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The work at the Columbia laboratory concentrated on two matters: (1) expansion of the work that began last year aimed at uncovering the laws of spatial summation between and within members of parallel line sets with regard to the influence on the setting of visually perceived eye level (VPEL); (2) to begin work on the separation of components of the body-referenced mechanism and to determine their separate influence on VPEL. The work on summation was reported at 4 presentations at professional meetings in 1992 (Abstracts 2, 3, 4, and 5) and a fifth set of experiments has been submitted for presentation in 1993 (Abstract 9). The completed experimental work on the body-referenced mechanism has been submitted for presentation in 1993 (Abstracts 6 and 9). In addition to the above, at Columbia we have begun work in which eye movements are being measured (scleral search coil technique) in conjunction with variation of visual field pitch with the first interest in determining whether a subject's setting of eye level to VPEL is differently influenced by the visual field than is the discrimination of VPEL.

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Report # 002

VISUAL PERCEPTION OF ELEVATION

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25 January 1993

Interim Report for Period 1 January 1992 - 31 December 1992

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Prepared for:

DIRECTORATE OF LIFE SCIENCES
Spatial Orientation Program
Program Manager: Lt. Col. Dan Collins
Department of the Air Force
Bolling Air Force Base, DC 20332

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PROJECT TITLE: VISUAL PERCEPTION OF ELEVATION

SPATIAL ORIENTATION PROGRAM, DIRECTORATE OF LIFE SCIENCES
PROGRAM MANAGER: Lt. Col. Dan Collins
DEPARTMENT OF THE AIR FORCE
BOLLING AIR FORCE BASE, DC 20332

PROGRESS REPORT: Jan. 1, 1992-Dec. 31, 1992

Principal Investigator: Professor Leonard Matin
Department of Psychology
Columbia University
New York, NY 10027

Date Submitted: Jan. 25, 1993

The work at the Columbia laboratory concentrated on two matters: (1) expansion of the work that began last year aimed at uncovering the laws of spatial summation between and within members of parallel line sets with regard to the influence on the setting of visually perceived eye level (VPEL); (2) to begin work on the separation of components of the body-referenced mechanism and to determine their separate influence on VPEL. The work on summation was reported at 4 presentations at professional meetings in 1992 (Abstracts 2, 3, 4, and 5) and a fifth set of experiments has been submitted for presentation in 1993 (Abstract 9). The completed experimental work on the body-referenced mechanism has been submitted for presentation in 1993 (Abstracts 6 and 9). In addition to the above, at Columbia we have begun work in which eye movements are being measured (scleral search coil technique) in conjunction with variation of visual field pitch with the first interest in determining whether a subject's setting of eye level to VPEL is differently influenced by the visual field than is the discrimination of VPEL.

The first experiment in the slow rotation room at Brandeis University been completed. The work has been submitted for presentation at ARVO (Abstract 7), and an article on this work is being written.

influences of pitched-from-vertical and slanted-from-horizontal 2-line visual fields on both VPEL and visually perceived straight ahead (VPSA) discriminations. This work has been submitted for presentation (Abstract 6). In addition, the first presentation of the dark adaptation work has been made (Abstract 1).

A great deal of time has been spent on writing and revising manuscripts for publication. The six manuscripts that are in preparation but have not yet had initial submission are not listed below. Theoretical work is continuing on both the Great Circle Model and on the model describing how stimulation from the visual field combines with inputs from the body-referenced mechanism.

In May 92, the PI visited the centrifuge facility at Wright-Patterson AFB to determine if extensions of the present research would be feasible at that facility. The facility appears to be well suited for research that would provide extremely useful information. The principal investigator has submitted a request for support for an initial experiment to be conducted there in Aug. 93, and, in addition, is including a request for support of the continuation of this work within a new proposal that is in preparation for submission shortly.

A copy of each of the 3 articles and 5 abstracts published in 1992 are appended to this report.

Publications: Jan. 1, 1992 -

Articles

1. Matin, L. and Li, W. (1992). Visually perceived eye level: Changes induced by a pitched-from-vertical 2-line visual field. Journal of Experimental Psychology: *Human Perception and Performance*. **18**, 257-289.

2. Matin, L. and Li, W. (1992). Mislocalizations of visual elevation and visual vertical induced by visual pitch: The Great Circle Model. In B. Cohen, D. Tomko and F. Guedry (eds.), Symposium on Sensing and Controlling Motion: Vestibular and Sensorimotor Function (Chapt. 20). *Annals of the New York Academy of Sciences*. **656** 242-265.

3. Li, W. and Matin, L. (1992). Visual direction is corrected by a hybrid extraretinal signal. In B. Cohen, D. Tomko and F. Guedry (eds.), Symposium on Sensing and Controlling Motion: Vestibular and Sensorimotor Function, *Annals of the New York Academy of Sciences*. **656**, 865-867.

