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SUMMARY

The present study was designed to examine the human-computer interface for data entry while performing experimental procedures within a glovebox work volume in order to make a recommendation to the Space Station Biological Research Project for a data entry system to be used within the Life Sciences Glovebox. Test subjects entered data using either a manual keypad, similar to a standard computer numerical keypad located within the glovebox work volume, or a voice input system using a speech recognition program with a microphone headset. Numerical input and commands were programmed in an identical manner between the two systems. With both electronic systems, a small trackball was available within the work volume for cursor control. Data, such as sample vial identification numbers, sample tissue weights, and health check parameters of the specimen, were entered directly into procedures that were electronically displayed on a video monitor within the glovebox. A pen and paper system with a "flip-chart" format for procedure display, similar to that currently in use on the Space Shuttle, was used as a baseline data entry condition.

Procedures were performed by a single operator; eight test subjects were used in the study. The electronic systems were tested under both a "nominal" or "anomalous" condition. The anomalous condition was introduced into the experimental procedure to increase the probability of finding limitations or problems with human interactions with the electronic systems. Each subject performed five test runs during a test day: two procedures each with voice and keypad, one with and one without anomalies, and one pen and paper procedure. The data collected were both quantitative (times, errors) and qualitative (subjective ratings of the subjects).

The results showed no substantive quantitative differences between the two electronic systems for: time to complete the whole test run, time to complete the subtasks within each test run, or time to enter data into a field when no errors occurred. The time to complete the whole test run was slower in the Pen and Paper condition, compared to the electronic conditions, but was not different from the electronic systems for time to complete the subtasks and for data entry into a field (with no errors). The times for data entry into a field were similar in the Pen and Paper and the Keypad conditions (irrespective of the occurrence of subject or system problems or presentation of an Anomaly), and, in addition, were similar to the data entry times into a field when no errors or problems occurred. However, the times for data entry into fields when subject or system errors occurred in the Voice conditions was substantially longer than in the Keypad or Pen and Paper conditions.

The fewest number of errors occurred in the Pen and Paper condition; however, four of the five errors which occurred in the Pen and Paper condition were left uncorrected. The number of errors in the Manual and Voice conditions were higher than those in the Pen and Paper condition, and were similar to each other. In addition, virtually all the errors were corrected in both electronic data entry device conditions. There was no consistent effect of the anomaly on the frequency of total errors during the test runs. When the number of subject errors or system problems in the two fields immediately following a planned anomaly was examined, there was no effect in the Keypad condition. In the Voice condition, however, the number of errors/problems was greater under the anomalous condition. It appeared that the Voice system was sensitive to some additional level of stress produced by the anomaly. Error rates (the proportion of errors which were preceded by an error/event compared to the total number of errors/problems/events during a test run) were not statistically different across the entry device conditions.

When given a choice to use the electronic device (Keypad or Voice) or the trackball to move through the procedures, subjects used the electronic entry system approximately 65% of the time, in both the Keypad and Voice conditions, compared to using the trackball.

Data from the questionnaires showed an overall preference by the subjects for the electronic systems over the Pen and Paper system and a preference for the Keypad over the Voice system. Subjects ranked the electronic systems similarly, with a somewhat lower ranking for the Pen and Paper system. Subjects liked the "hands-free" operation of the Voice system, but felt more comfortable, familiar and confident with the Keypad system.

Despite considerable effort to acquire a voice system that would perform well with a short learning curve and perform free of errors, the Voice system displayed a considerable number of "wrong responses" and "no responses" to subject data entry. The recognition rate for essential utterances (numbers, "enter," "wake up," and "go to sleep"), not including "page up" and "page down" or "erase," during a test run, under the Voice Condition without Anomaly was 88.6% and for the Voice condition with Anomaly was 90.4%. When all possible data and command entries were considered, the voice system had an overall efficiency rating of 85%, with a range of 73% to 100%.

Overall, the results of this study show no substantive quantitative differences between the Manual Keypad and the Voice systems regarding times and errors during the performance of experimental procedures within a glovebox work volume, with the exception that errors committed by the test subjects showed a slight increase during the Voice with Anomaly condition. All these errors were corrected by the subject. Subjective evaluation of the data entry devices showed a preference for the Keypad over the Voice system, based primarily on familiarity and a lack of confidence with the system. More training time than was available in the study, combined with more practice with the Voice system, would likely have increased the subject preference for this data entry device.

It is likely that, in the next five to ten years, voice system technology will improve, and, at the same time, a larger population of users will become more familiar and comfortable with voice recognition systems. Nevertheless, the intent of this study was to evaluate electronic data entry device systems at the current level of technology so that a recommendation could be made now for a system to be incorporated in the development of the Space Station Life Sciences Glovebox. The qualitative data from the subject preferences and the quantitative data regarding voice system recognition and efficiency rates argue against a recommendation for a voice system in the glovebox development.

Recommendation:

In summary, the recommendation by the study team for an electronic data entry system to be used within the glovebox would be a Manual system, such as a keypad. The cost, development time, training time and potential non-universality of a voice system across a variety of international user imparts a level of difficulty into its implementation that is not found with a more conventional manual (keypad) type of system. In addition, the inherent characteristic of a voice system for "non-recognition" or "misunderstanding" of data entry conveys a risk regarding the necessity for accurate data entry during Space Station glovebox operations. Ultimately, redundant data entry systems must be employed in order to ensure accurate and reliable data entry under these conditions.

INTRODUCTION

The International Space Station marks the beginning of the next phase of non-human life sciences research in space. Experiments will be conducted that will more fully investigate the influence of gravity on living organisms. Activities to support this research will require the use of a glovebox within which specimens, including plants and animals and other organisms, can be manipulated, procedures performed, and experimental data collected and recorded. The glovebox provides a bioisolated work area within which these activities can take place.

For life sciences research currently being conducted on the space shuttle, experimental procedures are displayed in procedure books or on cue cards and data recorded by hand, using paper and pencil. However, this simple system has many drawbacks when long-duration missions such as those planned for the space station are considered. The protocols used and data collected would require a considerable volume of procedure books and data sheets and the data would not be available for months until their return to earth. Recognizing these drawback, the space station is evolving to a "paperless" environment where procedures will be displayed on video display terminals and experimental data recorded electronically and then transmitted to the ground.

In order to perform a thorough series of evaluations of equipment requirements for the glovebox, a full-scale prototype mockup of the hardware was constructed by the Space Station Biological Research Project. An initial experiment was conducted to compare operations (experimental and data entry) using a manual data input device (a touchpad) versus a voice system, using either one or two operators (1; Appendix, Document 18). The results of this study showed that the voice system used was faster for command inputs, while the manual system was faster for data entry. The second operator did not cut task time in half, but did decrease it considerably. There were more "correct responses" but also more "wrong data" entered using the manual system compared to voice input. In addition, there were fewer "no responses" and "wrong responses" associated with use of the manual system. The level of voice input system technology used in the study resulted in a large percentage of responses where the device either did not respond or gave the wrong response to correct input by the test subject. In addition, the manual device also had some undesirable features, including the necessity of selecting a button to switch between input and cursor control modes, as well as erratic sensitivity during cursor control operations.

The present study is a follow-on to the previous study and utilized "next generation" data input devices to provide better definition of the data input device requirements. In addition, comparisons were made to current data entry systems, e.g. paper and pen and cue cards. The performance of the electronic devices was evaluated both with and without the introduction of an anomaly, e.g. a "procedure display failure" during performance of the experimental procedures.

METHODS

Study Plan/Approach

The utility and efficiency of two electronic data entry devices (manual and voice) were evaluated for their ability to enter and correct data input into procedures displayed within a glovebox work volume. The Manual Data Entry System required manipulation of a keypad, the Genovation 6.0 serial micropad, located inside the glovebox. This device looked and worked like a standard computer numerical keypad; however, all keys were programmable. The Voice Data Entry System entered data using voice input through a microphone headset which was connected to a voice recognition system installed on the computer. Eight subjects entered data directly into fields located within electronically-displayed surgical procedures. With both electronic conditions, a small trackball was available within the work volume for cursor control. Subjects could also navigate through the procedures with voice or keypad commands. Finally, a baseline condition (Pen and Paper) was included, in which procedures were read from cue cards and data was recorded by pen onto a data sheet into fields identical to those used in the electronic conditions. This task also included entering the data into an electronic summary on the computer after the test run.

For the purposes of this study, manual Keypad, Voice, and Pen and Paper conditions represent reasonable choices for use in the glovebox. However, data manipulation and entry during Glovebox operations on Space Station may utilize a number of other techniques: e.g. a bar code reader would greatly facilitate the speed and accuracy of data entry; a direct electronic input from the mass measurement devices into the database would also enhance data entry; in addition, a voice recording system may also be available for backup. However, the purpose of the current study was to evaluate "data entry devices" and the use of a bar code reader or direct electronic input would have greatly reduced the data points for evaluation and, therefore, were not used in this study.

The comparisons used in this study provided a baseline condition of no electronic device as well as two feasible electronic devices, manual keypad and voice. Computer input device technology will undoubtedly continue to improve, but the basic characteristics of voice, manual device, and paper and pen systems should remain the same. The use of paper and pen comparison has not often been investigated in the large literature on input devices. Much of this literature uses a "mouse" as at least one alternative, and the mouse has been found to be very difficult to use under microgravity conditions (2). Most studies have found that a keyboard is best for data entry, while other devices may be better for commands.

In the usual performance of a familiar task, little difficulty is encountered by expert operators; most problems with automated systems do not occur during normal operations, but during unusual events that may distract an operator's attention. Therefore, such anomalies were introduced into the experimental procedure to increase the probability of finding limitations or problems with human interactions with the electronic systems. This made it possible to evaluate subject performance with the devices under ordinary conditions. compared with performance under a minor stressor, and increased the chances of finding device problems. The anomaly chosen for use in this study was "returning the procedure display to the beginning of the procedure." The anomaly was presented twice in a test run, once each with the manual system and once with the voice system. The timing of the anomaly was consistent across all subjects and was chosen so that at least two data entry fields followed the presentation of the anomaly. The Test Observer inserted the anomaly at the appropriate time.

In order to maximize the hypothesized stressful effects of this "simple anomaly," a time constraint was introduced to create some additional performance anxiety. A small timer (2" wide x 2" long x 0.5" deep) was placed in the work volume. The subjects were informed that the average time to complete the procedure was 25 to 30 minutes and the timer was there so that they could gauge their time against this "average" time. In reality, the time to complete the procedure was closer to 35 minutes.

In summary, the study design incorporated five conditions:

1. Pen and Paper: Current shuttle/spacelab procedures. Reading of procedures from cue cards and hand recording of data with pen and paper. Recording took place within the glovebox work volume. This task also included transcription of the data following the test session, by entering it into an electronic database for storage. No anomaly was introduced under this condition.

2. Voice Electronic Data Entry: This condition assessed the use of a "speaker independent" voice electronic system interfacing with electronic procedures displayed on a monitor in the work volume. A trackball was used for cursor control. No anomaly was introduced under this condition.

3. Manual Keypad Electronic Data Entry: Same as #2, above, except a manual electronic system with a trackball was used. No anomaly was introduced under this condition.

4. Voice Electronic Data Entry with Anomaly: Two anomalies per session were introduced. This condition assessed the effects of an anomaly on the efficiency of using the voice system.

5. Manual Keypad Electronic Data Entry with Anomaly: Same as #4, above, except a manual electronic system was used. This condition assessed the effects of an anomaly on the efficiency of using the Manual Keypad system.

The study design is shown below:

Table 1 Data Entry Device Evaluation Study Design

	No Anomalies			Two Anomalies/Test Run	
Subject	Keypad	Voice	Pen and Paper and Cue Cards	Keypad	Voice
S1					
S2					
S3					
S4					
S5					
S6					
S7					
S8					

The conditions were presented to the subjects in a random order.

A total of eight subjects were tested in the study. A statistical computation of the power of the test, the probability of obtaining a significant result if there was one, showed that the probability was 0.98 with eight subjects. Increasing the "n" to ten increased the power only to 0.99 and, therefore, the study was conducted with eight subjects.

Procedures were modified from experimental operations with rodents defined in the "Characterization of Flight Verification Increments for the Centrifuge Facility."

Specimens for dissection were preserved adult male rats, weighing between 400 and 500 grams (Wards Natural Science, Rochester, NY). Early in study development, the study team considered using live animals; however, it was decided that the preserved specimens provided sufficient complexity for the purposes of the study.

Entry Device Selection

General

The purpose of the present study was to evaluate the suitability of different modes of interacting with experimental procedures and recording data within the confines of an enclosed volume such as the Life Sciences Glovebox. General requirements for electronic data systems are presented in the Appendix, Document 1.

Data input and command capability by a voice recognition system provides users with the ability to interact with a computer display, without the need for additional equipment within the work volume. This capability eliminates requirements (listed below) that would have to be imposed on any manual unit that would reside and function within the work volume. However, the potential problems of a voice system for nonrecognition or misunderstanding of input imparts a risk to its use not typically associated with a manual system. However, interaction by voice provides a mode that would impose the least disruption to ongoing tasks by providing a hands-free computer interface.

Requirements for a manual system include programmability, small size, capability to work with gloved hands, tactile (and possibly visual) feedback and imperviousness to fluids.

A trackball was included in the study to provide cursor control during use of the keypad or the voice systems. The basic requirement for the trackball was small size; while not included in the present study, additional requirements would be imposed on a flight unit, including a sealed system so that it could be cleaned and the ability to function in microgravity.

Finally, in order to provide a baseline comparison to current data collection and recording methods utilized in a microgravity condition (shuttle/spacelab), a baseline system, the paper and pen condition, was also evaluated for its possible constraints for use while conducting biological procedures within an enclosed work volume.

Voice Condition

The voice recognition system utilized in the Glovebox I study was a speaker-dependent system available "off the shelf." The majority of the subjects experienced problems with the system and a significant number of "wrong responses" or "no responses" to subject input was observed.

An extensive survey of the currently available voice recognition systems showed a wide variation in system performance and cost. In all, 16 vendor packages were evaluated for their suitability. The selection of the vendor was based on ability to meet the requirements as indicated in the Appendix, Document 2, within the required time frame and budget allocated to the project. Demonstrations of the Lernout and Hauspie product indicated an acceptable level of performance on repeated occasions.

The voice recognition system used in the present study was custom developed specifically for use in this test by Lernout and Hauspie Speech Products (Woburn, MA). The software was built around the Lernout and Hauspie Automatic Speech Recognition SDK version 2.0 in C and developed using version 1.51 of the Microsoft Visual C++ compiler (Redmond, WA). It is a speaker-independent system that was designed to interface with the FileMaker Pro database as a means of inputting data by voice and providing command capability.

The software was developed so that identical commands and numeric input capability as the manual keypad would be provided by the voice system. However, two additional commands were required to turn the voice recognition off and on as required. A list of voice commands was provided within the work volume on a cue card (with magnets attached) during the voice condition so that test subjects would not be required to memorize commands. The active vocabulary list is shown in Table 4.

Table 4 Voice System Vocabulary

Word/Phrase	Action Within File MakerPro
One	Inputs the number **1** at the current location of the cursor.
Two	Inputs the number **2** at the current location of the cursor.
Three	Inputs the number **3** at the current location of the cursor.
Four	Inputs the number **4** at the current location of the cursor.
Five	Inputs the number **5** at the current location of the cursor.
Six	Inputs the number **6** at the current location of the cursor.
Seven	Inputs the number **7** at the current location of the cursor.
Eight	Inputs the number **8** at the current location of the cursor.
Nine	Inputs the number **9** at the current location of the cursor.
Point	Inputs a **.** at the current location of the cursor. Must use with proper grammar, e.g. "0.4"
Check Mark	Inputs a "**x**" at the current location of the cursor
Enter	Activates the "enter" script
Tab	Tabs to the next field - same action as "enter"
Page up	Activates the "page-up" script
Page down	Activates the "page-down" script
Erase	Deletes the previous entry
Go to sleep	Turns the voice system off so that users are able to speak without the voice system active.
Wake up	Turns the voice system on so that recognition can occur.

In order to input decimal values, subjects were required to say "a number", "point", followed by another "number." For example, a mass of 0.5 grams would have to be spoken as "zero, point, five", all as a single phrase. This was an idiosyncrasy of how this system was programmed and not necessary indicative of other voice recognition programs.

Test subjects wore a head-mounted GN Netcom Profile Ultra Noise Canceling microphone (Copenhagen, Denmark). The microphone was installed through the input port of the Diamond Multimedia sound card (Diamond Multimedia Systems, Inc., Sunnyvale, CA). The use of a head-mounted microphone afforded test subjects freedom of movement and reproducible microphone placement (See Figure 1).

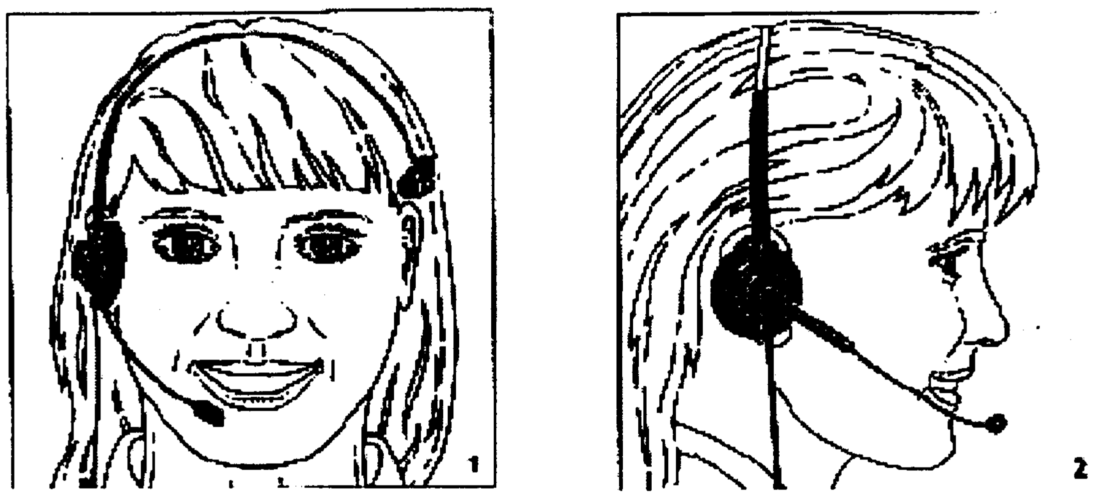


Figure 1 Microphone Headset Type Used with the Voice System

Manual Keypad Condition

In selecting a manual entry system for the Glovebox I study, a trade study was conducted and the results are shown in Table 2. The UnMouse™, a small programmable touch tablet (MicroTouch Systems, Inc., Methuen, MA) was the only Macintosh compatible unit that provided a programmable keypad and cursor control capability in a single unit and therefore was selected for use in the Glovebox I study.

