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The U.S. Army Aeromedical Research Laboratory Virtual Reality Vection System

Leonard Temme & Ryan Nagy

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14. ABSTRACT
This presentation describes and documents the USAARL Virtual Reality Vection System (VRVS), a versatile, inexpensive, tool to investigate and characterize vection as a form of spatial disorientation (SD). In aviation, SD refers to the potentially catastrophic situation in which a pilot fails to correctly understand the position, motion, direction, or attitude of the aircraft with respect to the Earth's surface. Vection is a form of SD that generates the feeling of movement in an individual who is not moving. Since vection can be reliably generated under controlled laboratory conditions, it is a convenient model of SD. The VRVS is described, including its components, software, hardware and user interfaces. Tests and evaluations conducted while creating the VRVS demonstrate that the system reliably provokes vection-based SD. The VRVS includes two complementary methods for quantifying the presence and magnitude of the vection illusion. The VRVS enables the simultaneous measurement of vection as well as symptoms of cybersickness.
Poster presented at the Military Health System Research Symposium, 14-17 August, 2023 in Kissimmee, FL.

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Vection, spatial disorientation, SD, aviation, virtual reality, cybersickness, visual illusions, motion, visually induced motion sickness

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The U.S. Army Aeromedical Research Laboratory Virtual Reality Vection System

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Background

Definitions

Spatial Disorientation (SD): In aviation, a pilot's failure to sense correctly the position, motion, or attitude of the aircraft with respect to the fixed coordinate system that the Earth's surface and the gravitational vertical provide. That is, you don't know where you're going relative to the surface of the Earth, so you're flying blind.

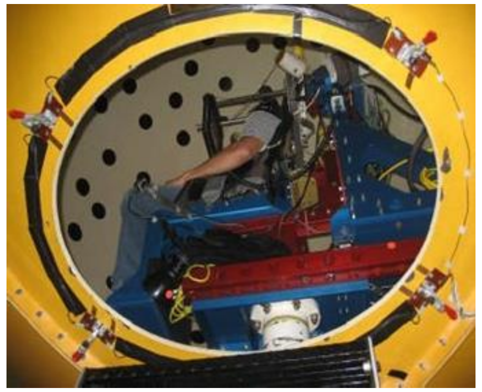
Vection: The illusion of self-motion in an individual who is not moving; hence vection is a powerful form of SD that can be reliably generated under controlled laboratory conditions. Thus, vection is a convenient model to study and characterize SD.

Virtual Reality (VR): The use of computer modeling, intersensory stimulation, and display technology to immerse an individual in an experience of a simulated environment that approximates reality.

Purpose

Create the Virtual Reality Vection System (VRVS), a versatile inexpensive tool to investigate and characterize vection as a model for SD.

Optokinetic Drum



Visual Vestibular Sphere Device

Varjo XR-3

Methods

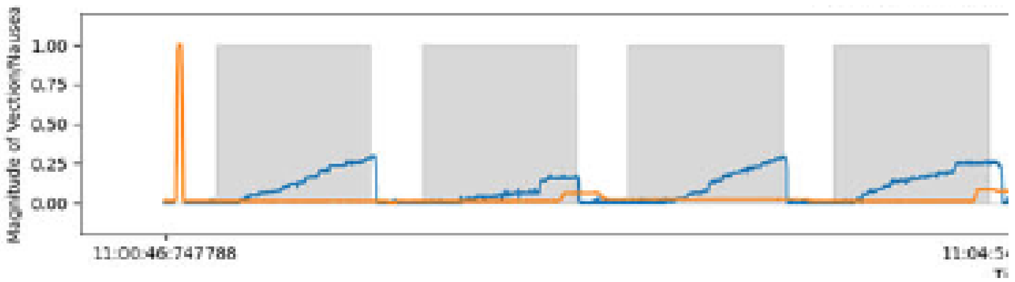
Approvals: The work reported here was conducted under an approved protocol determined not to be human research (USAARL # 2021-028).

Instrumentation: The companion poster, "The Response Slider: An Inexpensive, Microprocessor Controlled Linear Potentiometer for Acquiring Multivariate Magnitude Estimation Data," provides a detailed description of the VRVS software and hardware.

Research Plan: Study team members created the VRVS, and using two different paradigms, tested and evaluated its ability to generate vection. For both paradigms, the VRVS used the Varjo XR-3 VR headset to display solid, dark, circular dots on a lighter background. The dots were all the same size and contrast and slewed uniformly either to the left or right across the frontal plane.

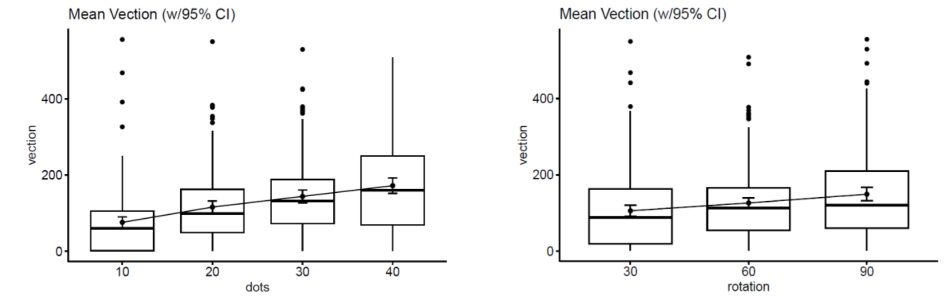
Results

Paradigm 1: Four evaluators rated vection using the kinesthetic sense to make Likert-type magnitude estimates with a linear potentiometer using one hand. Simultaneously, a measure of cybersickness was made with a second linear potentiometer using the other hand. The vection stimulus was 10, 20, 30, or 40 dots slewing at 30, 60, or 90 degrees per second (°/sec) for a total of 12 conditions, each presented for 45 seconds. The sequence of presentations was random.



The graph shows sample raw data from an individual vection evaluation. Magnitude of vection (blue) and cybersickness (orange) is plotted as a function of time. The spike at the beginning is the full range scale calibration. The gray shaded rectangles show vection stimulus timing. The duration of the stimulus is 45 seconds with a 15 second interval with no stimulus. Thus, about 4 minutes of the stimulus/response trace is displayed, which is half the duration of this trial. The dot density for these stimuli was 20, 30, 30, and 40, all with a 90°/sec velocity. The direction of motion alternated between stimuli.

Results Continued



Box plots summarizing the descriptive statistics of the 576 data points characterizing the effect on vection of dot density (left) and dot velocity (right). The regressions are statistically significant ($p < 0.01$).

Paradigm 2: The vection display contained 100 dots, of which 20, 50, or 80 dots slewed uniformly to the left or right, whereas the remainder of 80, 50, or 20 dots, respectively, moved at the same speed but in a random direction creating a random pattern to mask the appearance of vection. Three evaluators identified the presence of vection by pressing a button when it was present and releasing the button when it was absent. Simultaneously, the evaluators estimated vection strength using the method used in Test 1.

Box plots summarizing the descriptive statistics characterizing the effect of dot density on vection strength (left) and duration (right).

Discussion

1. The VRVS successfully generates vection.
2. The effects of VRVS stimulus density and velocity are as expected from the literature.
3. The VRVS enables, essentially, instantaneous manipulation of stimulus characteristics, thereby increasing research capabilities.
4. The methods reported here will be used in future studies of vection.
5. On one hand, vection is powerful experience, on the other hand it is an illusion that can be hard to define. The challenge of developing reliable, valid measures of vection remains.

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