INFORMATION PRESENTATION

Human Research Program - Space Human Factors & Habitability
Space Human Factors Engineering Project

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Abstract

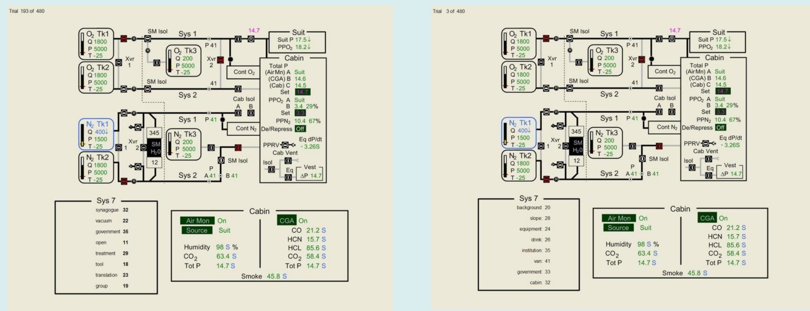
The goal of the Information Presentation Directed Research Project (DRP) is to address design questions related to the presentation of information to the crew. The major areas of work, or subtasks, within this DRP are: 1) Displays, 2) Controls, 3) Electronic Procedures and Fault Management, and 4) Human Performance Modeling. This DRP is a collaborative effort between researchers at Johnson Space Center and Ames Research Center.

Visual displays

Label Alignment and Label-Value Distinction

The purpose of the FY08-FY09 studies was to investigate the effects of label orientation and label alignment on visual search. FY08 studies looked at the effect of label orientation, alignment, label length, and wrapping of text on visual search in various display group sizes. To inform development of best-practice guidelines for label formatting, the study in FY09 examined the effects of the visual distinction of labels and values, label length, and label alignment on visual search times.

To inform development of best-practice guidelines for label formatting, the study examined the effects of the visual distinction of labels and values, label length, and label alignment on visual search times. After reading a target word, participants searched for its associated value in an array of eight label-value pairs embedded within an Orion-type display.



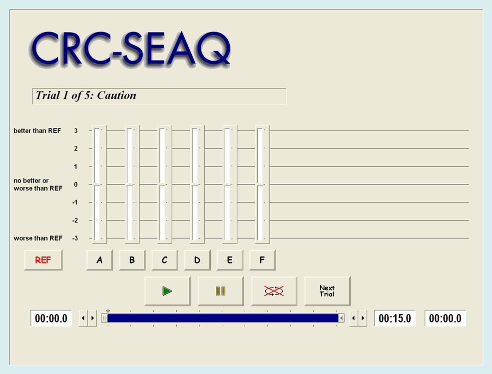
Examples of labeled data columns using left and data-alignment

The visual distinction of the label/value pairs did not significantly affect response times (RTs) in either uniform (all words were either short or long) or mixed displays, meaning the use of neither bolding nor colons affected RTs. Label length and label alignment, however, did alter RTs: short labels led to shorter RTs than did long labels in uniform and mixed displays and data-aligned labels resulted in shorter RTs than did left-aligned labels. Thus, to decrease RTs for finding a particular value in a display, one should use a short, data-aligned label in a mixed display.

Auditory displays

Alarms

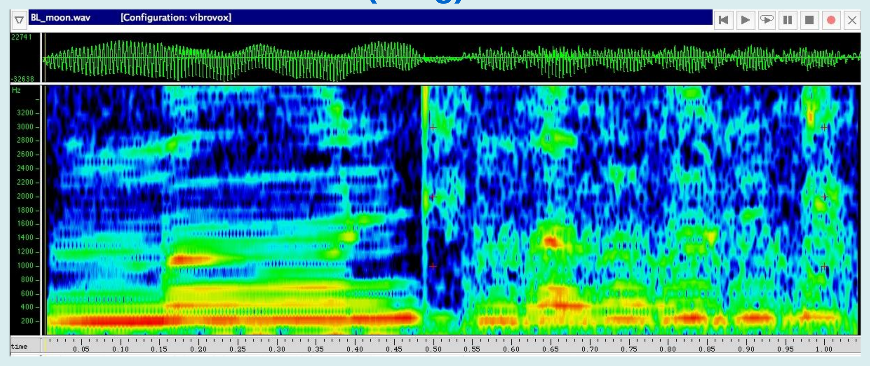
In this study alarms currently in use with NASA flight deck displays and proposed candidate alarms have been evaluated. Eleven non-crew and 3 crew subjects were asked to rate six candidate alarms in comparison to the current alarm for each category of alert used: caution, warning, fire/smoke, and depressurization. Five of the candidate alarms were based on the current alarm or a runner-up alarm sound from previous studies. The sixth sound included a speech component that gave specific information about the situation. The sound of choice for each category was also rated on perceived urgency level, overall satisfaction, and the perceived value of a potential speech component. The results show that the use of a speech component is preferred by both crew and non-crew.



Software user-interface used in the study.