Table 2 Evaluation of Manual Entry Devices

Input Device	Numerical Input	Cursor Control	Volume/ Surface Area Cost	Accessibility	Maintenance
Keyboard	Yes	**Limited**	**High**	Easy, movable	Difficult to keep clean.
Mouse	No	Yes	Low	Easy, movable	Difficult to keep clean.
Trackball	No	Yes	Low	Easy, movable	Difficult to keep clean.
Joystick	No	Yes	Low	Easy, movable	Not evaluated.
UnMouse	Yes	Yes	Low	Easy, movable	Not perceived as an issue.
Touchscreen	No	Yes	Low	Fixed location, presents reach problems for smaller users if screen is placed on the rear surface of the glovebox	Not perceived as an issue.

While the UnMouse did provide all the initial requirements originally identified for a manual input device, it was clearly not ideal. Test subjects found it frustrating to switch back and forth between the keypad and cursor modes. Also, the smooth surface provided for cursor control did not provide users tactile feedback known to be the major source of useful feedback to users when using manual devices (2). Based on the results obtained from the Glovebox I study, it was clearly necessary to identify and evaluate a different manual input unit.

An exhaustive search was performed to locate a manual device (keypad) that would satisfy requirements identified in the Glovebox I study. The requirements that were used in device selection are identified in the Appendix, Document 3. Requirements for the manual device included:

- PC compatibility
- Small device dimension
- Cleanable surface
- Tactile feedback
- Non-handed
- Visual feedback of the data on the device
- Programmability of keys

Several methods to provide all these requirements simultaneously were explored. Loaner units of programmable keypads with liquid crystal display (LCD) capability and membrane surfaces were obtained from Termiflex. Inc. (Merrimack, NH) and evaluated for their suitability. However, programmability/compatibility with the computer system would not have been possible without costly development in both time and funds.

The need for data display on the manual device itself, in addition to the display provided by the monitor within the glovebox, was further explored. An evaluation was performed to determine the usefulness of the "on device" display requirement prior to continuing the search for an appropriate device. Test subjects (n = 15) were asked to input numeric data sets consisting of ten, 8-digit numbers representing identification numbers, and 16, decimal numbers representing mass measurements, using two systems. The first system consisted of a PC computer with the monitor mounted on a shelf at approximately eye level, three feet away from the test subject. The numeric keypad portion of a standard computer keyboard was used as the input device. This setup was to simulate the environment that users would find in the glovebox if no display capability was provided on the manual device. The second system consisted of a small printing calculator with a small LED display. Keys on both the computer keyboard and the calculator were standard 0.5 inch square keys. Devices and data sets were presented to the test subjects in an alternating order. The number of errors and the total time to enter the data was determined for each data system.

The results from this study are presented in Table 3. No statistically significant difference was found in the mean number of errors or the mean data entry time.

Table 3 Comparison of Computer Display System vs. Calculator with Display (Mean ± SEM)

	Computer System	Calculator with Display
Mean number of errors	0.13 ± 0.09	0.67 ± 0.32
Mean data entry time (sec)	126.8 ± 10.25	132.1 ± 9.64

Based on this study, the team felt that the requirement to provide display capability on the manual device was no longer necessary and that programmable keypads without displays could now be considered. A copy of the report from this study is provided in the Appendix, Document 4.

The final device selected for evaluation was a Micropad (Genovation, Inc. Irvine, CA). The unit is a small numeric keypad (3.5" x 5.25"), with the identical number key configuration as that typically found on computer keyboards. The function keys (=, /, *, -, +, Enter) were reprogrammed using the Genovation redefinition program. Small laser printed labels were attached to the top of each key including the number keys and the decimal point so that all keys were identical in appearance (See Figure 2). The unit was installed on the second serial port of the computer.

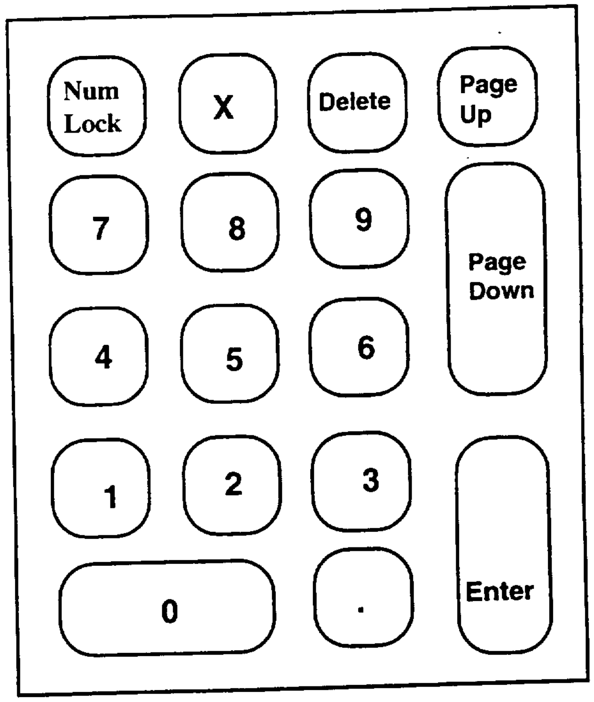


Figure 2 Manual Keypad Device Layout

In order to provide a surface that could get wet during the tests, several types of materials were evaluated to cover and protect the unit. For the purposes of this study, the Genovation keypad was covered with plastic food wrap and secured on the underside with tape. This covering provided the keypad with a transparent surface through which the keys below could be viewed/accessed, that was impermeable to fluids, and could easily be cleaned. Magnetic strips were mounted to its underside to allow for attachment to metal work volume surfaces.

Trackball

A trackball (Microspeed Incorporated, Fremont, CA, Figure 3) was installed in the first serial port of the computer. This unit, approximately 1 x 2 inches in dimension (x 1 inch deep) was used to provide the test subjects with cursor control and selection capability within data fields. This unit was available for use with both the manual electronic and voice recognition systems. It was determined by the team that no comparative system could be provided within both the manual and voice systems, so the decision to use a common device with both systems was made. The unit was used by test subjects to activate the Time Stamp button, to move to a previous data field, to move the cursor to a specific location within a data field, to select the entire contents within a data field, and to page up/page down/scroll within the procedures (as an alternative to the capabilities provided by the manual and voice systems). Small magnetic strips were mounted to its underside to allow test subjects to attach the trackball to various metal surfaces within the work volume.

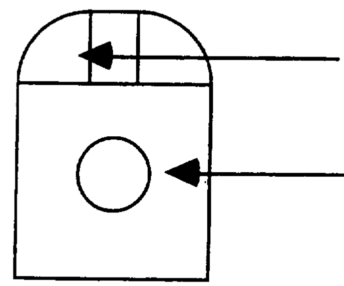


Figure 3 MicroTrack™ Trackball

Pen and Paper Condition

Current Shuttle/Spacelab data entry techniques were simulated with the Pen and Paper System to provide a baseline for comparison with the Electronic Data Entry Systems.

The Pen and Paper system consisted of procedures, a pen and a data entry sheet. The paper procedures had exactly the same wording and content as the electronic procedures. Several different presentations of the procedures were tested before one was chosen. One option was to present the procedures on a shuttle-like cue card format using both sides of an 8 1/2 x 11 inch card. This method was not selected, however, because the procedural instructions could not be abbreviated or shortened to the extent of the actual cue cards used on shuttle. Shuttle users have far more training in procedures than was available in the present study. Our limited time for training resulted in having to present too much information in the cards so that they were difficult to read. Attempts to alleviate this problem with changes to the format (e.g. multiple columns, color coding, different fonts or spacing, or vertical instead of horizontal orientation) were not successful.

The method chosen to present the procedures was a "flip chart," again modeled after a method used for Shuttle/Spacelab procedures. The flip chart consisted of nine pages each showing only a small number (approximately 11) of the procedures. This presentation is more comparable to the electronic procedures in that periodically the operator had to perform an action, either turn the paper page or scroll through the electronic procedures, to see the next group of instructions.

The data sheet was printed with labeled spaces for recording the numerical data with a pen. The format was similar to the electronic procedures where data was entered. See Appendix, Document 5, for a copy of the data sheet.

An inherent difference between the Pen and Paper System and the Electronic Data Entry Systems is that the Electronic Data Entry Systems allow data to be entered directly into the computer data base. In order to make a fair comparison between the Pen and Paper System and the Electronic Data Entry Systems, the subjects were required to transcribe the data recorded with Pen and Paper into a computer data base after the completion of the Pen and Paper test run. In addition, the rationale provided to the test subjects for transcribing the data was that during a three month mission increment on the International Space Station, data may have to be transmitted to the ground. The form presented to the test subjects to enter data into the database was designed to appear similar to the paper data sheet used in the test run. See Appendix, Document 6, for a copy of the form into which the data were transcribed.

Computer System/Database

To allow for a wide selection of PC compatible input devices/systems, a TAG RAM 486 DX (486 MHz) Personal Computer (TAG RAM System Corporation, Tustin, CA) was used. System software included Windows 3.11 (Microsoft Corporation, Redmond, WA) and was run in the Windows 32 operating mode. The database used to present electronic procedures was FileMaker Pro for Windows, Version 2.0 (Claris Corporation, Santa Clara, CA). FileMaker Pro was chosen over other systems because it is user-friendly and currently used for multiple functions in various projects at Ames Research Center and Kennedy Space Center.

Data, including specimen mass, checkboxes for specimen health parameters, and container identification numbers were collected directly into database fields. The database was programmed to automatically determine the elapsed time to complete the entire session, and the time to complete whole tasks within the session. This was accomplished by requiring test subjects to activate Time Stamp buttons at the beginning, end, and strategically placed points throughout the procedures. A summary of the session times and data entered by the test subjects was also provided by the database; a copy of the summary sheet is provided in the Appendix, Document 7.

Test Environment

All dry runs, training and test runs were conducted in a dedicated trailer, T-5-C at NASA Ames Research Center. No special acoustical isolation was provided. The test room contained a full-sized mockup of the glovebox, a video camera mounted to record the glovebox interior showing movement of the subject's hands on the keypad, trackball, and with pen and paper. A video display terminal and VCR connected to the camera were in an adjacent room.

The glovebox mockup used for this study, constructed of aluminum and lexan, was the same as that used in the Glovebox I study, with some minor modifications. It has an internal volume of approximately 17 cubic feet, compared to the current glovebox in use in Spacelab which has a volume of approximately 13 cubic feet. It is based on the "wrap-around work volume" concept conceived by the Centrifuge Facility Project Office (Figure 4). Previous work (3) indicated that this design provided users with accessible surfaces and work areas where operations could be efficiently performed. Access doors on the floor of the work volume permit attachment of up to two habitats or equipment modules through which equipment and specimens may be retrieved.

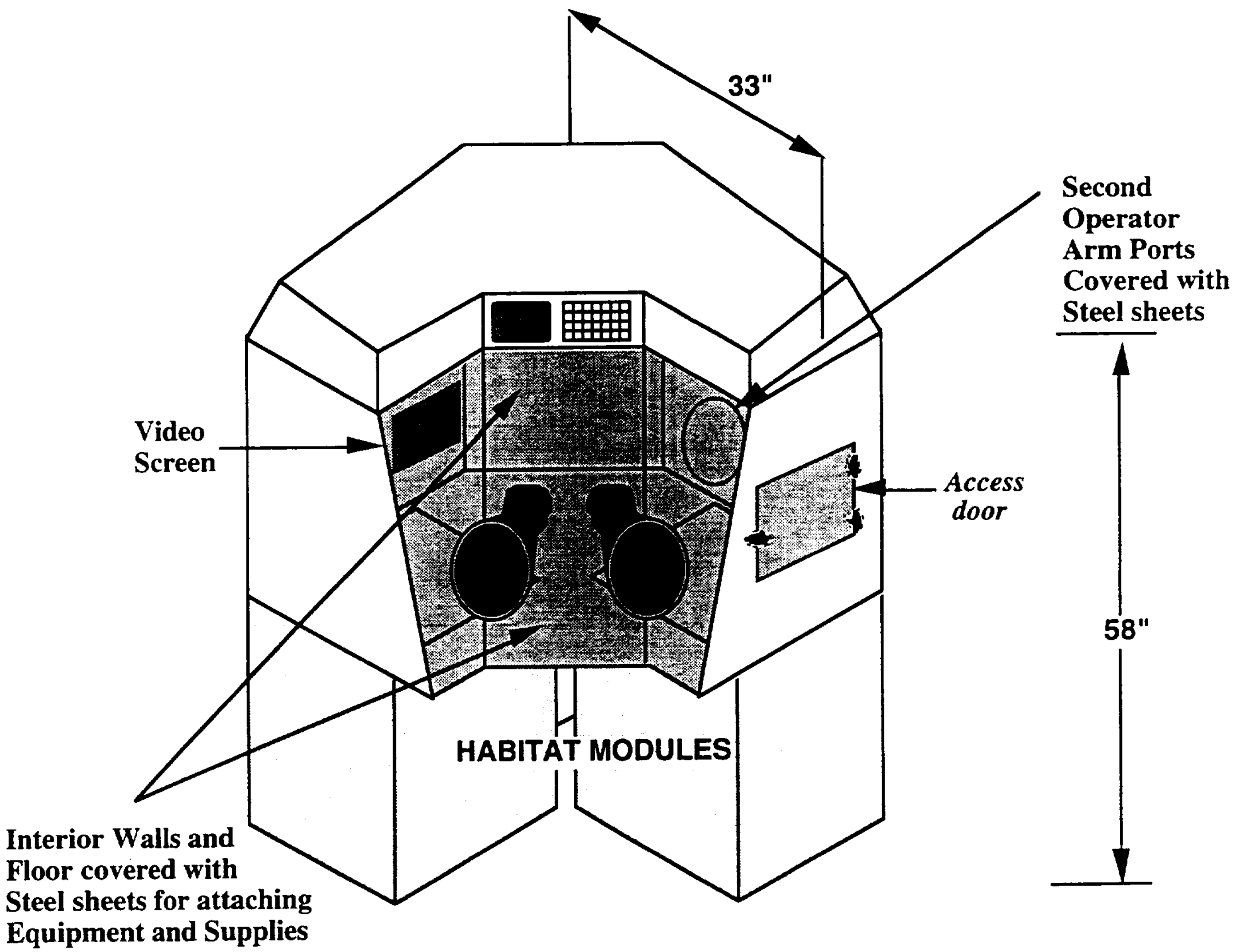


Figure 4 Wrap-Around Glovebox Mock-Up

Metal sheets (0.030 inch steel) on the surface of the interior walls and the floor of the work volume allowed instruments and supplies to be attached with magnetic strips. The arm holes for a second operator were not needed for this study and were covered with a metal sheet to provide more wall area for attaching equipment and supplies. A door in the right side panel permitted access to the interior volume for transferring items in and out of the work area without disturbing equipment set-up on the work surface (which doubled as the habitat/equipment access doors). Two fluorescent lamps (15 watts each) on top of the glovebox provided illumination of the work volume. Room lights were turned off during test runs as they produced reflective glare on the front panel of the work volume and impeded visibility into the interior. A shelf on the outside of the glovebox and cut-out on the wall at the left rear of the exterior work volume allowed mounting of the video monitor used to display procedures. The monitor cut-out in the wall had a close-out door to cover the monitor during the pen and paper condition, or the door could be latched in an open position to reveal the monitor for the electronic data entry conditions.

Equipment and Supplies

The guideline in choosing equipment and supplies was to create as realistic a work environment as possible in order to test the data entry systems in a flight-like context. By simulating the zero-gravity environment, the test data could be interpreted with a higher degree of confidence, resulting in recommendations that apply directly to the situation in which the selected system(s) will actually be used.

The Science Payload Support group in Code SL loaned the following training and flight equipment to the study: Rodent Carcass Containers, fixative bags and clips, and Nintendo boxes from which the two types of supply kits were made. Supply Kit 1 contained gloves, large and small towels, small and large ziplock bags, and one rodent restraint cone. Supply Kit 2 contained the sample containers: four fixative bags, with two clips each and 10 cc of water to simulate fixative, four 2 cc sample vials, and two 10 cc sample vials, one of which contained water to simulate saline.

The Refrigerator Storage Pouch was constructed from a layered, biaxial nylon thin foil material which has been used to construct dissection kits and other flight kits for Shuttle/Spacelab missions. The waste bag was simply a ziplock bag. A clipboard, a small clock, and a small thermos for use as the Cryo Sample Holding Unit were purchased for the study. The surgical instruments and tray, dissecting platform, dispatcher, lab coats, one clock and the quick-snap freezer mock-up were available from the Glovebox I Study.

Some of the equipment and supplies chosen for this study were not flight-like, such as the Mass Measurement Devices; 1-g balances were used in order to generate data that could be entered during the test runs. A cup and syringe were available for removal of excess preservative within the body cavity of the specimen. This procedure is peculiar to preserved specimens and would not be required in microgravity.

All equipment was restrained within the work volume using velcro, magnets or rubber-bands. The work volume walls and floor were covered with steel to allow the equipment with magnets to be moved and placed wherever it was needed. It was recognized, however, that there may be restrictions on the use of magnets on the International Space Station due to interference with biotelemetry signals or other potential problems, such as the possibility of inadvertently erasing video or audio tapes. Velcro was used mainly with disposable items such as sample containers. The concern with using Velcro inside the Life Sciences Glovebox work volume for Space Station is cleanability during long-duration missions.