4. Matin, L. and Li, W. (in press). Light and dark adaptation of visually perceived eye level controlled by visual pitch. *Perception and Psychophysics*.

5. Li, W., and Matin, L. (submitted for publication). Differences in influence between pitched-from-vertical and slanted-from-frontal horizontal lines on egocentric localization. Perception and Psychophysics.

6. Matin, L., and Li, W. (revision submitted for publication). The influence of the orientation of a stationary single line in darkness on the visual perception of eye level. *Vision Research*.

7. Matin, L., and Li, W. (submitted for publication). Spatial summation among parallel lines across wide separation (50o): spatial localization and the great circle model. *Vision Research*.

8. Matin, L. and Li, W. (submitted for publication). Bilateral parity violation in visual processing of egocentric spatial localization: With implications for the evolution of partial decussation. *Vision Research*.

Abstracts of Presentations at Meetings and Symposia

1. Matin, L. and Li, W. (1992). Light and dark adaptation of egocentric

spatial localization. *Inv. Ophth. & Vis. Sci.*, **3 3**, 959.

2. Li, W. and Matin, L. (1992). Linear averaging of the influences from 2 lines of different pitch or obliquity on visually perceived eye level. *Inv. Ophth. & Vis. Sci.*, **3 3**, 1154.

3. Li, W., and Matin, L. (1992). Rotation in depth of linear arrays of points systematically influences egocentric localization. *Bulletin of the Psychonomic Society*, **3 0**, 453.

4. Matin, L., and Li, W. (1992). Spatial summation of visual influence on egocentric localization: variations with eccentricity. *Proceedings in the Society for Neroscience*, **1 8**, 1397.

5. Matin, L., and Li, W. (1992). Egocentric spatial localization and summation among spatially separated lines. *Bulletin of the Psychonomic Society*, **3 0**, 439.

6. Dallal, N., Li, W., and Matin, L. (1993). Visually perceived eye level and straight ahead: influences from visual field pitch, visual field slant, observer orientation, and gravity. *Eastern Psychological Association.*

7. DiZio, P., Li, W., Lackner, J. R., and Matin, L. (submitted for presentation, 1993). Elevation of visually perceived eye level: combined influences of gravitoinertial force level (g) and visual pitch magnitude. *Association for Research in Vision and Ophthalmology.*

8. Li, W., and Matin, L. (submitted for presentation, 1993). Eye & head position, visual pitch, and perceived eye level. *Association for Research in Vision and Ophthalmology.*

9. Matin, L., and Li, W. (submitted for presentation, 1993). Spatial summation among parallel lines for visually perceived eye level. Association for Research in Vision and Ophthalmology.

10. Servos, P., Matin, L., and Goodale, M. (submitted for publication, 1993). Visually perceived eye level in a visual form agnosic. *Association for Research in Vision and Ophthalmology.*

e Association for Research in Vision and Ophthalmology

Investigative Ophthalmology & Visual Science

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LIGHT AND DARK ADAPTATION OF EGOCENTRIC SPATIAL LOCALIZATION.
Leonard Matin and Wenxun Li, Psychology Dept., Columbia Univ., NY

The development in light and decay in darkness of the influence of pitch on visually perceived eye level (VPEL) was measured in 3 experiments on 6 subjects. Measurements were made by requiring the subject to set the elevation of a small target to appear at eye level on the pitched wall facing him at 1 min intervals during 5 min of monocular light adaptation (LA) and 20 min subsequent dark adaptation (DA). During LA the visual field was pitched +20° (topforward) or -30° (topbackward) in separate sessions.

In Exp. 1 LA (right eye) was to a complexly-structured, well-illuminated visual field ("pitchroom"; avg 3.4 ml). Change of VPEL was essentially complete in less than 1 min following onset of LA; avg VPEL was 18.8° below true eye level (TEL) during -30° pitch, 12.2° above TEL during +20° pitch. Return of VPEL to asymptote in darkness, measured with the right eye, was exponential ($VPEL = a + be^{-kt}$) with avg time constants approximating 4 min.

In Exp 2 LA to the pitchroom at -30° was with the left eye; subsequent DA was measured with the right eye. The crossadaptation magnitude of VPEL change (b in above eq.) during DA was 85% of the magnitude in Exp 1, but time constants of decay were no different.

In Exp. 3, during LA the subject viewed 2 dim (0.01 ml) 64° long lines in darkness at 25° eccentricity on the pitched wall, one line on each side of the median plane. Avg deviation of VPEL from TEL during LA was 15.5° below TEL for -30° pitch and 13.5° above TEL for +20° pitch. Decay during DA was exponential with time constants approximately 0.6X the values during adaptation to the complexly-structured, well-illuminated visual field.

The loci of adaptation and storage will be discussed.