VIBROVOX: Evaluation of speech communications under simulated launch vibration (0.7 g)

The potential effects of extreme acceleration and vibration during Ares-I launch scenarios may impact the crew's speech production. We studied the effect of 0.5 and 0.7 g whole body vibration on the speech production of words (using the standardized Diagnostic Rhyme Test word list). Six subjects were recorded in a supine position using a specially designed chair and vibration platform. Vocal warbling, pitch modulation, and other acoustic distortion were observed.

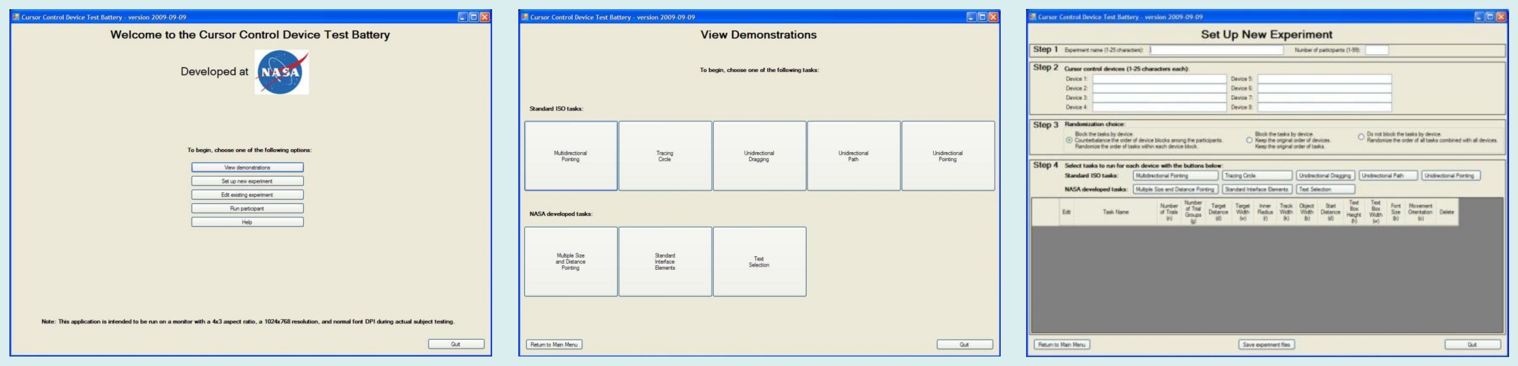


The effect of vibration can be seen by comparing the right and left halves of the graphs below. Under vibration, the voice's temporal waveform becomes "rougher" due to the addition of higher frequency vibrations and greater amplitude modulation. In the spectral plots (bottom), these effects correspond to interruption of the horizontal red and yellow lines (representative of acoustical energy at specific frequency regions). This temporal and spectral distortion under vibration results in perceptual effects (e.g., vocal warbling, pitch modulation) that may impact intelligibility.

Controls

Cursor Control Device Test Battery

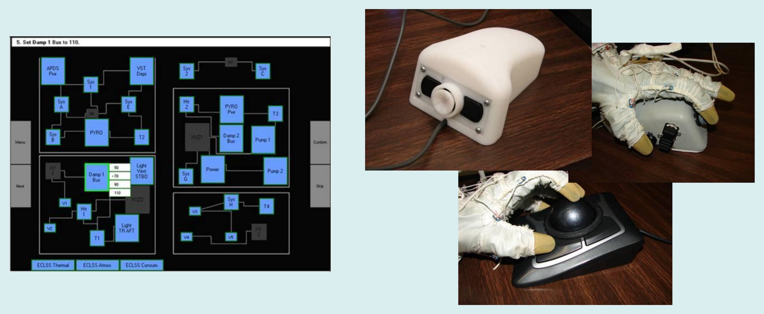
The cursor control devices test battery was developed in Visual Basic. Five tasks were based on ISO 9241-9 (2000). Non-ISO tasks that had been used in previous evaluations were also added, including a multi-size and multi-distance pointing task (Everett, Holden & Whitmore, 2005), a text selection task (Gillan, Holden, Adam, Rudisill, & Magee, 1992), and a new task that includes interaction with standard interface elements such as drop-down menus, sliders, and checkboxes. The test battery software captures pointing, tracking or dragging times, as well as the number and types of errors. Furthermore, parameters such as target size, pointing direction, and distance between targets are adjustable for all tasks.
In FY09 the test battery has been updated with a main menu that allows researchers to set up studies for multiple subject and devices. The user guide has been updated as well to reflect the changes.



Updated main menu, demonstrations ,and experiment set-up page of the cursor control device test battery.

Cursor Movement

The purpose of the FY09 study was to compare the performance of multiple discrete CCDs on an Orion-type display. Twelve participants used the display with four devices in 2-way mode and all but the rocker switch in 4-way mode with their left-hands in extravehicular activity (EVA) gloves. Tasks for each device consisted of three elements: main menu navigation, navigation to objects within the display, and commanding or selecting options for those objects. Response times, errors, and subjective ratings were collected for each device and mode combination.