Test Development

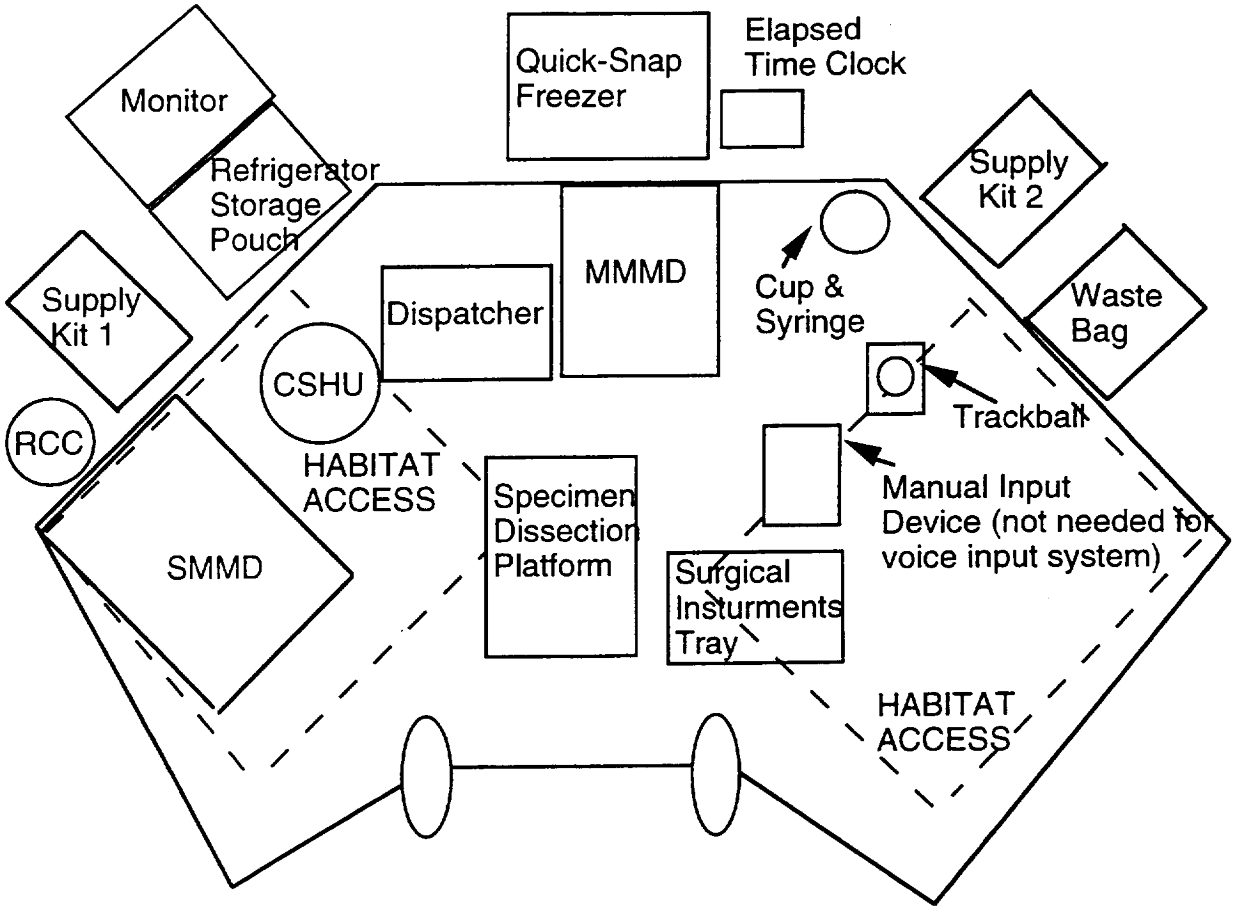
The initial development of the test concentrated on evaluation and acquisition of the data entry devices, procurement of the equipment and supplies and development of the electronic displays for the surgical procedures.

The surgical procedures were modified from four reference experiments described in the "Characterization of Flight Verification Increments for the Centrifuge Facility." The procedures outlined in detail the operations required to remove the following tissue samples from a rat: heart (further divided into numerous samples), testes, duodenum and adrenals. The procedures were expanded to include removal of the specimen from the holding tray below the glovebox, entering of mass and health check parameters, decapitation of the specimen, removal of tissues and either preserving or freezing them, and data entry of vial and fixative bag identification numbers and some tissue weights. A copy of a generic procedure is attached in the Appendix, Document 8.

The procedures were incorporated in a relational database, where data such as specimen or tissue mass, sample vial identification numbers and health check parameters could be entered directly into fields displayed within the procedures. A total of 17 data entry fields, in addition to four Health Check Parameters, comprised the data entries. The specimen identification number, mass and health check parameters were listed on a cue card attached to the specimen. The procedures were modified during numerous dry runs and wet runs conducted by the test developers. During "dry runs," the procedures were performed with a dummy specimen (usually a banana); during "wet runs," a preserved rat specimen was used.

Specimen and vial identification numbers were randomly-generated numbers, 5 digits long, with no numbers sequentially repeated. The configuration of these numbers was deliberately chosen to increase the likelihood that subject errors might occur. On Space Station, a sequential series of identification numbers is more likely to be used, which would make it easier to develop an error-free system.

Prior to the start of each test run, the work volume was set up by the study team members to contain all required equipment and supplies. The layout of the equipment and supplies was optimized during the dry runs and the wet runs to a baseline. The test subjects were allowed to customize the layout for their own preference during the training day, which was especially important for the two left-handed test subjects. For the test day, however, the layout was identical for all test runs for one given test subject. The baselines for the Electronic and Pen and Paper Data Entry Systems are shown below in Figures 5 and 6. The only differences between the two layouts are that in the pen and paper condition, the clipboard with the data sheet, pen and time clock replaced the manual input device and trackball, and the paper procedures (flip-chart) were placed on the monitor close-out door.

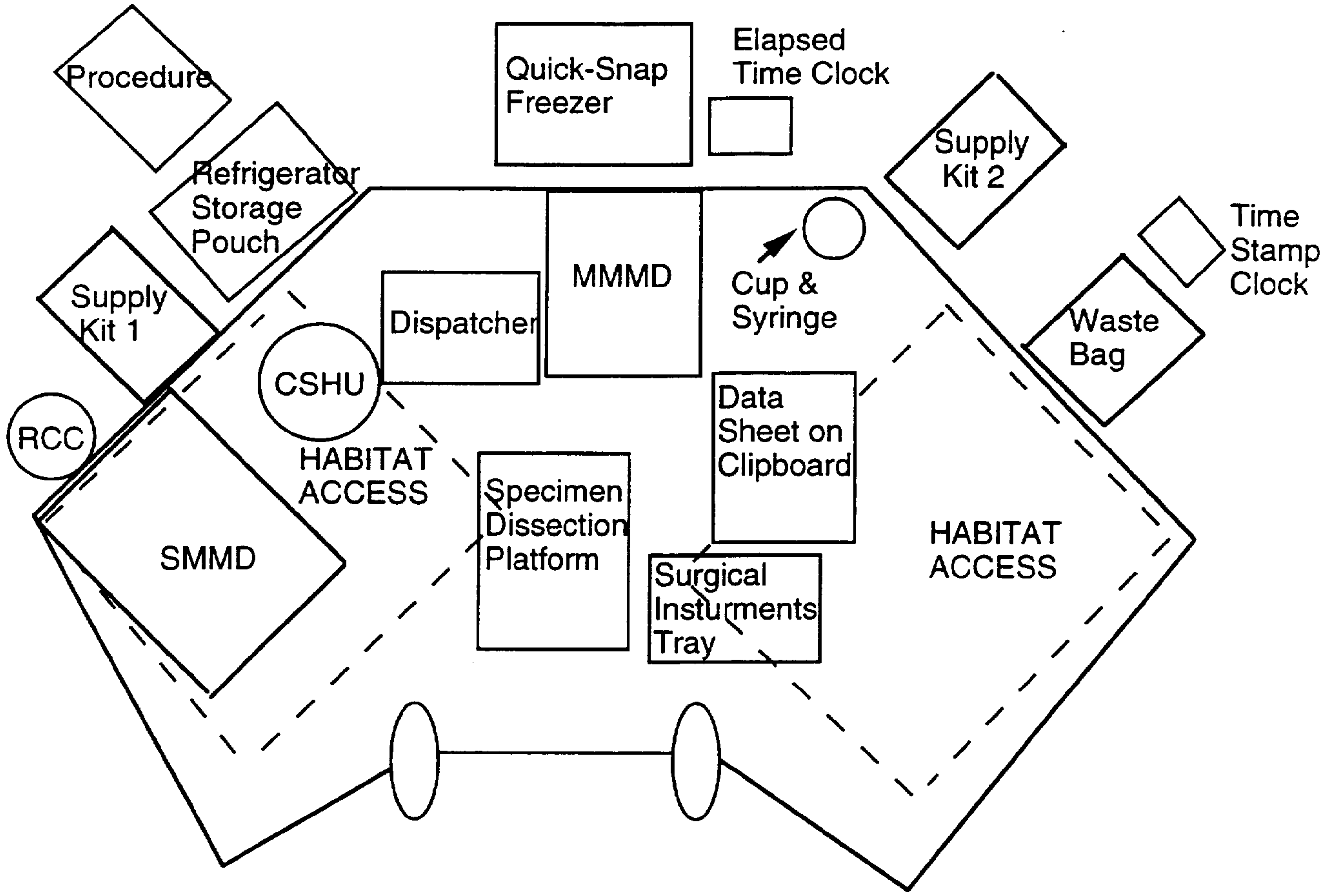


NOT TO SCALE

ITEMS OUTSIDE FOOTPRINT ARE MOUNTED ON THE WALL ABOVE

SMMD: Small Mass Measurement Device
MMMD: Micro Mass Measurement Device
RCC: Rodent Carcass Container
CSHU: Cryo Sample Holding Unit

Figure 5 Layout of Equipment and Supplies in the Glovebox Work Volume, Manual or Voice Data Entry System, Right-handed Operator



NOT TO SCALE

ITEMS OUTSIDE FOOTPRINT ARE MOUNTED ON THE WALL ABOVE

SMMD: Small Mass Measurement Device
MMMD: Micro Mass Measurement Device
RCC: Rodent Carcass Container
CSHU: Cryo Sample Holding Unit

Figure 6 Layout of Equipment and Supplies in the Glovebox Work Volume, Pen and Paper System, Right-handed Operator

A video camera, monitor and recorder were borrowed from Imaging Technology Branch, Ames Research Center.

Personnel

The following personnel were required to perform the tests:

The Test Subject performed both the surgical procedure and the data entry.

The Trainer compiled the training manual for each test subject and was responsible for coordinating the training and practice sessions in the use of each data entry device and performance of the procedures (See Training).

During the test runs, the Test Conductor prompted the test subject when necessary to read and follow the procedures, answered questions and clarified issues.

During the test runs, the Test Observer recorded data on the observation sheets documenting the types of data entry errors and any other problems which occurred during the test session. Separate observation sheets were developed for each of the five conditions and are included in the Appendix, Documents 9 to 13. The Test Observer had the additional responsibility to introduce the anomalies during the System Failure Conditions.

Test Subjects

Three women and five men were recruited as test subjects. All were science, engineering and operations personnel from Ames with differing amounts of experience with dissection procedures. Their ages ranged from 27 to 53 years old, with a mean age of 37. Two were left-handed.

Experiment Design

Training Day

Each subject was provided with a training manual containing an overview of the study, the schedules for the training and test days, equipment layouts, descriptions of the data entry systems, and a copy of the procedures and the questionnaire. Prior to the official training day, subjects had a brief introduction to the Voice Data Entry System in order to allow for the parameters to be optimized for each subject.

At the beginning of the actual training day, the objectives of the study were discussed with the subject, the test schedule was reviewed, and the test subject was given an overview of the glovebox and equipment. The subjects had time to practice the fixative bag procedure for inserting samples into the bag and replacing the fixative bag clips. The subjects were then instructed to put their hands in the glovebox gauntlets to become familiar with the equipment and practice their micro-gravity simulations. They were allowed to customize the layout for their reach and preference, and to practice some of the procedures using the pen and paper system. The subjects were instructed to double-check their data for accuracy, concentrate on doing a good dissection, and attempt to complete the procedure in 30 minutes.

Instruction on the use of the trackball, manual keypad and voice devices followed, emphasizing practical usage of the devices to enter numerical data into data fields. In addition, the use of the device versus the trackball for moving the electronic display (e.g. "page up," "page down) was practiced. The dissection procedures were reviewed, followed by a bench-top demonstration of the dissection procedure. The afternoon consisted of two practice dissections by the test subject inside the work volume, one with the Manual Data Entry System and one with the Voice Data Entry System. The schedule for the training day is shown in the Appendix, Document 14.

Test Day

Test runs began on the day following training. Each test subject performed the procedure five times: two procedures each with voice and keypad, one with and one without anomalies, and one pen and paper procedure. There was a rest period of one half hour between each test run and a one-hour lunch break after the completion of the third test run. The test runs were performed in a different random order of presentation for each subject in order to eliminate any order effects.

Data: Quantitative Variables

Times

The completion time for each subtask was recorded by the subject in the Pen and Paper Condition or by the computer in the electronic conditions, and the times for each subtask and for the whole procedure were determined. In the Pen and Paper Condition, total procedure time included transcription time into the electronic database. The videotape recordings of the test sessions were used to determine the "time to enter data in each field."

Errors

Errors were divided into several categories. First, "incorrect data" entered by the subject was tabulated as either "corrected" or "not corrected." In addition, the frequency of errors in the two fields following an anomaly, (either planned in the test design or unplanned due to mistakes by the subject or malfunction of the test equipment), was calculated. Finally, the concept of whether "errors beget errors" was tested. In each device condition, we determined the number of data entry fields with errors (subject or system) which were preceded in either of the previous two fields by another error, an anomaly or some other event. "Some other event" included a failure of the scale to work properly or hitting the keypad with the habitat access door so that extraneous numbers were entered in a field. This number was compared with the total number of fields in which errors occurred, regardless of what preceded the field. For example, for one of the subjects in the Manual Keypad without Anomaly condition, there was a total of six fields with errors and three of these fields were preceded by "errors," resulting in an "error begetting error" probability of 50%. This comparison across devices was designed to determine whether one device condition was more susceptible than the other to this phenomenon.

Trackball versus Electronic System

The preference of the test subjects to use the trackball or the electronic entry system for "page up" or "page down" to move through the procedure was also determined. Use of the trackball to select "Time Stamp" was not included in this calculation, since the subject was not given a choice for this operation. Furthermore, the use of the trackball for error correction was also not included in this analysis because the decision by the subject to use one or the other would likely be influenced by where the error occurred in the data entry, e.g. if the error occurred at the start of a five-digit number, the trackball might be used to position the cursor rather than erase/delete the correct numbers; however, if the error occurred at the end of the entry, the keypad or voice system might be preferentially used.

Voice System Analysis

The performance of the Voice system was analyzed in two ways: (1) the number of no responses and wrong responses were determined; and (2) the distribution of no or wrong responses by subject and by word used was determined. A full spread sheet describing the latter data (2) is presented in the Appendix, Document 15.

Statistical Analyses

Quantitative data for whole sessions or within a subtask across conditions were analyzed by Analysis of Variance for a factorial design, with post-hoc tests to determine significant differences between groups. A probability ("p") value of less than or equal to 0.05 was considered significant. A Macintosh computer-based statistical package was used for the analyses (StatView, Version 4.02, Abacus Concepts Inc., Berkeley, Ca., 1994)

Data: Subjective Information from Questionnaires and Subject Interviews

Questionnaires were administered at the end of the test day, after presentation of all the conditions, so that subjects could compare the methods of data entry. A paired comparison rating scale was used in which subjects were asked to compare two device conditions, such as voice versus pen and paper or voice versus keypad, and make a decision which one was better than the other on one of ten characteristics, such as ease of entering data or correcting wrong numbers. In addition, the Questionnaire poled the subjects about their overall preference and rating of the data entry systems. The questionnaire is included in the Appendix, Document 16.

Later on in the study, when it became apparent that additional information regarding the entry device systems was necessary, the subjects were requested to complete a more open-ended, follow-up questionnaire (listed in the Appendix, Document 17). The follow-up questionnaire was generated almost exclusively from comments by the test subjects in order to determine if there [illegible] agreement concerning various features and characteristics of the voice system. The [illegible]as that perhaps the Voice System would compare more favorably with the Keypad [illegible] some slight design modification were made.

RESULTS

Time

Mean whole session time (minutes) to complete the test procedures under each of the five entry device conditions for the eight test subjects are presented in Figure 7. The "Whole Session Time" includes the time for the subjects to make error corrections, time spent dealing with problems with a data entry system (e.g. "no response" by the voice system) and other problems (e.g. failure of the scale to work properly). There was a significant main effect of entry device, but no effect of anomaly and no significant interaction between entry device and anomaly condition. The Manual Keypad conditions were not significantly different from the Voice conditions. The Pen and Paper condition was significantly slower than the Manual Keypad conditions but no slower than the Voice conditions.

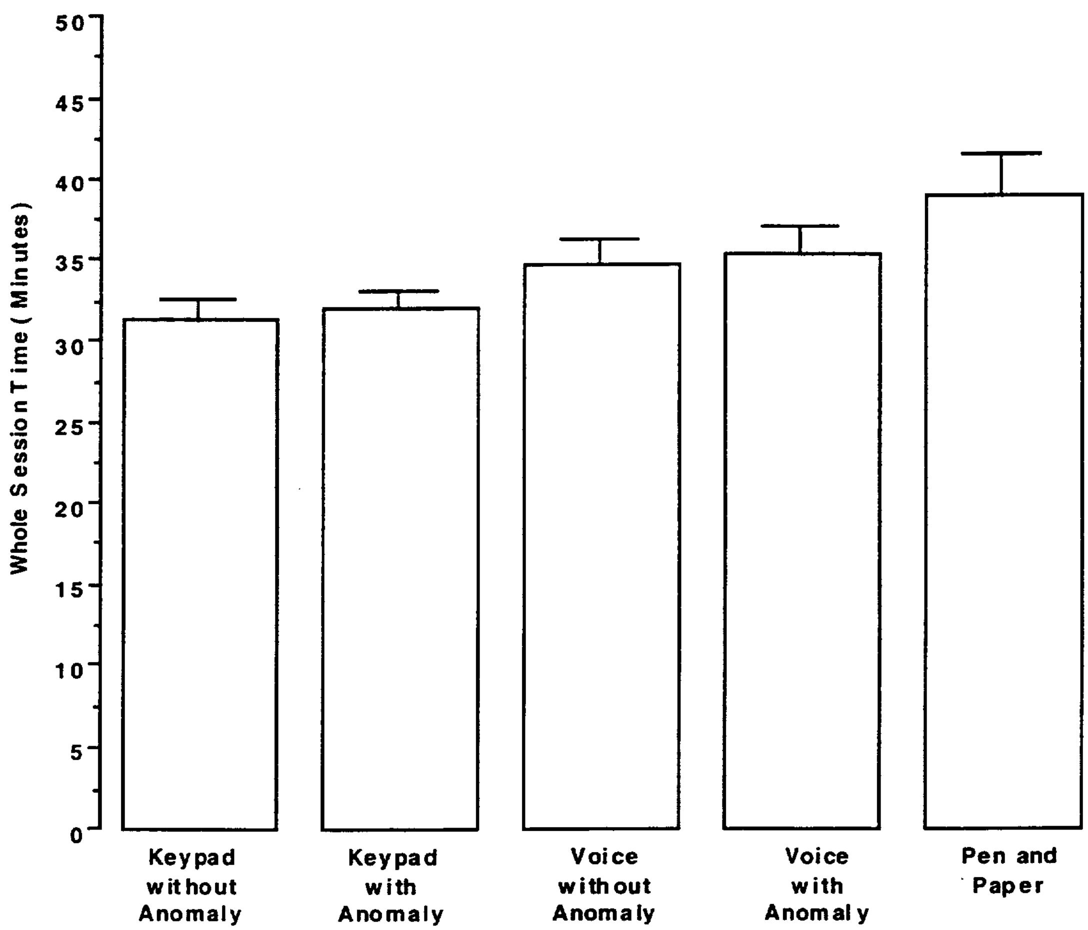


Figure 7 Mean Whole Session Times (minutes, ± SEM)

Mean subtask times (minutes) within a test run across the five conditions are presented in Table 5, below. Times include subject error correction time and time spent dealing with problems with a data entry system. There were no statistically significant differences between the conditions for the subtasks main effects or interactions.