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LINEAR AVERAGING OF THE INFLUENCES FROM 2 LINES OF DIFFERENT PITCH OR OBLIQUITY ON VISUALLY PERCEIVED EYE LEVEL.
Wenxun Li and Leonard Matin, Psychology Dept., Columbia Univ., NY

The elevation of a target set to visually perceived eye level (VPEL) changes linearly with the pitch of either a complexly-structured, well-illuminated visual field or a visual field consisting of only 1 or 2 lines in total darkness (ARVO'86, '89, Vis Res'89). In the 1st of the two present experiments VPEL was measured in the presence of 2 simultaneously-presented 64° long lines in darkness at 25° eccentricity from independently pitched planes, one on each side of the median plane. Each of the 2 lines was set at one of 7 pitches (±10°, ±20°, or ±30°, or 0° [erect]), and the 49 possible 2-line combinations were examined. VPELs were indistinguishable for all pairs with identical average-of-pitches (e.g., the -20°/+10° pair and the -30°/+20° pair); but VPEL increased linearly with the average-of-pitches. With the 1st line's pitch fixed, variation of VPEL with the pitch of the 2nd line was linear with half the slope obtained by varying the pitch of 2 lines with the same pitch.

In Exp. 2 oblique lines in an erect frontoparallel plane were experimentally set to stimulate retinal loci identical to those stimulated in Exp. 1. The obliquity of the lines was experimentally varied so that each of the 49 conditions paralleled a different one of the conditions in Exp. 1. The results were identical to those of Exp. 1 when stimuli were transformed to retinal orientation measure. The identity implies that influences from accommodation, from the difference in depth planes, and from retinal gradients of line width and light flux are uninvolved.

The Great Circle Model employs the linear averaging rule of combination to explain these and previous results.

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ABSTRACTS

SOCIETY FOR NEUROSCIENCE

22ND ANNUAL MEETING • ANAHEIM, CALIFORNIA • OCTOBER 25–30, 1992

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Part 2

Includes:
Key Word Index
Author Index

Abstract of 22nd Annual Meeting of Society for Neuroscience
Vol. 18, Part 2, Page 1397, November 25-30, 1992

587.7

SPATIAL SUMMATION OF VISUAL INFLUENCE ON EGOCENTRIC LOCALIZATION: VARIATIONS WITH ECCENTRICITY.

L. Matin* and W. Li,
Psychology Dept., Columbia Univ., New York, NY 10027.

The elevation of a target set to appear at visually perceived eye level (VPEL) varies linearly with the pitch of a visual field that is complexly-structured or consists of only 1 or 2 vertical lines (Vis Res'89, JEPHPP'92).

The influence on VPEL of the pitch of 1 vertical line of variable length was measured at 2 eccentricities (ecc), 5° and 25°; slopes of VPEL/Pitch functions increased exponentially w/length with space constants of 5° and 13°, respectively. For the shortest line (3°) pitch was 33% more potent at 5° ecc, but this predominance decreased and reversed with longer lines so that at 64° length the more peripheral stimulus was 55% more potent. Max. VPEL/Pitch slopes were 0.36 and 0.55 at 5° and 25° ecc, respectively. However, VPEL is uniformly more sensitive to retinal orientation of the parafoveal line than the peripheral line.

The relative effectiveness for egocentric localization of short and long lines in the parafovea as compared to the periphery and the variation in space constant is in a similar relation to that found for visual acuity and for V1 receptive field size. However, the 13° space constants for VPEL are at least an order of magnitude larger than is appropriate for visual acuity or V1 receptive field size, but they do correspond to receptive field sizes reported in MT, MST, and 7a. (Supported by AFOSR 91-0146)

BULLETIN
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(Continued on back cover)

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8:55-9:10 (9)

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Egocentric Spatial Localization and Summation Among Spatially Separated Lines. LEONARD MATIN & WENXUN LI, *Columbia University*—Visually perceived eye level (VPEL) was measured in the presence of either one or two parallel pitched-from-vertical lines symmetrically positioned around the median plane in darkness. Eighty-four combinations of pitch, line length, and location were investigated. The slope of the VPEL/pitch function increased linearly with length in the 3°-24° range examined. Summation of influences between line segments horizontally separated by 50° was as great or slightly greater than summation between coextensive line segments.

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Rotation in Depth of Linear Arrays of Points Systematically Influences Egocentric Localization. WENXUN LI & LEONARD MATIN, *Columbia University*—Two 64° long vertical arrays of equally spaced visible points in a frontoparallel plane were symmetrically positioned around the median plane (25° eccentricity) in darkness. Visually perceived eye level (VPEL) was measured at 63 combinations of array pitch (7 values) and number of points (NOP, 9 values). The slope of the VPEL/pitch function was linear and increased with NOP along a negatively accelerated exponential. For NOP = 25, the slope reached the value measured for two continuous 64° lines.