis entitled: "The Function of Visual Search and Memory in Sequential Looking Tasks" is already in press in Vision Research with Epelboim as first author. The second chapter entitled: "Coordination of the Head and Eyes during Sequential Looking

Tasks" is currently being prepared for publication in this journal. Once again, Epelboim will be first author. The Ph.D.-degree will be conferred in December 1995 after which Dr. Epelboim will begin a postdoctoral collaboration with Prof. P. Suppes from Stanford University. Their project involves using the Maryland MRFM to measure the scanpaths of expert mathematicians as they solve problems requiring geometrical reasoning. The goal is to develop a mathematical model of the reasoning processes used by experts to solve geometrical problems of various types and difficulties. A description of this project is included in an Epilogue in her doctoral thesis.

Publications in Refereed Journals:

Epelboim, J. & Kowler, E. (1993) Slow control with eccentric targets: Evidence against a position-corrective model. *Vision Research*, 33, 361-380.

Epelboim, J., Booth, J. R. & Steinman, R. M. (1994). Reading unspaced text: Implications for theories of reading eye movements. *Vision Research*, 34, 1735-1766.

Pizlo, Z., Rosenfeld, A. & Epelboim, J. (1995). Exponential model of the time-course of size processing. *Vision Research*, 35, 1089-1107.

Epelboim, J., Steinman, R. M., Kowler, E., Edwards, M., Pizlo, Z., Erkelens, C. J. & Collewijn, H. (in press). The function of visual search and memory in sequential looking tasks. *Vision Research*.

Epelboim, J., Kowler, E., Steinman, R. M., Collewijn, H., Erkelens, C. J. & Pizlo, Z. (in press). When push comes to shove: compensation for passive perturbations of the head during natural gaze shifts. *Journal of Vestibular Research*.

Epelboim, J., Booth, J. R. Booth (in press) Much ado about nothing: The place of space in text. *Vision Research*.

Refereed Conference Proceedings:

Epelboim, J., Collewijn, H., Edwards, M., Erkelens, C.J., Kowler, E, Pizlo, Z & Steinman, R.M. (1994). Natural oculomotor performance in looking and tapping tasks. *Proceedings of the Cognitive Society*, 16, 272-277

Booth, J. R., Epelboim, J. & Steinman, R.M. (1994) The relative importance of spaces and meaning in texts. *Proceedings of the Cognitive Society*, 17.

Published abstracts:

Kowler, E., Pizlo, Z., Epelboim, J. & Steinman, R.M., 1990. Slow control is driven by velocity, not position signals. *Investigative Ophthalmology and Visual Science Supplement*, 31, p. 532.

Pizlo, Z., Rosenfeld, A. & Epelboim, J., 1991. Speed-accuracy tradeoff in a spatial-interval identification task. *Investigative Ophthalmology and Visual Science Supplement*, 32, p. 1272

Epelboim, J., Booth, J., Airey, D. & Steinman, R.M., 1992. Eye movements while reading unspaced text. *Investigative Ophthalmology and Visual Science Supplement*, 33, p. 1358.

Epelboim, J., Collewijn, H., Edwards, M., Erkelens, C.J., Kowler, E., Pizlo & Steinman, R.M. (1993) Coordination of eyes, head and hand in a natural 3-D tapping task. *Investigative Ophthalmology and Visual Science Supplement*, 34, p. 1502.

Epelboim, J., Collewijn, H., Edwards, M., Erkelens, C.J., Kowler, E., Pizlo & Steinman, R.M. (1994). Coordinated movements of arm and head increase gaze-shift velocity. *Investigative Ophthalmology and Visual Science Supplement*, 35.

Invited lectures:

Participated in a panel chaired by Prof. Dr. Han Collewijn, at the Neural Control of Movement meeting in Maui, HI, April 13-18, 1994. Name of the panel: *Coordination of eyes, head and hands in natural tasks.*

Presented a paper at the Conference on the Binocular Oculomotor Coordination and Plasticity sponsored by the Directorate General for Science Research and Development of the Commission of the European Communities, in Santorini, Greece, October 12-14, 1994. Title of the talk: *Head, Eye and Hand Coordination during Performance of Tapping and Looking Sequences.*

Presented a paper at the Head/Neck Conference in Vail, CO, July 2-6, of the Barany Society. Title: *Cognitive and Motor Coordination in Sequential Looking tasks.*

Participating Professionals:

Han Collewijn	Prof. Dr., Physiol. Erasmus U. Rotterdam
Mark Edwards	Asst. Prof., Physics, Georgia Southern U.
Julie Epelboim	Doctoral Candidate, Psyc., UMCP
Casper J. Erkelens	Prof. Dr., Biophysics, Helmholtz Inst., Utrecht U.
Eileen Kowler	Prof., Psyc., Rutgers U.
Zygmunt Pizlo	Asst. Prof., Psyc., Purdue U.
Azriel Rosenfeld	Prof., Cntr. Auto. Res. and Psyc, UMCP
Robert M. Steinman	Prof., Psyc., UMCP

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