Table 5 Mean Subtask Times (minutes)

	Keypad without Anomaly	Keypad with Anomaly	Voice without Anomaly	Voice with Anomaly	Pen and Paper
Health Check	2.66 ± 0.21*	2.57 ± 0.4	2.87 ± 0.22	2.72 ± 0.21	2.63 ± 0.26
Specimen ID	3.13 ± 0.24	3.37 ± 0.26	3.79 ± 0.29	4.06 ± 0.39	3.50 ± 0.27
Heart Dissection	10.88 ± 1.03	11.11 ± 0.53	11.16 ± 0.41	11.39 ± 0.56	11.88 ± 1.03
Testes Dissection	5.23 ± 0.4	5.59 ± 0.2	6.51 ± 0.34	7.04 ± 0.38	5.88 ± 0.44
Duodenum Dissection	3.71 ± 0.17	4.13 ± 0.12	4.60 ± 0.34	4.41 ± 0.35	4.75 ± 0.41
Adrenal Dissection	5.59 ± 0.26	5.18 ± 0.31	5.73 ± 0.35	5.75 ± 0.37	6.38 ± 0.42

* minutes, mean ± SEM

Mean data entry time (seconds) per field, where no subject errors or system problems occurred, for the five data entry conditions are shown in Figure 8. No statistically significant differences were found between the data entry conditions (p= 0.25).

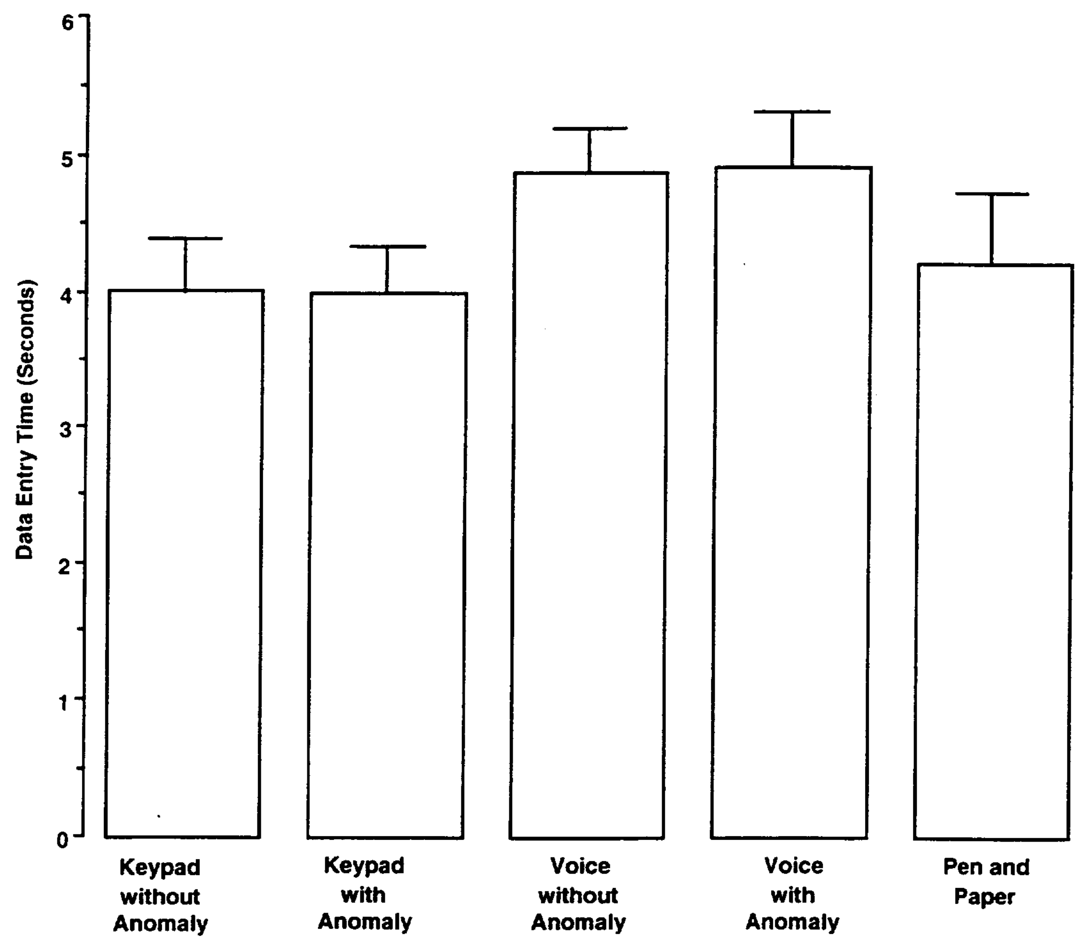


Figure 8 Mean Data Entry Times (seconds, $\pm$SEM) per Field with no Subject or System Errors

When the above data were analyzed for only the two electronic conditions (pen and paper excluded), there was a significant effect of device (Keypad versus Voice, p = 0.047) with no effect of Anomaly and no interaction between Device and Anomaly. While this comparison is statistically significant, the degree of difference between the devices (Keypad: 3.99 $\pm$ 0.39 seconds versus Voice: 4. 90 $\pm$ 0.40 seconds; e.g. approximately 1.0 second) is minimal in the context of a 35 minute task.

Table 6 shows the mean data entry time (seconds) per field within a subtask, where no subject errors or system problems occurred, for the five subtasks requiring numerical input during the test runs. Small but significant differences between the data entry conditions were found on the Testes Dissection and on the Adrenal Dissection.

Table 6 Mean Data Entry Time (seconds) per Field with no Subject or System Errors.

	Keypad without Anomaly	Keypad with Anomaly	Voice without Anomaly	Voice with Anomaly	Pen and Paper
Specimen ID	4.7 ± 0.58*	4.37 ± 0.61	6.11 ± 0.74	5.31 ± 0.58	5.16 ± 0.56
Heart Dissection	3.91 ± 0.45	4.24 ± 0.38	5.75 ± 0.56	5.01 ± 1.12	4.9 ± 0.63
Testes Dissection **	4.19 ± 0.41	3.69 ± 0.26	4.29 ± 0.21	5.21 ± 0.45	3.58 ± 0.34
Duodenum Dissection	4.06 ± 0.48	4.38 ± 0.85	4.75 ± 0.63	5.88 ± 0.52	4.19 ± 0.47
Adrenal Dissection#	3.31 ± 0.32	3.74 ± 0.27	4.63 ± 0.28	4.52 ± 0.35	3.91 ± 0.43

* seconds, mean ± SEM

** $p = 0.02$, Voice with Anomaly was significantly slower that Keypad with or without Anomaly and from Pen and Paper.

\# $p = 0.05$, Keypad without Anomaly was significantly faster than Voice with or without Anomaly.

The mean data entry times per field (seconds) when subject errors or system problems did occur are shown in Table 7. These times include error correction time. No statistical analyses were performed on these data due to the high number of empty cells (no errors or problems) in the Pen and Paper and Keypad with Anomaly conditions. Nevertheless, it is apparent that the times under these conditions, as well as generally under the Keypad without Anomaly conditions, are similar to those for data entry times when no subject or system error occurred (Figure 8 and Table 6 above; range of 3.31 to 6.11 seconds). Subject errors and system problems occurred for all the subjects in the Voice conditions, and required a considerable period of time for correction (range of 11.00 to 40.14 seconds).

Table 7 Mean Data Entry Times (seconds) per Field with Subject Errors or System Problems

Subject	Keypad without Anomaly	Keypad with Anomaly	Voice without Anomaly	Voice with Anomaly	Pen and Paper
1	no problems	no problems	37.14	14.00	no problems
2	14.00	6.00	24.7	40.14	no problems
3	30.5	no problems	16.20	16.00	11.00
4	13.00	no problems	21.14	27.4	5.00
5	7.50	no problems	21.67	10.33	no problems
6	no problems	no problems	17.00	19.00	no problems
7	no problems	4.00	11.00	11.00	no problems
8	3.00	5.00	24.67	11.66	4.00
Number of Subjects	5/8	3/8	8/8	8/8	3/8
Mean ± SEM	13.60 ± 4.67	5.00 ± 0.58	21.69 ± 2.75	18.69 ± 3.64	6.67 ± 2.19

Errors

The number of subject errors (wrong entry by the subject) are presented in the tables below. Table 8 shows the number of errors under the Pen and Paper, Keypad, and Voice conditions which occurred during a test run and were subsequently corrected or left uncorrected. Pen and Paper had the fewest total number of errors; however 4 of the 5 errors were left uncorrected. Viewing the video tapes showed that the subject was unaware that these errors had been made. The number of errors in the Manual and Voice conditions were higher than those in the Pen and Paper conditions, and were similar to each other. In addition, all but one of the errors were corrected in both electronic data entry device conditions. It is interesting to note that, out of 680 possible data entry fields (17 fields per procedure x 8 subjects x 5 data entry device conditions) only 5 uncorrected entries occurred and four of these were in the Pen and Paper condition.

Table 8 Total Number of Subject Errors by Entry Device Condition during Test Runs

Keypad		Voice		Pen and Paper	
Corrected	Uncorrected	Corrected	Uncorrected	Corrected	Uncorrected
13	1	12	0	1	4

When the entire test run was considered, the presence of a planned anomaly, "procedure display failure," did not produce a consistent effect upon the occurrence of subject errors. As can be seen in Table 9, an opposite distribution of errors occurred in the Manual versus the Voice conditions, with and without Anomaly.

Table 9 Total Number of Subject Errors during the Test Runs with or without Anomaly

Keypad		Voice	
Without Anomaly	With Anomaly	Without Anomaly	With Anomaly
10	4	3	9

A slightly different result, however, was seen when the number of errors in the two data entry fields immediately following the planned anomalies, compared to the number of errors in the same two fields under the test conditions without an anomaly, is considered (Table 10, below).

The number of subject errors in the two data fields under the Keypad condition were very similar with and without an anomaly. However, in the Voice condition, the anomaly appeared to produce an increased number of subject errors. With the introduction of a planned anomaly, the Voice system may be sensitive to some additional level of stress in the test subject so that the number of errors/events increased compared to the non-anomalous condition.

When considering "Errors/Events of Any Kind," the voice system is inherently affected. The Keypad system could not have "no response" to a data entry, nor was it likely to have a "wrong response" to a correct data entry. Interestingly the occurrence of these events was unaffected by the presence of an anomaly, since the increase under the Anomalous Voice condition can be explained by the increase in subject errors. This point is further elucidated in Table 11.

Table 10 Total Number of Errors in the Two Data Fields Immediately Following a Planned Anomaly

	Keypad		Voice	
	Without Anomaly	With Anomaly	Without Anomaly	With Anomaly
Subject Errors*	3	2	1	5
Errors/Events of Any Kind **	3	3	10	16

* Subject Error: incorrect data entry, selecting the "enter" key twice
** Errors/Events of Any Kind: includes subject errors, voice system failures (no response/wrong response)

Table 11, below, compares the number of errors that were preceded by errors in the previous two fields to the total number of errors which occurred during each of the test runs. Although the rate appeared to be less for Pen and Paper and higher for Voice with Anomaly, error rates were not statistically different between the device conditions.

Table 11 Number of Errors Preceded by Errors Compared to Number of Total Errors

	Keypad without Anomaly		Keypad With Anomaly		Voice without Anomaly		Voice With Anomaly		Pen and Paper	
	P*	ALL#	P	ALL	P	ALL	P	ALL	P	ALL
# Errors	9	21	8	19	16	37	32	59	1	6
Mean Error Rate	**0.43**		**0.42**		**0.43**		**0.54**		**0.17**	

* P: Errors that were preceded in the previous two fields by another error, a planned anomaly or unplanned event.
#ALL: The total number of fields in which errors occurred.

<u>Trackball versus Device Usage</u>

Table 12, below, lists the number and per cent of times that, given a choice situation, the test subjects used the Keypad or the Voice system, compared to the trackball, for "page up" or "page down." As can be seen, the actual number of usages was very similar between the data entry devices, both with and without anomalies. In the Keypad without Anomaly condition, there were 31 total choices, while in the Voice without Anomaly, there were 30. The distribution between device versus trackball was almost identical in both conditions (60%:40%). The occurrence of a planned anomaly increased the times for a choice between the device and trackball; under both the Keypad and Voice conditions with Anomaly, 47 opportunities existed for a choice. Again, little difference was seen in the distribution of preference between the device versus the trackball (Keypad, 62%:38%; Voice 68%:32%)

Table 12 Usage of the Data Entry Device versus the Trackball (TB) under Anomalous and Non-Anomalous Conditions

	Keypad Without Anomaly		Voice Without Anomaly		Keypad With Anomaly		Voice With Anomaly	
Device:	Keypad	TB	Voice	TB	Keypad	TB	Voice	TB
# of Choices	18	13	18	12	29	18	21	15
Total Choices	31	31	30	30	47	47	47	47
%	**58**	**42**	**60**	**40**	**62**	**38**	**68**	**32**

Table 13, below, provides a summary of the quantitative data analyses comparing the data entry device conditions performed for the study.

Table 13 Summary of Quantitative Results

Analysis	Results
Figure 7: Whole Session Time	There was a significant main effect of entry device, but no effect of anomaly and no significant interaction between entry device and anomaly condition. The Manual Keypad conditions were not significantly different from the Voice conditions. The Pen and Paper condition was significantly slower than the Manual Keypad conditions but no slower than the Voice conditions.
Table 5: Subtask Times/ Subtask	There were no statistically significant differences between the conditions for the subtasks main effects or interactions.
Figure 8: Entry Times for Session w/o Errors	No significant differences between data entry conditions. When the data were analyzed for only the two electronic conditions (pen and paper excluded), there was a significant effect of device (Keypad versus Voice, $p = 0.047$) with no effect of Anomaly and no interaction between Device and Anomaly. While this comparison is statistically significant, the degree of difference between the devices (Keypad: 3.99 ± 0.39 seconds versus Voice: 4.90 ± 0.40 seconds; e.g. approximately 1.0 second) is minimal in the context of a 35 minute task.
Table 6: Entry Times for Subtasks w/o Errors	Small but significant differences between the data entry conditions were found on the Testes Dissection and on the Adrenal Dissection. Testes: Voice with Anomaly was significantly slower that Keypad with or without Anomaly and from Pen and Paper. Adrenal: Keypad without Anomaly was significantly faster than Voice with or without Anomaly.
Table 7: Entry Times for Session with Errors	No statistical analyses were performed on these data due to the high number of empty cells (no errors or problems) in the Pen and Paper and Keypad with Anomaly conditions. Nevertheless, it is apparent that the times under these conditions, as well as generally under the Keypad without Anomaly conditions, are similar to those for data entry times when no subject or system error occurred (Figure 8 and Table 5, above; range of 3.31 to 6.11 seconds). Subject errors and system problems occurred for all the subjects in the Voice conditions, and required a considerable period of time for correction (range of 11.00 to 40.14 seconds).
Table 8: Number of Errors by Subject by Device Condition	Pen and Paper had the fewest total number of errors; however 4 of the 5 errors were left uncorrected. The number of errors in the Manual and Voice conditions were higher than those in the Pen and Paper conditions, and were similar to each other. In addition, virtually all the errors were corrected in either electronic data entry device condition. No consistent effect of the anomaly.

Analysis	Results
Table 9: Total Number of Subject Errors during the Test Runs with or without Anomaly	The presence of a planned anomaly, "procedure display failure," did not produce a consistent effect upon the occurrence of subject errors during a test run. An opposite distribution of errors occurred in the Manual versus the Voice conditions, with and without Anomaly.
Table 10: Frequency of Errors in Fields following a Planned Anomaly	The number of subject errors using the Keypad were very similar with and without an anomaly. However, in the Voice condition, the anomaly appeared to produce an increased number of subject errors. With the introduction of a planned anomaly, the Voice system appeared to be sensitive to some additional level of stress in the test subject so that the number of errors/events increased compared to the non-anomalous condition. No effect on "errors/events of any kind".
Table 11: Number of Errors Preceded by Errors Compared to Number of Total Errors	The error rate appeared less for Pen and Paper and higher for Voice with Anomaly; however, error rates were not statistically different between the device conditions.
Table 12: Use of Trackball vs Device during Session (with or without Anomaly)	In the Keypad without Anomaly condition, there were 31 total choices, while in the Voice without Anomaly, there were 30. The distribution between device versus trackball was almost identical in both conditions (60%:40%). The occurrence of a planned anomaly increased the times for a choice between the device and trackball; under both the Keypad and Voice conditions with Anomaly, 47 opportunities existed for a choice. Again, little difference was seen in the distribution of preference between the device versus the trackball (Keypad, 62%:38%; Voice 68%:32%)

Voice System Analysis

Despite the fact that significant effort had been made to identify a voice system with a high degree of recognition, there were still a considerable number of instances of "wrong responses" and "no responses" by the system (Table 14). Rough calculations based on the possible number of essential utterances (numbers, "enter," "wake up," and "go to sleep"), not including "page up" and "page down" or "erase," during a test run, show that the recognition rate for the Voice Condition without Anomaly was 88.6% and for the Voice Condition with Anomaly was 90.4%.