Display and CCDs used in the cursor movement study

Vibration studies

Effects of Thrust Oscillation Vibration on Maintaining Situation Awareness and Assuming Manual Flight Control

Constellation Program (CxP) analyses indicate that the Orion crew vehicle will experience heightened vibration caused by thrust oscillation (TO) in the Ares-I launch vehicle just prior to first-stage separation. In 2009, an HRP-CxP jointly funded study examined the effects of TO vibration on the ability of thirteen Astronaut Office participants to maintain situation awareness of an evolving flight simulation and to then hand-fly the spacecraft shortly after the vibration had stopped.

On each trial, participants seated in a semi-supine chair were repeatedly exposed to vibration in the body x-axis (chest-to-spine direction). Participants made a speeded judgment as to whether the behavior of the pitch rate indicator, pitch needle, and predictor dots along the ascent trajectory line elements on a prototype Orion Primary Flight Display (PFD) provided consistent information, or, if not, which one of these three elements was inconsistent with the others. Two seconds after the vibration ended, participants provided joystick inputs to null PFD indicators of pitch and roll errors.

The ~5 s average time to complete the PFD indicator assessment task grew steadily as the magnitude of representative TO vibration was increased from the baseline vibration-free condition, slowing down by up to 10% for the study's maximum 0.7 g-peak vibration profile. At the same time, participants' ratings of PFD usability and task workload were significantly degraded at the highest vibration levels when compared with the baseline. Surprisingly, the post-vibration hand-flying task revealed a statistically significant six-fold growth (2.1% to 12.5%) in incorrect initial joystick inputs from the zero to 0.7 g-peak vibration conditions. These errors when they occurred, however, were quickly corrected with no other vibration aftereffects observed in the participants' manual flight control performance.

The results from this study guided CxP's establishment of vibration limits (i.e., launch and crew vehicle design requirements) to assure sufficient display usability by crew during periods of ascent thrust oscillation.

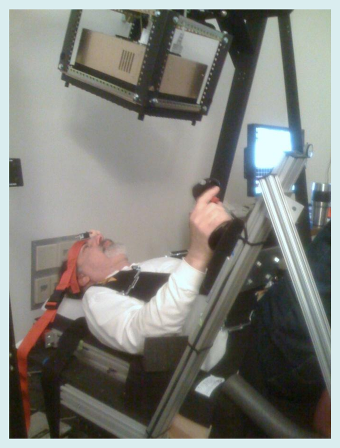
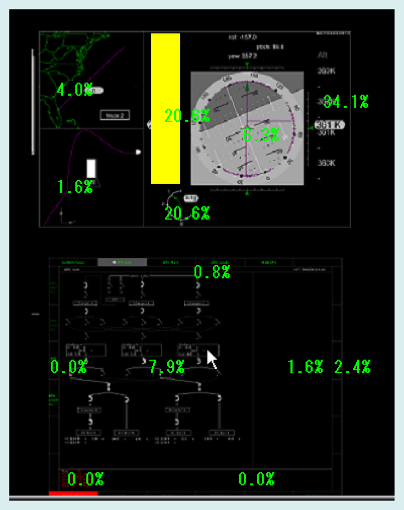


Figure 1. Semi-supine vibration seat occupant viewing display for PFD indicator assessment and post-vibration hand-flying tasks. Responses for both tasks are entered via the joystick.

Figure 2. Rapid Prototyping Lab's prototype Orion Primary Flight Display (PFD) showing pitch rate indicator, pitch needle, and ascent trajectory predictor dots for the indicator assessment task developed in collaboration with the Astronaut Office.

Fault management studies

We analyzed eye-movement data (collected during a previous human-in-the-loop Fault Management study) at a more granular level. This allowed us to subdivide originally identified "regions of interest" into more specific "areas of interest" corresponding to individual display elements, such as edge-key labels. We then used the temporal sequences of fixations to these areas of interest as input to develop a visualization tool. This tool allows us to visualize (given the current area of interest), the likelihood that each area of interest will be the next fixation target.



The Visualization Tool's next-fixation likelihoods, given the operator's current fixation (yellow bar) on the velocity tape of the Primary Flight Display (PFD). The operator is most likely to fixate next on the PFD's altitude tape (34.1%) or the g-meter (20.6%).

This tool feeds into SHFE's multi-year research effort to develop a human performance model capable of predicting completion times and completion accuracy for a wide variety of targeted spacecraft tasks, with a wide variety of user interface and human/machine functional allocation choices. The analyses of operator information acquisition patterns at this more detailed level, along with the ability to visualize those patterns, are enabling direct empirical comparisons between the information acquisition strategies of human operators and the strategies generated by the human performance model, as currently configured. Ongoing identification of systematic discrepancies between model-derived patterns and operator-derived patterns are informing and shaping model development efforts in 2010 and beyond.