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The Response Slider: An Inexpensive, Microprocessor Controlled Linear Potentiometer for Acquiring Multivariate Magnitude Estimation Data

Ryan Nagy, Keaton Meredith, Kevin O'Brien, & Leonard Temme

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14. ABSTRACT

The present report describes and documents a component of the USAARL Virtual Reality Vection System (VRVS). The VRVS is a versatile, inexpensive, tool designed to investigate and characterize vection as a model 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 motion in an individual who is not moving. Since vection can be reliably generated under controlled laboratory conditions, it is a convenient model to study, characterize, and demonstrate SD. The response slider is designed to record a measure of estimated vection magnitude as a function of stimulus duration.
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Vection, spatial disorientation, SD, aviation, virtual reality, cybersickness, visual illusions, motion, visually induced motion sickness

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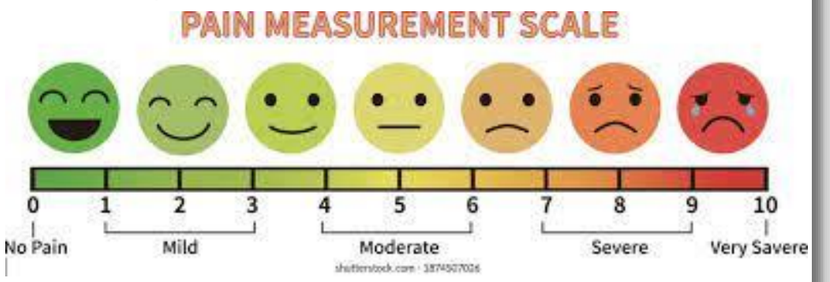
Introduction

Subjective magnitude estimation (ME) is among the most widely used methods for measuring psychological constructs. Early development of ME as a technique for quantifying sensory impressions is associated with Stevens (1951), who used ME and related methods to describe the functional relationship between the physical strength of a sensory stimulus and the magnitude of the subjective experience or sensation the stimulus evokes. Stevens characterized numerous different sensory modalities using the ME.

A great variety of methods implementing this ME strategy currently exist, for example:



This strategy is easily extended to a visual analogue scale in which the subject is provided a sheet of paper containing a line of defined length and the instruction to estimate a position on the line that is analogous to the magnitude of the specified perceptual dimension the stimulus occasions. The end points of the visual analogue scale are typically described as representing 0% and 100%, creating essentially a number line.

0 20 40 60 80 100

Visual Analogue Line

A common, widely used, influential example of a multivariate visual analogue-type response scale is the NASA Task Load Index (TLX) designed for operators to rate the magnitude of cognitive workload the performance of a task imposes.

Capability Description

The Response Slider (RS) is an inexpensive, hand-held mechanical version of the visual analogue scale that does not require the use of vision. The RS contains a microprocessor and linear analog potentiometer that enables the user to indicate the magnitude of a sensation such as discomfort, pain, fatigue, or some other internal state as a continuous response function. The RS is modular in that it can be expanded to support simultaneous recording of multiple response dimensions.

Methods/Technical Approach

Hardware & software: The RS is built on Arduino Nano 33 Bluetooth Low Energy (BLE) microcontrollers, L298 dual h-bridge motor driver breakout boards, and motorized linear potentiometers.

A plug connection provides direct current (DC) power, so the Arduino needs only a power outlet to function over BLE. The Arduino can also export data via a wired serial connection within ArduinoIDE or other pre-programmed serial monitors, but that capability is not used in the present application.

Software is edited preexisting BLE program code using Python's BLE platform Agnostic Klient (bleak) library, and the ArduinoBLE library to connect the RS to the computer for automated data acquisition.

RS Operation: The RS requires powering the Arduino and computer, running the Python acquisition program, and awaiting connection. Upon successful connection, the Arduino immediately starts blinking its onboard yellow light emitting diode (LED) at sampling frequency (20 hertz [Hz] by default), changes its status light to green, and sends RS information to the computer. Within five seconds of connection, 20 Hz output of analog to digital converter (ADC) values corresponding to RS position ranging from 0 to 1023 are broadcast from the Arduino into an automatically created comma separated value (CSV) file on the data acquisition computer. Commands can be given to the Python script to move the slider using its integrated DC motor, to change the sample rate, or to create a new CSV file.

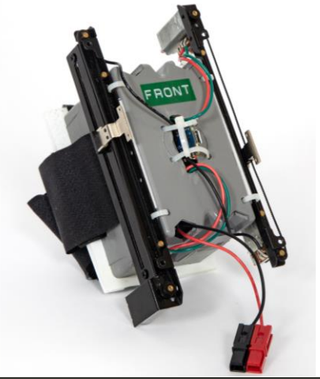
Security Special precautions, including a known naming scheme and media access control (MAC) address whitelisting, ensure that only known devices only can connect to known devices. If the RS attempts

Methods/Technical Approach Continued

to connect via the Python BLE script, the RS must be named in a standardized way. Using the device name is the first way the Python script verifies it is being connected to an authorized device. Unauthorized names are ignored. Assuming the Arduino's BLE chip is broadcasting an allowed name, and that the computer has the Arduino's MAC address saved and the Arduino's firmware has the computer's MAC address saved, they will attempt connection.

Results

The handheld RS to the left below contains a single potentiometer while the one on the right has a pair of potentiometers for providing two simultaneous ME responses. Both versions have a Velcro secured strap for fastening on the knee.



Applicability to Medical Roles of Care

The RS enables individuals to provide simultaneous quantitative multivariate responses without using vision and without distracting or disrupting other primary tasks or clinical exams that do require vision. In the present application, the magnitude of cybersickness symptoms is recorded simultaneously with the magnitude of the illusory experience of vection during visual virtual reality (VR) stimulation.

Significance & Developmental Status

The RS was developed as a response input device for the Virtual Reality Vection System (VRVS) that generates an essentially unlimited stimulus pallet to be presented under computer control on VR headsets such as the Vajo-XR3 to support the systematic study of vection. The VRVS and RS can be shared with Department of Defense partners.

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