There is no statistically significant effect of a planned anomaly on the frequency of "no responses" or "wrong responses" by the Voice system.

Table 14 Frequency of Voice System Problems

Voice without Anomaly		Voice with Anomaly	
No Response by System	Wrong Response by System	No Response by System	Wrong Response by System
9.63 + 4.60*	5.38 + 1.70	7.00 + 3.30	5.63 + 1.90

* number of occurrences per test run; mean + SEM

The efficiency of the Voice system, when all the possibly entries were considered, is shown in Table 15. These data tabulate the total number of times a particular entry was necessary to be used during the test runs across all the test subjects (Column A) as well as the total number of attempts that were required to input the entry correctly (Column B). Dividing (B) by (A) resulted in a ratio which indicated the efficiency of the voice system. The overall (mean) efficiency was 85%; with a range of 73 to 100%.

The efficiency of an entry was unrelated to the presence or absence of the anomaly (see Appendix, Document 15) as well as to the number of times that an entry was used in a data field. For example, "page up" was used only three times and had an efficiency rating of 100%; "zero" was used 80 times with a rating of 93%; "enter" was used 414 times and had a rating of 94%. The lowest rating, 73%, was associated with "two" which was used 143 times. These data suggest that it is not the number of times used which affects the efficiency of the entry, but rather that something in the phonetics of the entry made it difficult for the system to recognize. For example, the term "erase" had a relatively low efficiency rating of 77% and, of course, was used only when an error, either subject or system, occurred. It is possible that the anxiety associated with error occurrence and subsequent correction affected the pitch, volume or pronunciation of the word such correct recognition by the voice system was reduced. On the other hand, the term "enter" had a rating of 94% - possibly reflecting the confidence and comfort-level of the subjects when a correct entry was contained within a field. However, this "emotion-related" hypothesis does not explain the difficulties with "two."

Table 15 Efficiency of the Voice Data Entry System

Entry	(A) Total Number of Times Used in Data Fields	(B) Total Number of Attempts to Enter Correctly	Efficiency Index*
0	80	86	0.93
1	99	114	0.87
2	143	197	0.73
3	106	112	0.95
4	86	97	0.89
5	154	175	0.88
6	155	173	0.90
7	72	85	0.85
8	128	145	0.88
9	99	119	0.83
Point	94	109	0.86
Check Mark	65	71	0.92
Enter	414	441	0.94
Erase	134	175	0.77
Page Up	3	3	1.00
Page Down	54	66	0.82
Go To Sleep	246	296	0.83
Wake Up	244	320	0.76
Overall	**2376**	**2784**	**0.85****

* Efficiency Index: Total Number of Attempts to Enter Correctly (B) divided by Total Number of Times Used in Data Fields (A)

** A ratio of the overall real numbers

Subjective Data

Immediately following the test runs, the test subjects were given a Questionnaire to allow them to record their opinions about the data entry systems. Aspects of the systems such as ease of learning the system, ease of entering data and commands, correcting anomalies and errors and efficiency of performing the procedures were evaluated in a paired comparison format, as described in the Test Design section. In addition, the Questionnaire asked the subjects about their overall preference and rating of the data entry systems.

The responses to the Questionnaire are shown in Table 16; the number of times the systems were chosen for each paired comparison are tabulated. The higher number for each paired comparison is highlighted to indicate the preferred system. The response to the first question showed that the Voice System was clearly perceived as the most difficult system to learn, while the Pen and Paper System was thought to be the easiest to learn. For the second characteristic, the ease of entering data, the Keypad System was clearly preferred over both of the other systems. Questions 3, 6 and 8 pertained only to the electronic systems, and the Keypad System was preferred over the Voice System for all three performance characteristics: ease of entering commands, remembering commands and recovering from anomalies. Responses to questions 4 and 5 indicate that the Keypad was the best system for correcting mistakes, while the voice system was the least preferred system for correcting mistakes. Both electronic procedures were preferred over the Pen and Paper System for keeping place in the procedures and efficiency of performing the procedures (Questions 7 and 9).

In their response to the last question, the test subjects indicated a strong overall preference for either electronic system over the Pen and Paper System, and slightly preferred the keypad over the voice system. It is interesting, however, that in totaling the number of times each system was chosen in the paired comparisons of these nine specific aspects of the systems, a slightly different conclusion could be reached. For those aspects covered in the questionnaire, the keypad still was clearly preferred over the other two systems, but the Voice and the Pen and Paper Systems were chosen about the same number of times overall.

Table 16 Results from the Questionnaire Comparing Characteristics of the Three Data Entry Devices *

PAIRED COMPARISONS	PEN VS KEYPAD		PEN VS VOICE		KEYPAD VS VOICE	
	PEN	KEYPAD	PEN	VOICE	KEYPAD	VOICE
1. EASE OF LEARNING THE SYSTEM	5	3	7	1	8	0
2. EASE OF ENTERING DATA	1	7	4	4	7	1
#3. EASE OF ENTERING COMMANDS	N/A	N/A	N/A	N/A	5	3
4. EASE OF CORRECTING WRONG NUMBERS	2	6	5	3	8	0
5. EASE OF CORRECTING WRONG FIELD	3	4	5	2	6	1
#6. EASE IN RECOVERING FROM ANOMALIES	N/A	N/A	N/A	N/A	7	1
7. EASE OF KEEPING PLACE IN PROCEDURE	2	5	2	5	3	3
#8. EASE OF REMEMBERING COMMANDS	N/A	N/A	N/A	N/A	6	1
9. EFFICIENCY OF PERFORMING PROCEDURES	2	6	3	5	5	3
10. OVERALL PREFERENCE	1	7	2	6	5	3
TOTAL TIMES CHOSEN	16	38	28	26	60	16

* Highlighted cells indicate the preferred device
# Applicable to electronic system only

Test subjects were also asked to provide an overall numerical rating of the data entry systems, with 10 for the best system, and 1 as the worst. The results are shown in Table 17. The numerical ranking by the subjects was consistent with the results of the paired comparison of overall preference (Table 16, above), with the Keypad System ranking highest, the Voice System second, and the Pen and Paper System last.

Table 17 Results of Questionnaire: Numerical Ranking of the Data Entry Devices

Test Subject	Pen and Paper	Keypad	Voice
1	4	8	6
2	3	9	8
3	7	9	4
4	4	3	5
5	7	8	6
6	3	9	8
7	4	6	8
8	7	4	8
Average (Mean)	4.9	**7.0**	6.6

Ranking of 10 = Best System, 1 = Worst System

Another way to look at the overall preferences of the test subjects is shown in Table 18, which summarizes the number of times the test subjects chose each data entry system as their first, second or third choice. Again, the Keypad emerges as the first choice, the Voice second, and the Pen and Paper System last.

Table 18 Results of Questionnaire Ranking the Overall Preference of the Data Entry Systems

	First Choice	Second Choice	Third Choice
Keypad System	**5**	1	2
Voice System	3	3	2
Pen and Paper System	0	4	4

Additional comments were written in at the end of the questionnaire or submitted sometime after the test runs. The test subjects had varying perspectives and concerns, but some comments were quite consistent. The comments on the Pen and Paper System repeatedly describe it as cumbersome, awkward, in the way, and least preferred, whereas the Keypad System was described as very familiar, less cumbersome and requiring the least attention. Each of the following comments describing the voice system was also mentioned by several test subjects:

- The Voice System is very desirable due to the "hands free" operations
- It was inconvenient to have to turn the voice system on and off during the procedures
- The Voice System was the least familiar system and required more training to begin to feel comfortable

- It is very irritating when the Voice System makes a recognition error
- One or two backup systems would be required: pen and paper, a keypad, tape or video recorder

There were also many varying comments regarding the Voice System, which prompted the study team to develop another questionnaire. The follow-up questionnaire was generated almost exclusively from comments by the test subjects in order to find out if there was agreement concerning various features and characteristics of the voice system. The thought was that perhaps the Voice System would compare more favorably with the Keypad System if some slight modifications were made. The results of the follow-up questionnaire made it clear that there was little agreement in what additional features or modifications would be desirable, aside from perfecting the voice recognition capabilities. Table 19 summarizes the questions and responses.

Table 19 Summary of Responses by Test Subjects to the Follow-up Questionnaire

	Question	Representative Responses
1.	What did you like about using the voice system?	Hands free, efficient, more room in glovebox.
2.	What functional capabilities did you like to use the voice system for? Navigation? Numerical data input?	Navigation(1 person), Numerical data input (3 people), Both (3 people), Neither (1 person). Comments: Numerical entry was difficult. Numerical entry was great!
3.	What changes can you think of that would make the voice system more user friendly?	Better recognition. Ability to customize commands. Prompt to show what procedure you're on. Audible cue of failure. Audible input verification. Cue in procedures to remind operator to put system to sleep.
4.	If these changes were made to the voice system, do you think you would prefer the voice system over a keypad or pen and paper system if you didn't before?	Yes; No; I think so; No; Absolutely; Yes; Liked voice before; No.
5.	If the following changes were made, would the voice system be significantly easier to use? a)System "Goes to Sleep" automatically; b)System turns on automatically; c)change vocabulary, d) Visual verification of operating mode; e)Cue of recognition error	6 people said yes it would be significantly easier, 2 said no. 3 didn't want a), mixed response to b) and c), and generally positive feedback to d) and e)
6.	Agree or Disagree with each of 7 comments	Agreement on ease of knowing system status, efficiency of hands free, vocabulary easy to remember, wearing headset not a problem and concern about accuracy of data. No consensus on how much time to learn voice well or difficulty to pronounce vocabulary.

	Question	Representative Responses
7.	How much would more training and practice working with the voice system have affected your impressions?	Big difference (1 person), some difference (4 people), little difference (2 people), no difference (1 person)
8.	How would it affect your impression of the voice system if additional commands were available which would minimize or eliminate the need for a trackball?	Great idea (4 people), might be OK (3 people), no difference (1 person)
9.	Is current recognition technology mature enough to judge?	Yes (1 person), No (1 person), Don't know (2 people), Our system showed potential for technology (2 people), we didn't have most mature technology (1 person), the technology is not acceptable (1 person).
10	Other comments?	No (2 people), I like it (2 people), recognition problems were frustrating and irritating (2 people), effort should be continued because potential has been proven (2 people)

DISCUSSION

The purpose of this study was to examine the utility and efficiency of two types of electronic systems (Keypad or Voice) for entering data directly into electronically displayed experimental procedures inside a glovebox work volume. The effects of introducing a planned anomaly into the testing for the electronic systems were also evaluated. The results were compared to a baseline Pen and Paper system.

The results of the study showed no substantive quantitative differences between the two electronic systems for time to complete the whole test run and time to complete the subtasks within each test run (Figure 7, Table 5). The times for these variables include the times for the subject to make error correction, deal with problems with the data entry systems (e.g. "no response" by the voice system) and other events (e.g. failure of the scale to work properly). These data show that, while the time to correct subject or system errors was longer with the voice system than with the other systems (Table 7), it was not long enough to have a significant effect on total or subtask completion time. Finally, the introduction of a planned anomaly in the electronic systems had no effect on these parameters.

Regarding data entry time in a field where no subject or system problems occurred, there were no statistically significant differences between Keypad, Voice or Pen and Paper systems, with or without Anomaly (Figure 8), when mean data entry time for the whole test run was considered. However, when the Pen and Paper system was excluded from the analysis and only the electronic systems were compared, the Voice system was slightly slower than the Manual, independent of a planned anomaly. Although the difference of approximately 1.0 second was statistically significant, it is a minimal contributor to time within the context of a 35 minute task. A similar finding was seen when subtask time was evaluated (Table 6): small but statistically significant differences were seen in the Testes and Adrenal dissections, with the Voice system slower than the Keypad. Again, the difference was approximately 1.0 second and probably inconsequential in the context of time to perform a 35 minute task.

The total number of number of subject errors during a test run were equivalent between the Keypad and Voice systems and virtually all the errors were noticed and corrected by the subject (Table 8). The Pen and Paper system had far fewer errors than the electronic systems but, interestingly, most of them were left uncorrected. It may be that, because of the extreme familiarity of the Pen and Paper system, even though subjects were instructed to verify their data entries, the subjects were slightly more casual regarding verifying the accuracy of their entries. With this scenario, errors would be passed on in the recording of the data and would never be corrected. False data would become part of any further analyses that might be performed and incorrect conclusion might be drawn. Despite any other problems with electronic systems, this possibility suggests that electronic systems may be more reliable than the ostensibly well-practiced recording of numbers on a piece of paper.

The presence or absence of an Anomaly had no consistent effect on the total number of subject errors which occurred during a test tun (Table 9); in fact, the distribution of subject errors during a test run was 180^{o} out of phase between the Keypad and the Voice conditions. In addition, the hypothesis that "errors will beget errors" (Table 11) was not supported: there was no difference between the anomalous and non-anomalous conditions with either device regarding the proportion of errors that were preceded by "events" compared to the total number of errors which occurred during a test run. Lastly, there was no difference between the Keypad and Voice conditions (independent of anomaly) regarding "errors begetting errors" for the test runs.

However, when total errors/events (subject errors, procedural mistakes, system problems) in only the two data fields immediately following an Anomaly are considered, the Voice system was more susceptible to errors than the Keypad (Table 10). A voice recognition system is sensitive to changes in speech patterns, pitch, and loudness, and the anomaly may have affected the subjects in a manner that then resulted in these changes in their speech (3). Despite that fact that considerable effort had been made to select a voice system which was robust and impervious to these variables, these data suggest that it may indeed have been sensitive to these effects. In fact, previous research (3, 4, 5) indicate that the accuracy of speech recognition attained in this study (88.0 - 90.0%) is similar to other reported recognition rates.

Taken together, the above quantitative data actually speak highly for the performance of the Voice system. This system was far less familiar and required more training than the Keypad and was considered frustrating and irritating by many of the subjects because of the non-recognition and wrong recognition problems. Nevertheless, no substantive differences in time or errors (with the exception of errors immediately following a planned anomaly) were seen between the Keypad and Voice systems.

However, the test subject's subjective evaluations of the electronic systems revealed substantive differences between the two electronic systems (see Table 16). The Voice system was perceived as far more difficult to learn than the Keypad or Pen and Paper systems. This perception is certainly not hard to understand and is, in fact, based on reality. Use of pen and paper and keypads (calculators, computer keyboards) is commonplace and they are used practically every day, particularly by the test subjects in this study. Use of Voice systems, however, is not common in the general workplace and none of the subjects had any previous experience with this technology. During the training sessions, the subjects reported that they were nervous and anxious and felt somewhat intimidated by the system. Once they had practiced with the system for awhile, their comfort-level increased, but, of course, never reached the level of that with the Keypad or Pen and Paper systems.

This difference in familiarity of the subjects with the two electronic systems is an inherent problem with this study and certainly contributed to the overall preference rating (Tables 17 and 18) of the devices which showed that, although Voice and Keypad were preferred to Pen and Paper, Keypad was preferred to Voice. To paraphrase a verbal comment made by a few of the subjects: "Ten years ago I might have preferred the Pen and Paper system to the Keypad, based on familiarity and practice, but now, I am so familiar with a keypad-like system (computers, calculators) that there is no comparison. Ten years from now, with more exposure, I might very well prefer Voice to Keypad. But, right now, Keypad is what I feel comfortable with." This feeling was reflected in the number of Total Times Chosen (Table 16), with Keypad being chosen 60 times compared to the Voice system being chosen 16 in the forced-choice situation. However, only one subject commented that more training and practice would have made a "big difference" in their impressions of the voice system (Table 19, Question 7)

The responses to the follow-up questionnaire (Table 19) reveal the great subject variation in perceptions of the Voice system and suggestions on how to improve it. The only responses that were consistent across all subjects were: the positive attribute of "hands-free" operations in the glovebox, the observation that recognition capability should be improved and the comment that they did not mind wearing a headset while working. Other than that, opinions covered the whole spectrum of possibilities. For example, for Question 4, "If (these) changes were made to the voice system, do you think you would prefer it over keypad?", the answers ranged from: "Yes, No, I think so, No, Absolutely, Yes, No, I liked it before." Clearly, there was no consensus on changes that should be made or on what effect they would have on the useability of the system.

In a group debrief following the completion of all the testing with all the subjects, the subjects were surprised that there were no quantitative differences in time and errors between Keypad and Voice conditions; they perceived the Voice system as difficult and error-prone and had assumed that whole session times and the number of errors must certainly have been greater using the Voice system.

The subjective data discussed above demonstrate clearly that quantitative data (time and errors) alone are not sufficient to evaluate the usefulness of a particular data entry system. The perceptions of the user are critical, and, as was seen in the comments in the follow-up questionnaire, show great variability from subject to subject.

The usefulness of a voice system in a closed work volume such as a glovebox appears self evident: hands-free operations are a positive aspect of this system and it has the appearance of an efficient, high-technology system. Nevertheless, even the very best voice system technology has a correct recognition rate of approximately 98%. The voice system used herein was considerably worse than that. The absolute necessity for accurate data entry during procedures on Space Station would argue against accepting even a 98% accuracy rate; however, error correction is always possible and was 100% for the voice system in the present study.

An additional consideration regarding voice systems is the voice recognition vocabulary to be implemented. All the subjects in this study were native English speakers (seven American and one English) and the vocabulary file used with the software application was "American English." On the International Space Station, users of the Life Sciences Glovebox will originate from a number of countries, with varying accents and languages, and this also could increase the complexity of a voice system used under these conditions.

A further consideration in data entry device selection is development time and impact to schedule. Considerable time was spent in developing, installing and trouble-shooting the performance of the voice system software, much more so than that with the Manual system. In addition, although all study participants were English speakers and the software was designed to recognize this idiom, a significant amount of time was spent training each subject, as well as the system itself, to achieve a reasonable recognition rate. Familiarity and a feeling of comfort with a system is critical for an accurate and reliable interaction between a user and a data entry system. None of the subjects in the present study had experience with a voice system, and, although their interest and curiosity were very high, they were nervous during the training and on the test day. All subjects were very comfortable with the Manual system. Such a situation may exist with future users of data entry systems on the Space Station. Not all users will be pilots, but instead may be scientists and researchers; experience with a voice system may be limited with these operators also.

A manual system has many obvious benefits: familiarity (e.g. less training required), and, possibly, additional reliability on-orbit since it is not susceptible to factors that can affect voice, such as changes in stress level, health or positioning of a microphone. In addition, it's development time will likely be short, with less impact on budget and schedule. However, its main disadvantage is its use of glovebox "real estate," a limited and precious commodity in a confined volume.

Although the Voice system used in this study did not prove to be more efficient than the Manual system, the fact that times and errors were equivalent, in spite of recognition problems and familiarity, clearly shows the potential of the technology to provide a more efficient voice system in the future. However, the intent of this study was to evaluate electronic data entry device systems at the current level of technology so that a recommendation could be made now for a system to be incorporated in the development of the Space Station Life Sciences Glovebox. The qualitative data from the subject preferences and the quantitative data regarding voice system recognition and efficiency rates argue against a recommendation for a voice system in the glovebox development.

Whatever system is utilized in the Glovebox, it is apparent that reduction of risk is a primary consideration. With either a Voice or a Manual electronic system, redundancy is a necessity. Even with a manual system, a back up system would be required to ensure continual data processing in the face of a failure of the primary system.

CONCLUSION

The recommendation by the study team is for a manual electronic data entry system to be used within the glovebox. Electronic data entry systems were preferred to the baseline Pen and Paper type system, and their performance was not affected significantly by the introduction of an anomaly. The lack of familiarity, cost, development time, training time and potential non-universality of a voice system across a variety of international users imparts a level of difficulty into its implementation that is not found with a more conventional manual (keypad) type of system. In addition, the inherent characteristic of a voice system for "non recognition" or "misunderstanding" of data entry conveys a risk regarding the necessity for accurate data entry during Space Station glovebox operations. Ultimately, redundant data entry systems must be employed in order to ensure reliable data entry under these conditions.

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APPENDIX

Document 1. General Requirements for Data Entry Systems

Parameter	Requirement	Rationale/Use
Data type	Numeric input	- Need a reliable means of recording specimen identification numbers, sample mass, etc.. - If a barcode reader and/or direct input from laboratory equipment is used as the primary input mode, still require a back up system to record numeric data in the event of barcode reader failure.
Cursor control/navigation	Cursor navigation & control	- Need a means to navigate the cursor to the desired location on the video screen and to select options/menu options.
Training	Require limited training of new users	- The ultimate users of the data input system will be the Space Station astronauts. The amount of time required to learn the data input system should be as small as possible since training time from the astronauts will be very precious and difficult to obtain. - If the data input system is too difficult to learn or has a very steep learning curve, new users will quickly become frustrated and not want to use the device.
Training/Recall	System should be "intuitively obvious" to first time/previously trained users	- The system should be simple/obvious enough so that users will be able to use the system after a potentially long period of time between device training and actual use on station.

Parameter	Requirement	Rationale
Error correction	Ability to correct data input errors efficiently	- Uncorrected errors could severely contaminate or invalidate experimental results. Input system must accommodate correction of data input errors.
Operational requirement	Ability to program defined function "keys" - macros	- Use of function keys for frequently used keystroke sequences will reduce the time required to perform the task each time. Reduction in the time required to input data will result in a reduction in the total time required to perform procedures at the glovebox.
Functional environment	Data input system must function in both μg and in 1g	- Input device training will be conducted on the ground within a 1-g field. The flight unit must function within the μg environment on the Space Station.

APPENDIX

Document 2. Specific Requirements for the Voice Data Entry System

Parameter	Requirement	Rationale
Substitution error (Incorrect word recognized)	Less than 2% *	- Critical that the system have a high recognition accuracy and that words are not incorrectly recognized. - As the efficiency of the input device degrades from some expected level, the frustration of the user will increase, making for an "unfriendly" system. (applies to the next two requirements as well)
Rejection error (Correct input not recognized)	Less than 3% *	- Important that valuable astronaut time is not spent reentering data that was not recognized the first time.
Spurious response error (Invalid input recognized)	Less than TBD *	- System should be robust enough to distinguish non-verbal sounds from spoken input.
Recognizer type	Speaker independent	- Given the limited amount of training time that will be available, the system should require as little pre-training as possible.
Recognizer type	Adaptive	- The effects of microgravity on the acoustical quality of the human voice have not been rigorously investigated. However, anecdotal information indicates that the voice may change due to fluid shifts experienced in the microgravity environment. The voice system should be capable of adapting (automatically or with as little additional "training" as possible) to the changes that may occur to the voice (from previous voice files made on the ground).

Parameter	Requirement	Rationale
Response time	Less then TBD	- System should respond to verbal input within a "reasonable" amount of time. If the response time is greater than expected, users will experience greater frustration. Error rate may increase.
Functional environment	Functional in Space Station cabin acoustical environment (Cabin design specification: to meet NC-40 noise contour. Overall SPL 65.0 dB. *(Additional information available upon request)*	- Must be able to perform efficiently within the Space Station cabin acoustical environment. (Also applies to microphone)

Microphone (Part of Voice):		
Signal to Noise Ratio	Greater than TBD	- In order to use a voice recognition system within potentially "noisy" environments such as the space station, the microphone should have the ability to reject as much of the background noise as possible - increasing the recognition rate.
Mounting	Should be "head" mounted	- Want to give the glovebox operators the maximum freedom of movement while not sacrificing recognition rate. "Headset" mounting appears to best meet this need.

APPENDIX

Document 3. Specific Requirements for the Manual Data Entry System

Parameter	Requirement	Rationale
Dimensions of input device (portion that resides within the work volume)	As small as possible and yet still provide functional capability	- Space within the glovebox work volume will be at a premium. Every effort should be placed on defining an input device that will not take up much needed floor area and volume.
Surface characteristics	Portions of the data input system that reside in the work volume, must be cleanable and water-resistant.	- The surfaces of items that will be used within the Life Sciences Glovebox work volume will become wet and dirty since operations expected to be performed will wet the hands of users and therefore, the input device.
Surface characteristics	Portions of the data input system that reside in the work volume, must be capable of functioning even if the operator is wearing gloves. *(typically, surgical)*	- Many operations that will be performed with the hands of operators covered with (surgical) gloves. The input device must function within this constraint.
Surface characteristics	For the manual data input system, the surface should be textured (i.e. raised, dimpled, etc.) to give users tactile feedback during use.	- Many operators find tactile feedback that buttons or indentations provide, to be useful. - May reduce the number of data input errors.
Spacing of "keys"	For the manual data input system, "keys" should be adequately spaced so that "keys" will not be accidentally activated.	- Proper spacing of "buttons/keys" will reduce the number of data input errors.
Handedness of device	Should not be handed or be more difficult to use with one hand or the other.	- Must be able to work efficiently for both left handed and right handed users.

Parameter	Requirement	Rationale
Visual Feedback	Visual representation of data input on computer screen such as the "electronic calculator" or on input device	- Reduces the number of data input errors since the "keypad" could be view simultaneously with the data entry field. As indicated above, uncorrected errors could severely contaminate or invalidate experimental results.
Relocation	Must be able to move portion of device that is in/resting on the work volume interior	- Users must be able to move the device to the optimal location for each procedure.

APPENDIX

Document 4

THE EFFECT OF TYPE OF SCREEN DISPLAY ON TIME AND ERRORS IN A DATA ENTRY TASK

Moira LeMay, PhD

The type of data entry device to be used in a bioisolation laboratory aboard the Space Station has been of concern for sometime. In addition to a voice system and simple pen and pencil data entry, a keypad with a cursor control capability has also been proposed. The question then arose: must a keypad be provided with a small window display (probably LED) just above the pad to display the numbers as they are entered, or can the operator be required to observe the numbers being entered on a display screen which is several feet away? The latter would require a head movement to observe both fingers and the keypad and then the displayed numbers.

The literature did not provide an answer to this very specific question, therefore the study described here was performed to determine whether or not this small display difference would affect the time taken or errors made in entering a set of data, similar to the data that will be used in the Glovebox Risk Reduction Study.

METHOD

Subjects: A sample of convenience consisting of 15 students and faculty members (11 females and 4 males) at a New Jersey state university served as subjects.

Apparatus: A computer running Word Perfect on DOS was set up so that the monitor was on a shelf at approximately eye level and three feet away from a subject seated at a keyboard. The keyboard had a standard number pad with 1/2 inch keys mounted on the right side, and subjects were instructed to use it in entering the numbers in a specially prepared data set. In another room, a specially purchased printing calculator with similar 1/2 inch keys and with a small LED display which showed the numbers as they were entered was used by the subjects to enter a similar data set.

Two data sets were prepared, each with ten, 8-digit "identification" numbers and sixteen decimal numbers meant to simulate weight or mass measurements. Numbers were chosen from a table of random numbers. The sets are shown in Table 1.

Procedure: Each subject was seated in front of either the computer or the calculator and presented with one of the data sets. The order of presentation of the computer or the calculator was alternated between subjects and the data sets were alternated between the computer and the calculator. Subjects were instructed in the use of a reaction timer which they used to time their performance of the data entry task. The following instructions were then read:

> Your task is to enter this data set into the calculator (computer), and to time yourself on this reaction timer while doing it. To start, press this key (indicate key on reaction timer) and then begin to enter the data.
>
> (For calculator: After each number is entered correctly, press the "#p" key, and the number will be printed. You do not have to wait for the printing to finish before entering the next number. If you see on the display that you have entered a number incorrectly, press the "C/CE" key to clear it and then enter it again.)
>
> (For computer: Use the number pad on the side of the keyboard. Observe the numbers on the screen as you enter them and correct them as necessary. As you finish entering each number, press the "ENTER" key.)
>
> When you are finished entering the numbers, press this key (indicate the proper key on the reaction timer). This will display the time that you finished entering the data. Enter this time at the bottom of your data sheet.

RESULTS

Subjects' tapes from the calculator and printouts from the computer were compared with the original data entry sets to obtain the number of errors and the time in seconds to enter the data for each subject using each device. This data is presented in Table 2.

Table 2

	Computer	Calculator
Mean (± SEM) errors	0.13 ± 0.09	0.67 ± 0.32
Mean (± SEM) Time	126.30 ± 10.3 seconds	132.07 ± 9.64 seconds
Error rate	.005	.026

No significant differences between the computer and the calculator were found for mean errors, t=0.1.524, p=0.15, or for mean time, t=0.636, p=0.52. The insignificance of the large difference in mean errors is accounted for by great variability in number of errors, with most subjects making zero errors but three subjects making three errors each in the calculator condition. Two of these subjects noticed their first error (only one corrected it) and this appeared to lead to the other two errors.

DISCUSSION

The results indicate that there is no difference in performing data entry that is affected by having to look up at a screen to check the accuracy of the data entered as opposed to checking it on a small display immediately above the keypad. Even the seemingly large difference in mean error was only due to chance. It is not possible to assess error rate in a statistical test, but the observation that only three subjects contributed to the high rate with the calculator, and for two of them the errors seemed to be related, supports the finding of a chance difference in the means, i.e., once a chance error is made, it is likely to be followed by other errors.

Since no effect of device display mode was found on data entry, it should be possible to use a keypad without a display, similar to the computer mode in this experiment, for carrying out the main experiment to evaluate data entry performed in the glovebox.

Table 1

Data Set One	Data Set Two
39242954	17639382
7.41	5.94
59.81	21.99
46251254	42396401
65.55	12.21
99.18	33.28
35641003	13318141
1.40	9.29
60677150	60571547
66.31	26.28
20.42	18.55
28701569	72865168
7.45	8.65
62.61	3.96
93945062	56324310
75.69	77.92
29211691	78192212
14.29	91.39
5.03	7.23
57071903	64666347
12.91	97.29
8.89	9.27
78471577	82201756
41.13	28.08
89242793	15360737
84.39	40.91

APPENDIX

Document 5. Pen and Paper Data Sheet Used Within the Glovebox

Test Subject: ________________ __ Date: ___________

2. Time Start: [ ]

8. Perform Health Check.

Normal Coat [ ]
Hair Rough [ ]
Skin Lesions [ ]
Normal Eyes [ ]
Discharge From Eyes [ ]
Normal Respiration [ ]
Laborerd Breathing [ ]
Sneezing [ ]
Nasal Discharge [ ]
Abdomen Distended [ ]

9. Time Health Check Complete: [ ]

10. Locate and enter specimen ID number :

Specimen ID # [ ]

14. Determine specimen mass (with restraint):

Specimen Mass [ ]

20. Record RCC ID Number:

RCC ID # [ ]

25. Time Specimen ID Complete: [ ]

36. Determine mass of heart on MMMD:

Heart Mass [ ]

41. Record bag ID number:

Atria Bag # [ ]

45. Record bag ID number:

Right Ventricle Bag # [ ]

48. Record vial ID number:

Left Ventricle Vial # [ ]

51. Time Heart Dissection Complete [ ]

58. Determine testis mass on MMMD:

Testis #1 Mass [ ]

59. Record bag ID number.

Testis #1 Bag # [ ]

65. Determine testis mass on MMMD:

Testis #2 Mass [ ]

66. Record vial ID number:

Testis #2 Vial # [ ]

69. Time Testis Dissection Complete: [ ]

74. Record bag ID number:

Duodenum # 1 bag # [ ]

77. Record vial ID number:

Duodenum #2 vial # [ ]

80. Time Duodenum Dissection Complete [ ]

86. Determine mass of adrenal on MMMD:

Right Adrenal Mass [ ]

87. Record vial ID number.

Right Adrenal Vial # [ ]

95. Determine mass of adrenal on MMMD:

Left Adrenal Mass [ ]

96. Record vial ID number.

Left Adrenal Vial # [ ]

102. Time Adrenal Dissection Complete [ ]

APPENDIX

Document 6. Pen and Paper Summary Sheet for Transcription of Data Following Completion of the Glovebox Procedures

PEN AND PAPER SUMMARY SHEET

Test Subject	
Date of Procedure	3/6/96
TIME Start Entering Data	

Time Stamp

I. Recorded Data

2. Time Start

8. Perform Health Check

Normal Coat	
Hair Rough	
Skin Lesions	
Normal Eyes	
Discharge From Eyes	
Normal Respiration	
Labored Breathing	
Sneezing	
Nasal Discharge	
Abdomen Distended	

9. TIME Health Check Complete

10. Specimen ID #

14. Specimen Mass Grams

20. RCC ID Number

25. TIME Specimen ID Complete

36. Heart Mass Grams

41. Atria Bag #

45. Right Ventricle Bag #

48. Left Ventricle Vial #

51. TIME Heart Dissection Complete

58. Testis #1 Mass Grams

59. Testis #1 Bag #

65. Testis #2 Mass Grams

66. Testis #2 Vial #

69. TIME Testis Dissection Complete

74. Duodenum #1 Bag #

77. Duodenum #2 Vial #

80. TIME Duodenum Dissection Complete

86. Right Adrenal Mass Grams

87. Right Adrenal Vial #

95. Left Adrenal Mass Grams

96. Left Adrenal Vial #

102. TIME Adrenal Dissection Complete

TIME Stop
Entering Data

Time
Stamp

II. Calculated Times

Health Check Subtask

Identification Subtask

Heart Dissection Subtask

Testis Dissection Subtask

Duodenum Dissection Subtask

Adrenal Dissection Subtask

Entire Procedure

TIME To Enter Data

Total Time:
Procedure +
Entering Data: ______________________

APPENDIX

Document 7. Data Summary Sheet for the Elecronic Procedures

Test Subject

Date of Procedure 3/6/96

Time Start

MANUAL DATA DEVICE

I. Health Check Parameters

Normal Coat

Hair Rough

Skin Lesions

Normal Eyes

Discharge From Eyes

Normal Respiration

Labored Breathing

Sneezing

Nasal Discharge

Abdomen Distended

II. Entered Data

Specimen ID #

Specimen Mass Grams

RCC ID Number

Heart Mass Grams

Atria Bag #

Right Ventricle Bag #

Left Ventricle Vial #

Testis #1 Mass Grams

Testis #2 Mass Grams

Testis #1 Bag #

Testis #2 Vial #

Duodenum #1 Bag #	
Duodenum #2 Vial #	
Right Adrenal Mass	Grams
Right Adrenal Vial #	
Left Adrenal Mass	Grams
Left Adrenal Vial #	

III. Stamped Times

TIME Health Check Complete	
TIME Specimen ID Complete	
TIME Heart Dissection Complete	
TIME Testis Dissection Complete	
TIME Duodenum Dissection Complete	
TIME Adrenal Dissection Complete	

III. Calculated Times

Health Check Subtask	
Identification Subtask	
Heart Dissection Subtask	
Testis Dissection Subtask	
Duodenum Dissection Subtask	
Adrenal Dissection Subtask	
Entire Procedure	

APPENDIX

Document 8. Generic Electronic Glovebox Procedures

Test Subject ____________________ Date of Procedure __________

Data Entry Device ____________________

1. Place hands in glovebox gauntlets and on surgical gloves.

2. When ready to start procedure, record time.

TIME START____________________ **Time Stamp**

3. Tare empty rodent restraint cone on the small mass measurement device (SMMD). Leave on SMMD until required.

4. Secure two large towels to Specimen Dissection Platform.

5. Attach head bag to dispatcher to capture head.

6. Remove one specimen from the Habitat.

7. Close and seal habitat access door.

8. Perform Health Check.

"Tab" through the parameters

Select the proper parameters using "enter"

Normal Coat	☐	**Enter**
Hair Rough	☐	**Enter**
Skin Lesions	☐	**Enter**
Normal Eyes	☐	**Enter**
Discharge From Eyes	☐	**Enter**
Normal Respiration	☐	**Enter**
Labored Breathing	☐	**Enter**
Sneezing	☐	**Enter**
Nasal Discharge	☐	**Enter**

9. Record time.

TIME HEALTH CHECK COMPLETE [ ] **Time Stamp**

10. Locate and enter specimen ID number

Specimen ID # [ ] **Enter**

11. Obtain tarred rodent restraint cone.

12. Secure specimen in cone.

13. Place specimen on SMMD.

14. Determine specimen mass (with restraint).

Specimen mass [ ] **Enter**

15. Place specimen in Animal Dispatcher.

16. Decapitate specimen.

17. Discard rodent restraint cone in waste bag.

18. Secure body, ventral side up, specimen tail towards the operator, on specimen dissection platform.

19. Place head (in head bag) in Rodent Carcass Container (RCC).

20. Record RCC ID Number.

RCC ID # [ ] **Enter**

21. Replace RCC.

22. Clean dispatcher with small towels.

23. Discard towels in waste bag.

24. Secure dispatcher away from dissection area.

25. Record time.

Time Specimen ID Complete [ ] **Time Stamp**

26. Using forceps, pull up skin above lower abdomen.

27. With scissors, cut in a mid-ventral line forward all the way to the neck without cutting the body wall under the skin.

28. Pull skin aside and secure with hemostats.

29. Locate xiphoid cartilage. Holding cartilage with forceps, cut through body wall. Cut through diaphragm horizontally on either side of mid-line.

30. Turn scissors at right angle to incision and cut upward toward the neck through the side walls of the chest, through the ribs.

31. Repeat on other side, holding the ventral wall up to avoid injury to the heart.

32. Remove ventral wall of chest and discard in waste bag.

33. Remove thymus on cranial end of the heart and discard in waste bag.

34. Tare the 8.0 ml vial (with saline) on Micro-Mass Measurement Device (MMMD).

35. Remove heart and place carefully in saline in vial.

36. Determine mass of heart on MMMD.

Heart Mass [ ] **Enter**

37. With forceps, remove heart from vial and place onto towel.

38. Replace vial cap and replace vial in supply kit.

39. Remove atria with razor blade.

40. Place atria in fixative bag.

41. Record bag ID number.

Atria bag ID # [ ] **Enter**

42. Place bag in Refrigerator Storage Pouch.

43. Separate right and left ventricles with razor blade.

44. Place right ventricle in fixative bag.

45. Record bag ID number.

Right ventricle bag ID # [ ] **Enter**

46. Place bag with right ventricle in Refrigerator Storage Pouch.

47. Cut left ventricle in half and place both halves in a 2 ml vial.

48. Record vial ID number.

Left ventricle bag ID # [ ] **Enter**

49. Freeze vial containing left ventricle in Quick/Snap Freezer.

50. Place in cryo sample holding unit.

51. Record time.

Time Heart Dissection Complete [ ] **Time Stamp**

52. Tare a fixative bag on MMMD.

53. If testes are not visible within scrotum, apply slight pressure to the lower abdomen to push testes down.

54. Make an incision into the tip of each scrotal sac.

55. Pull out one testis with forceps, being careful not to damage testis.

56. Cut all attached blood vessels, connective tissue and ducts around the testis with scissors.

57. Place clean testis in tarred fixative bag.

58. Determine testis mass on MMMD.

Testis # 1 Mass [ ] **Enter**

59. Record fixative bag ID number.

Testis # 1 Bag # [ ] **Enter**

60. Place bag in Refrigerator Storage Pouch.

61. Tare 8.0 ml vial on MMMD.

62. Pull out other testis with forceps being careful not to damage testis.

63. Cut attached blood vessels, connective tissue and ducts around the testis with scissors.

64. Place clean testis in tarred 8.0 ml vial.

65. Determine testis mass on MMMD.

Testis # 2 Mass [ ] **Enter**

66. Record vial ID number.

Testis # 2 Vial # [ ] **Enter**

67. Freeze vial containing testes #2 in Quick Snap Freezer.

68. Place vial in Cryo Sample Holding Unit.

69. Record time.

Time Testis Dissection Complete [ ] **Time Stamp**

70. Open up portion of abdominal wall to locate the duodenum in the abdominal cavity.

71. Cut end of the duodenum connected to stomach. Make another cut approximately 2 inches along the intestine.

72. Cut tissue sample in half (two 1 inch portions).

73. Place one portion in a fixative bag.

74. Record bag ID number.

Duodenum #1 bag # [ ] **Enter**

75. Place bag in Refrigerator Storage Pouch.

76. Place other portion of duodenum in a 2 ml vial.

77. Record vial ID number.

Duodenum #2 vial # [ ] **Enter**

78. Freeze vial containing duodenum in Quick/Snap Freezer.

79. Place in cryo sample holding unit.

80. Record time.

Time duodenum dissection complete [ ] **Time Stamp**

81. Tare a 2 ml vial, with cap removed, on MMMD.

82. Locate right adrenal gland embedded in fat just anterior to the right kidney.

83. Using forceps, grasp adrenal and cut around it with dissecting scissors. Remove gland with some surrounding fat.

84. Place on surgery platform and remove attached fat.

85. Place adrenal gland in tarred 2 ml vial and replace cap.

86. Determine mass of adrenal on MMMD.

Right Adrenal Mass [ ] **Enter**

87. Record vial ID number.

Right Adrenal Vial # [ ] **Enter**

88. Freeze adrenal in Quick/Snap Freezer.

89. Place in cryo sample holding unit.

90. Tare a 2 ml vial, with cap removed, on MMMD.

91. Locate left adrenal gland embedded in fat just anterior to the left kidney.

92. With forceps, grasp adrenal and cut around it with dissecting scissors. Remove gland with some surrounding fat.

93. Place on surgery platform and remove attached fat.

94. Place adrenal gland in tarred 2 ml vial and replace cap.

95. Determine mass of adrenal on MMMD.

Left Adrenal Mass [ ] **Enter**

96. Record vial ID number.

Left Adrenal Vial # [ ] **Enter**

97. Freeze adrenal in Quick/Snap Freezer.

98. Place in cryo sample holding unit.

99. Place remaining carcass and towels in rodent body bag and seal.

100. Place rodent body bag next to dissection platform.

101. Record time.

Time Adrenal Dissection Complete [ ] **Time Stamp**

102. Remove gloves and place in waste bag.

103. Remove hands from glovebox gauntlets.

APPENDIX

Document 9. Pen and Paper Observation Sheet
(No anomalies)

Observer/recorder's procedure form

Test Subject ____________________ Date of Procedure ___________

Day # ______

Handedness: R ___ L ___ Time start: _______ Time end: _________

Test Conductor __________________ Test Observer _________________

Video Tape Number ____________ Trainer ____________________

Random Order
pen _____*
keypad, no anomalies _____
keypad, anomalies _____
voice, no anomalies _____
voice, anomalies _____

RECORDED NUMBERS

Specimen ID # ___________________ RCC ID # ___________________

Bag numbers

Bag # ___ ___ ___ ___ ___

Bag # ___ ___ ___ ___ ___

Bag # ___ ___ ___ ___ ___

Bag # ___ ___ ___ ___ ___

Vial numbers

Vial # ___ ___ ___ ___ ___

Vial # ___ ___ ___ ___ ___

Vial # ___ ___ ___ ___ ___

Vial # ___ ___ ___ ___ ___

Vial # ___ ___ ___ ___ ___

Save all bags and vials until errors are checked.

1. Place hands in glovebox gauntlets and don surgical gloves.

2.. When ready, record time.

TIME START ______________

3. Tare empty rodent restraint cone on the small mass measurement device (SMMD). Leave on SMMD until required.

4. Secure two large towels to Specimen Dissection Platform.

5. Attach head bag to dispatcher to capture head.

6. Remove one specimen from the Habitat.

7. Close and seal habitat access door.

8. Perform Health Check. *Start time* ________

Normal Coat	[ ]	Enter
Hair Rough	[ ]	Enter
Skin Lesions	[ ]	Enter
Normal Eyes	[ ]	Enter
Discharge From Eyes	[ ]	Enter
Normal Respiration	[ ]	Enter
Labored Breathing	[ ]	Enter
Sneezing	[ ]	Enter
Nasal Discharge	[ ]	Enter
Abdomen Distended	[ ]	Enter

End time ________

Problems? Y ____ *N* ____

	wrong number	corrected	other	corrected
entry				
entry				
entry				
entry				

9. Record time.

TIME HEALTH CHECK COMPLETE_______

Problem ? Y ___ N ___

Describe ____

10. Locate and enter specimen ID number

Start time _______

Specimen ID # [ ] **Enter**

End time _______

Problems? Y ____ N ____

	wrong number	corrected	other	corrected
entry				
entry				
entry				
entry				

11. Obtain tared rodent restraint cone.

12. Secure specimen in cone.

13. Place specimen on SMMD.

14.Determine specimen mass (with restraint).

*Start time*_______

Specimen mass____________________ ENTER

End time _______

Problems? Y ____ *N* ____

	wrong number	corrected	other	corrected
entry				
entry				
entry				
entry				

15. Place specimen in Animal Dispatcher.

16. Decapitate specimen.

17. Discard rodent restraint cone in waste bag.

18. Secure body, ventral side up, specimen tail towards the operator, on specimen dissection platform.

19. Place head (in head bag) in Rodent Carcass Container (RCC).

20. Record RCC ID Number.

*Start time*_______

RCC ID # [   ] **Enter**

End time ________

Problems? Y ____ *N* ____

	wrong number	corrected	other	corrected
entry				
entry				
entry				

21. Replace RCC.

22. Clean dispatcher with small towels.

23. Discard towels in waste bag.

24. Secure dispatcher away from dissection area.

25. Record time.

Time specimen ID complete ____________________

Problems? *Y* ___ *N* ___

Describe ____

HEART DISSECTION

26. Using forceps, pull up skin above lower abdomen.

27. With scissors, cut in a mid-ventral line forward all the way to the neck without cutting the body wall under the skin.

28. Pull skin aside and secure with hemostats.

29. Locate xiphoid cartilage. Holding cartilage with forceps, cut through body wall. Cut through diaphragm horizontally on either side of mid-line.

30. Turn scissors at right angle to incision and cut upward toward the neck through the side walls of the chest, through the ribs.

31. Repeat on other side, holding the ventral wall up to avoid injury to the heart.

32. Remove ventral wall of chest and discard in waste bag.

33. Remove thymus on cranial end of the heart and discard in waste bag.

34. Tare the 8.0 ml vial (with saline) on Micro-Mass Measurement Device (MMMD).

35. Remove heart and place carefully in saline in vial.

36. Determine mass of heart on MMMD.

Start time _______

Heart Mass [ ] **Enter**

End time ________

Problems? *Y* ____ *N* ____

	wrong number	corrected	other	corrected
entry				
entry				
entry				

37. With forceps, remove heart from vial and place onto towel.
38. Replace vial cap and replace vial in supply kit.
39. Remove atria with razor blade.
40. Place atria in fixative bag.
41. Record bag ID number.

*Start time*_______

Atria bag ID # [ ] **Enter**

End time ________

Problems? *Y* ____ *N* ____

	wrong number	corrected	other	corrected
entry				
entry				
entry				

42. Place bag in Refrigerator Storage Pouch.
43. Separate right and left ventricles with razor blade.
44. Place right ventricle in fixative bag.
45. Record bag ID number.

*Start time*_______

Right ventricle bag ID # [ ] **Enter**

End time ________

Problems? Y ____ N ____

	wrong number	corrected	other	corrected
entry				
entry				
entry				

46. Place bag with right ventricle in Refrigerator Storage Pouch.
47. Cut left ventricle in half and place both halves in a 2 ml vial.
48. Record vial ID number.

*Start time*_______

Left ventricle vial ID # ____________________ ENTER

End time ________

Problems? *Y* ____ *N* ____

	wrong number	corrected	other	corrected
entry				
entry				
entry				

49. Freeze vial containing left ventricle in Quick/Snap Freezer.
50. Place in cryo sample holding unit.
51. Record time.

Time Heart Dissection Complete __________________

Problems? *Y* ___ *N* ___

Describe ____

TESTES DISSECTION

52. Tare a fixative bag on MMMD.

53. If testes are not visible within scrotum, apply slight pressure to the lower abdomen to push testes down.

54. Make an incision into the tip of each scrotal sac.

55. Pull out one testis with forceps, being careful not to damage testis.

56. Cut all attached blood vessels, connective tissue and ducts around the testis with scissors.

57. Place clean testis in tared fixative bag.

58. Determine testis mass on MMMD.

*Start time*_______

Testis # 1 Mass [ ] **Enter**

End time ________

Problems? Y ___ *N* ___

	wrong number	corrected	other	corrected
entry				
entry				
entry				

59. Record fixative bag ID number.

*Start time*_______

Testis # 1 Bag # [.] **Enter**

End time ________

Problems? Y ___ *N* ___

	wrong number	corrected	other	corrected
entry				
entry				
entry				

60. Place bag in Refrigerator Storage Pouch.
61. Tare 8.0 ml vial on MMMD.
62. Pull out other testis with forceps being careful not to damage testis.
63. Cut attached blood vessels, connective tissue and ducts around the testis with scissors.
64. Place clean testis in tared 8.0 ml vial.
65. Determine testis mass on MMMD.

*Start time*_______

Testis # 2 Mass [ ] **Enter**

End time ________

Problems? Y ___ *N* ___

	wrong number	corrected	other	corrected
entry				
entry				
entry				

66. Record vial ID number.

*Start time*_______

Testis # 2 Vial # [ ] **Enter**

End time ________

Problems? Y ____ *N* ____

	wrong number	corrected	other	corrected
entry				
entry				
entry				

67. Freeze vial containing testes #2 in Quick Snap Freezer.

68. Place vial in Cryo Sample Holding Unit.

69. Record time. Place cursor on "Time Stamp" and select with middle key.

    Time testes dissection complete ______________________________

Problems? Y ___ N ___

Describe ____

DUODENUM DISSECTION

70. Open up portion of abdominal wall to locate the duodenum in the abdominal cavity.

71. Cut end of the duodenum connected to stomach. Make another cut approximately 2 inches along the intestine.

72. Cut tissue sample in half (two 1 inch portions).

73. Place one portion in a fixative bag.

74. Record bag ID number.

*Start time*_______

Duodenum #1 bag # [ ] **Enter**

End time ________

Problems? Y ___ N ___

	wrong number	corrected	other	corrected
entry				
entry				
entry				

75. Place bag in Refrigerator Storage Pouch.

76. Place other portion of duodenum in a 2 ml vial.

77. Record vial ID number.

*Start time*_______

Duodenum #2 vial # [ ] **Enter**

End time ________

Problems? Y___ N___

	wrong number	corrected	other	corrected
entry				
entry				
entry				

78. Freeze vial containing duodenum in Quick/Snap Freezer.

79. Place in cryo sample holding unit.

80. Record time Place cursor on "Time Stamp" and select with middle key.

Time Duodenum Dissection Complete ________________

Problems? Y___ N___

Describe ____

ADRENAL GLANDS

81. Tare a 2 ml vial, with cap removed, on MMMD.

82. Locate right adrenal gland embedded in fat just anterior to the right kidney.

83. Using forceps, grasp adrenal and cut around it with dissecting scissors. Remove gland with some surrounding fat.

84. Place on surgery platform and remove attached fat.

85. Place adrenal gland in tared 2 ml vial and replace cap.

86. Determine mass of adrenal on MMMD.

*Start time*_______

Right Adrenal Mass [ ] **Enter**

End time ________

Problems? Y ___ *N* ___

	wrong number	corrected	other	corrected
entry				
entry				
entry				

87. Record vial ID number.

*Start time*_______

Right Adrenal Vial # [ ] **Enter**

End time _______

Problems? Y ___ *N* ___

	wrong number	corrected	other	corrected
entry				
entry				
entry				

88. Freeze adrenal in Quick/Snap Freezer.

89. Place in cryo sample holding unit.

90. Tare a 2 ml vial, with cap removed, on MMMD.

91. Locate left adrenal gland embedded in fat just anterior to the left kidney.

92. With forceps, grasp adrenal and cut around it with dissecting scissors.Remove gland with some surrounding fat.

93. Place on surgery platform and remove attached fat.

94. Place adrenal gland in tared 2 ml vial and replace cap.

95. Determine mass of adrenal on MMMD.

*Start time*_______

Left Adrenal Mass [ ] **Enter**

End time ________

Problems? Y ___ *N* ___

	wrong number	corrected	other	corrected
entry				
entry				
entry				

96. Record vial ID number.

*Start time*_______

Left Adrenal Vial # [ ] **Enter**

End time ________

Problems? Y ___ *N* ___

	wrong number	corrected	other	corrected
entry				
entry				
entry				

97. Freeze adrenal in Quick/Snap Freezer.

98. Place in cryo sample holding unit.

99. Place remaining carcass and towels in rodent body bag and seal.

100. Place rodent body bag next to dissection platform.

101. Record time.

Time adrenal dissection complete ________________

Problems? Y ___ N ___

Describe ____

102.Remove gloves and place in waste bag.

103.Remove hands from glovebox gauntlets.

APPENDIX

Document 10. Keypad Data Entry Device Observation Sheet
(No anomalies)

Observer/recorder's procedure form

Test Subject ____________________ Date of Procedure ___________

Day # ______

Handedness: R ___ L ___ Time start: _______ Time end: _________

Test Conductor ___________________ Test Observer __________________

Video Tape Number _____________ Trainer _____________________

Random Order
- pen_____
- keypad, no anomalies _____*
- keypad, anomalies _____
- voice, no anomalies _____
- voice, anomalies _____

RECORDED NUMBERS

Specimen ID # ____________________

RCC ID # ____________________

Bag numbers Vial numbers

Bag # ___ ___ ___ ___ ___ Vial # ___ ___ ___ ___ ___

Bag # ___ ___ ___ ___ ___ Vial # ___ ___ ___ ___ ___

Bag # ___ ___ ___ ___ ___ Vial # ___ ___ ___ ___ ___

Bag # ___ ___ ___ ___ ___ Vial # ___ ___ ___ ___ ___

Vial # ___ ___ ___ ___ ___

Save all bags and vials until errors are checked.

1. Place hands in glovebox gauntlets and don surgical gloves.

2. When ready, place cursor on "Time Stamp" and select with middle key.

Start time _____

TIME START _____________TIME STAMP

End time _____

Problem with cursor: Y___N ___

3. Tare empty rodent restraint cone on the small mass measurement device (SMMD). Leave on SMMD until required.

4. Secure two large towels to Specimen Dissection Platform.

5. Attach head bag to dispatcher to capture head.

6. Remove one specimen from the Habitat.

7. Close and seal habitat access door.

8. Perform Health Check. *t p e*

Use "Enter" to move through parameters
Use "x" to select the proper parameter

Start time ________

Normal Coat	[ ]	**Enter**
Hair Rough	[ ]	**Enter**
Skin Lesions	[ ]	**Enter**
Normal Eyes	[ ]	**Enter**
Discharge From Eyes	[ ]	**Enter**
Normal Respiration	[ ]	**Enter**
Labored Breathing	[ ]	**Enter**
Sneezing	[ ]	**Enter**
Nasal Discharge	[ ]	**Enter**
Abdomen Distended	[ ]	**Enter**

End time ________

Problems? Y ____ N ____

t p e

t=trackball p=page down e=enter

	system response	wrong mode	wrong number	corrected	wrong command	corrected
entry						
entry						
entry						
entry						

9.Record time. Place cursor on "Time Stamp" and select with middle key.

Start time _______

TIME HEALTH CHECK COMPLETE_______ TIME STAMP

End time _______

Problems with cursor? Y___ N___

10. Locate and enter specimen ID number

Start time _______

Specimen ID # [   ] **Enter**

End time _______

Problems? Y____ N____ *t p e*

	system response	wrong mode	wrong number	corrected	wrong command	corrected
entry						
entry						
entry						
entry						

11. Obtain tared rodent restraint cone.

12. Secure specimen in cone.

13. Place specimen on SMMD.

14.Determine specimen mass (with restraint).

*Start time*_______

Specimen mass_____________________ ENTER

End time _______

Problems? *Y*____ *N*____ *t p e*

	system response	wrong mode	wrong number	corrected	wrong command	corrected
entry						
entry						
entry						
entry						

15. Place specimen in Animal Dispatcher.
16. Decapitate specimen.
17. Discard rodent restraint cone in waste bag.
18. Secure body, ventral side up, specimen tail towards the operator, on specimen dissection platform.
19. Place head (in head bag) in Rodent Carcass Container (RCC).
20. Record RCC ID Number.

*Start time*_______

RCC ID # [ ] **Enter**

End time ________

Problems? *Y*____ *N*____ *t p e*

	system response	wrong mode	wrong number	corrected	wrong command	corrected
entry						
entry						
entry						
entry						

21. Replace RCC.

22. Clean dispatcher with small towels.

23. Discard towels in waste bag.

24. Secure dispatcher away from dissection area.

25. Record time.

Start time _______

Time specimen ID complete ____________________ TIME STAMP

End time _______

Problems with cursor? *Y* ___ *N* ___

HEART DISSECTION

26. Using forceps, pull up skin above lower abdomen.

27. With scissors, cut in a mid-ventral line forward all the way to the neck without cutting the body wall under the skin.

28. Pull skin aside and secure with hemostats.

29. Locate xiphoid cartilage. Holding cartilage with forceps, cut through body wall. Cut through diaphragm horizontally on either side of mid-line.

30. Turn scissors at right angle to incision and cut upward toward the neck through side walls of the chest, through the ribs.

31. Repeat on other side, holding the ventral wall up to avoid injury to the heart.

32. Remove ventral wall of chest and discard in waste bag.

33. Remove thymus on cranial end of the heart and discard in waste bag.

34. Tare the 8.0 ml vial (with saline) on Micro-Mass Measurement Device (MMMD).

35. Remove heart and place carefully in saline in vial.

36. Determine mass of heart on MMMD.

t p e

*Start time*_______

Heart Mass [ ] **Enter**

End time ________

t p e

Problems? *Y* ____ *N* ____

	system response	wrong mode	wrong number	corrected	wrong command	corrected
entry						
entry						
entry						
entry						

37. With forceps, remove heart from vial and place onto towel.

38. Replace vial cap and replace vial in supply kit.

39. Remove atria with razor blade.

40. Place atria in fixative bag.

41. Record bag ID number.

t p e

*Start time*_______

Atria bag ID # [ ] **Enter**

End time ________

Problems? *Y* ____ *N* ____ *t p e*

	system response	wrong mode	wrong number	corrected	wrong command	corrected
entry						
entry						
entry						
entry						

42. Place bag in Refrigerator Storage Pouch.

43. Separate right and left ventricles with razor blade.

44. Place right ventricle in fixative bag.

45. Record bag ID number.

t p e

*Start time*_______

Right ventricle bag ID # [ ] **Enter**

End time ________

Problems? Y ____ *N* ____

t p e

	system response	wrong mode	wrong number	corrected	wrong command	corrected
entry						
entry						
entry						
entry						

46. Place bag with right ventricle in Refrigerator Storage Pouch.

47. Cut left ventricle in half and place both halves in a 2 ml vial.

48. Record vial ID number.

t p e

*Start time*_______

Left ventricle vial ID # ____________________ ENTER

End time ________

Problems? *Y* ____ *N* ____

t p e

	system response	wrong mode	wrong number	corrected	wrong command	corrected
entry						
entry						
entry						

49. Freeze vial containing left ventricle in Quick/Snap Freezer.

50. Place in cryo sample holding unit.

51. Record time.

Start time _______

Time Heart Dissection Complete [ ] **Time Stamp**

End time _______

Problems with cursor? *Y* ___ *N* ___

TESTES DISSECTION

52. Tare a fixative bag on MMMD.

53. If testes are not visible within scrotum, apply slight pressure to the lower abdomen to push testes down.

54. Make an incision into the tip of each scrotal sac.

55. Pull out one testis with forceps, being careful not to damage testis.

56. Cut all attached blood vessels, connective tissue and ducts around the testis with scissors.

57. Place clean testis in tared fixative bag.

58. Determine testis mass on MMMD. *t p e*

*Start time*_______

Testis # 1 Mass [ ] **Enter**

End time ________

Problems? Y ____ *N* ____ *t p e*

	system response	wrong mode	wrong number	corrected	wrong command	corrected
entry						
entry						
entry						
entry						

59. Record fixative bag ID number. *t p e*

*Start time*_______

Testis # 1 Bag # [ ] **Enter**

End time ________

Problems? Y ____ *N* ____ *t p e*

	system response	wrong mode	wrong number	corrected	wrong command	corrected
entry						
entry						
entry						
entry						

60. Place bag in Refrigerator Storage Pouch.

61. Tare 8.0 ml vial on MMMD.

62. Pull out other testis with forceps being careful not to damage testis.

63. Cut attached blood vessels, connective tissue and ducts around the testis with scissors.

64. Place clean testis in tared 8.0 ml vial.

65. Determine testis mass on MMMD. *t p e*

*Start time*_______

Testis # 2 Mass [ ] **Enter**

End time ________

Problems? Y ____ N ____ *t p e*

	system response	wrong mode	wrong number	corrected	wrong command	corrected
entry						
entry						
entry						
entry						

66. Record vial ID number. *t p e*

*Start time*_______

Testis # 2 Vial # [ ] **Enter**

End time ________

Problems? Y ____N____ *t p e*

	system response	wrong mode	wrong number	corrected	wrong command	corrected
entry						
entry						
entry						
entry						

67. Freeze vial containing testes #2 in Quick Snap Freezer.

68. Place vial in Cryo Sample Holding Unit.

69. Record time. Place cursor on "Time Stamp" and select with middle key.

t p e

Start time ______

Time testes dissection complete ______________________ TIME STAMP

End time ______

Problem with cursor ? *Y* ___ *N* ___

t p e

DUODENUM DISSECTION

70. Open up portion of abdominal wall to locate the duodenum in the abdominal cavity.

71. Cut end of the duodenum connected to stomach. Make another cut approximately 2 inches along the intestine.

72. Cut tissue sample in half (two 1 inch portions).

73. Place one portion in a fixative bag.

74. Record bag ID number.

Start time ______

Duodenum #1 bag # [ ] **Enter**

End time ______

t p e

Problems? *Y* ____ *N* ____

	system response	wrong mode	wrong number	corrected	wrong command	corrected
entry						
entry						
entry						
entry						

75. Place bag in Refrigerator Storage Pouch.

76. Place other portion of duodenum in a 2 ml vial.

77. Record vial ID number.

Start time_______

Duodenum #2 vial # [ ] **Enter**

End time ________

Problems? Y ____ N ____

t p e

	system response	wrong mode	wrong number	corrected	wrong command	corrected
entry						
entry						
entry						
entry						

78. Freeze vial containing duodenum in Quick/Snap Freezer.

79. Place in cryo sample holding unit.

80. Record time.

t p e

Start time _______

Time duodenum dissection complete [ ] **Time Stamp**

End time _______

Problem with cursor? Y ___ N ___

t p e

ADRENAL GLANDS

81. Tare a 2 ml vial, with cap removed, on MMMD.

82. Locate right adrenal gland embedded in fat just anterior to the right kidney.

83. Using forceps, grasp adrenal and cut around it with dissecting scissors. Remove gland with some surrounding fat.

84. Place on surgery platform and remove attached fat.

85. Place adrenal gland in tared 2 ml vial and replace cap.

86. Determine mass of adrenal on MMMD.

t p e

*Start time*_______

Right Adrenal Mass [ ] **Enter**

End time _______

Problems? *Y* ____ *N* ____

t p e

	system response	wrong mode	wrong number	corrected	wrong command	corrected
entry						
entry						
entry						
entry						

87. Record vial ID number.

t p e

*Start time*_______

Right Adrenal Vial # [ ] **Enter**

End time _______

t p e

Problems? *Y* ____ *N* ____

	system response	wrong mode	wrong number	corrected	wrong command	corrected
entry						
entry						
entry						
entry						

88. Freeze adrenal in Quick/Snap Freezer.

89. Place in cryo sample holding unit.

90. Tare a 2 ml vial, with cap removed, on MMMD.

91. Locate left adrenal gland embedded in fat just anterior to the left kidney.

92. With forceps, grasp adrenal and cut around it with dissecting scissors. Remove gland with some surrounding fat.

93. Place on surgery platform and remove attached fat.

94. Place adrenal gland in tared 2 ml vial and replace cap.

95. Determine mass of adrenal on MMMD. *t p e*

*Start time*_______

Left Adrenal Mass [ ] **Enter**

End time ________

t p e

*Problems? Y*____ *N*____

	system response	wrong mode	wrong number	corrected	wrong command	corrected
entry						
entry						
entry						
entry						

96. Record vial ID number. *t p e*

*Start time*_______

Left Adrenal Vial # [ ] **Enter**

End time ________

t p e

*Problems? Y*___ *N*___

	system response	wrong mode	wrong number	corrected	wrong command	corrected
entry						
entry						
entry						
entry						

97. Freeze adrenal in Quick/Snap Freezer.

98. Place in cryo sample holding unit.

99. Place remaining carcass and towels in rodent body bag and seal.

100. Place rodent body bag next to dissection platform.

101. Record time. Place cursor on "Time Stamp" and select with middle key

Start time _______

Time adrenal dissection complete ________________TIME STAMP

End time _______

Problem with cursor ? Y ___ *N* ___

102. Remove gloves and place in waste bag.

103. Remove hands from glovebox gauntlets.

APPENDIX

Document 11. Keypad Data Entry Device Observation Sheet
(**with** anomalies)

Observer/recorder's procedure form

Test Subject ______________________ Date of Procedure ____________

Day # ______

Handedness: R ___ L ___ Time start: _______ Time end: _________

Test Conductor ___________________ Test Observer __________________

Video Tape Number _____________ Trainer _____________________

Random Order

Anomalies will occur on subtasks

pen _____
keypad, no anomalies _____
keypad, anomalies _____ *
voice, no anomalies _____
voice, anomalies _____

RECORDED NUMBERS

Specimen ID # ____________________

RCC ID # ____________________

Bag numbers

Bag # __ __ __ __ __
Bag # __ __ __ __ __
Bag # __ __ __ __ __
Bag # __ __ __ __ __

Vial numbers

Vial # __ __ __ __ __
Vial # __ __ __ __ __
Vial # __ __ __ __ __
Vial # __ __ __ __ __
Vial # __ __ __ __ __

Save all bags and vials until errors are checked.

1. Place hands in glovebox gauntlets and don surgical gloves.

2.. When ready, place cursor on "Time Stamp" and select with middle key.

Start time _______

TIME START _____________ TIME STAMP

End time ________

Problem with cursor: Y ___N ___

3. Tare empty rodent restraint cone on the small mass measurement device (SMMD). Leave on SMMD until required.

4. Secure two large towels to Specimen Dissection Platform.

5. Attach head bag to dispatcher to capture head.

6. Remove one specimen from the Habitat.

7. Close and seal habitat access door.

8. Perform Health Check. t *p* *e*

Use "Enter" to move through parameters

Use "x" to select the proper parameter

Start time ________

Normal Coat	☐	Enter
Hair Rough	☐	Enter
Skin Lesions	☐	Enter
Normal Eyes	☐	Enter
Discharge From Eyes	☐	Enter
Normal Respiration	☐	Enter
Labored Breathing	☐	Enter
Sneezing	☐	Enter
Nasal Discharge	☐	Enter
Abdomen Distended	☐	Enter

End time ________

t p e

Problems? Y ____ N ____

t=trackball *p=page down* *e=enter*

	wrong mode	wrong number	corrected	wrong command	corrected
entry					
entry					
entry					
entry					
Xtra com					
Other					

9. Record time. Place cursor on "Time Stamp" and select with middle key.

Start time _______

TIME HEALTH CHECK COMPLETE_______ TIME STAMP

End time ________

Problem with cursor Y ___ N ___

Place lost? Y ___ N ___ *Step #* ________ t p e

10. Locate and enter specimen ID number

Start time _______

Specimen ID # [ ] **Enter**

End time _______

Problems? Y ____ N ____ t p e

Place lost? Y ___ N ___ *Step #* ________

	wrong mode	wrong number	corrected	wrong command	corrected
entry					
entry					
entry					
Xtra com					
Other					

11. Obtain tared rodent restraint cone.

12. Secure specimen in cone.

13. Place specimen on SMMD.

ANOMALY
[Ctrl + 1]

Anomaly start time ________

(Start anomaly as soon as specimen touches scale)

Subject started recovery with
trackball _____
trackball key ____
device - pg dn ____
device - enter _____

Subject overshot next field Y ___ N ___

If so, how many fields? _____

Subject returned with
trackball _____
trackball key ____
device - pg up ____
device - enter _____

Was there back and forth movement between fields? Y ___ N ___

Time at correct new field __________

14. Determine specimen mass (with restraint).

Start time_______

Specimen mass_____________________ ENTER

End time _______

Problems? Y ____ N ____

t p e

	wrong mode	wrong number	corrected	wrong command	corrected
entry					
entry					
entry					
Xtra com					
Other					

15. Place specimen in Animal Dispatcher.

16. Decapitate specimen.

17. Discard rodent restraint cone in waste bag.

18. Secure body, ventral side up, specimen tail towards the operator, on specimen dissection platform.

19. Place head (in head bag) in Rodent Carcass Container (RCC).

20. Record RCC ID Number.

Start time_______

RCC ID # [ ] **Enter**

End time ________

Problems? Y ____ N ____

t p e

Place lost? T ___ N ___ Step #_________

	wrong mode	wrong number	corrected	wrong command	corrected
entry					
entry					
entry					
Xtra com					
Other					

21. Replace RCC.
22. Clean dispatcher with small towels.
23. Discard towels in waste bag.
24. Secure dispatcher away from dissection area.
25. Record time. Record time. Place cursor on "Time Stamp" and select with middle key.

t p e

Start time _______

Time specimen ID complete ____________________ TIME STAMP

End time ________

Problem with cursor Y ___ N ___

Place lost? Y ___ N ___ Step # _______

t p e

HEART DISSECTION

26. Using forceps, pull up skin above lower abdomen.
27. With scissors, cut in a mid-ventral line forward all the way to the neck without cutting thebody wall under the skin.
28. Pull skin aside and secure with hemostats.
29. Locate xiphoid cartilage. Holding cartilage with forceps, cut through body wall. Cut through diaphragm horizontally on either side of mid-line.
30. Turn scissors at right angle to incision and cut upward toward the neck through the side walls of the chest, through the ribs.

31. Repeat on other side, holding the ventral wall up to avoid injury to the heart.

32. Remove ventral wall of chest and discard in waste bag.

33. Remove thymus on cranial end of the heart and discard in waste bag.

34. Tare the 8.0 ml vial (with saline) on Micro-Mass Measurement Device (MMMD).

35. Remove heart and place carefully in saline in vial.

36. Determine mass of heart on MMMD . *t p e*

*Start time*_______

Heart Mass [ ] **Enter**

End time ________

Problems? Y ____ N ____

Place lost? Y ___ N ___ Step # __________ t p e

	wrong mode	wrong number	corrected	wrong command	corrected
entry					
entry					
entry					
Xtra com					
Other					

37. With forceps, remove heart from vial and place onto towel.

38. Replace vial cap and replace vial in supply kit.

39. Remove atria with razor blade.

40. Place atria in fixative bag.

41. Record bag ID number. *t p e*

*Start time*_______

Atria bag ID # [ ] **Enter**

End time ________

Problems? Y ___ *N* ___

t p e

Place lost? Y ___ *N* ___ *Step #* _______

Problems? Y ___ N ___	wrong mode	wrong number	corrected	wrong command	corrected
entry					
entry					
entry					
Xtra com					
Other					

42. Place bag in Refrigerator Storage Pouch.
43. Separate right and left ventricles with razor blade.
44. Place right ventricle in fixative bag.
45. Record bag ID number.

t p e

*Start time*_______

Right ventricle bag ID # [ ] **Enter**

End time ________

t p e

Problems? Y ____ *N* ____

Place lost? Y ___ *N* ___ *Step#* __________

	wrong mode	wrong number	corrected	wrong command	corrected
entry					
entry					
entry					
Xtra com					
Other					

46. Place bag with right ventricle in Refrigerator Storage Pouch.

47. Cut left ventricle in half and place both halves in a 2 ml vial.

48. Record vial ID number.

t p e

*Start time*_______

Left ventricle vial ID # ____________________ ENTER

End time ________

t p e

Problems? *Y* ____ *N* ____

Place lost? Y ___ *N* ___ *Step #* _________

	wrong mode	wrong number	corrected	wrong command	corrected
entry					
entry					
entry					
Xtra Com					
Other					

49. Freeze vial containing left ventricle in Quick/Snap Freezer.

50. Place in cryo sample holding unit.

51. Record time. Place cursor on "Time Stamp" and select with middle key.

t p e

Start time ______

Time Heart Dissection Complete [ ] **Time Stamp**

End time ________

t p e

Problem with cursor *Y* ___ *N* ___

Place lost? Y ___ *N* ___ *Step#* ____________

TESTES DISSECTION

52. Tare a fixative bag on MMMD.
53. If testes are not visible within scrotum, apply slight pressure to the lower abdomen to push testes down.
54. Make an incision into the tip of each scrotal sac.
55. Pull out one testis with forceps, being careful not to damage testis.
56. Cut all attached blood vessels, connective tissue and ducts around the testis with scissors.
57. Place clean testis in tared fixative bag.
58. Determine testis mass on MMMD.

t p e

Start time _______

Testis # 1 Mass [ ] **Enter**

End time ________

t p e

	wrong mode	wrong number	corrected	wrong command	corrected
entry					
entry					
entry					
Xtra com					
Other					

59. Record fixative bag ID number. *t p e*

*Start time*_______

Testis # 1 Bag # [ ] **Enter**

End time ________

Problems? *Y* ____ *N* ____ *t p e*

Place lost? Y ___ *N* ___ *Step #* ___________

	wrong mode	wrong number	corrected	wrong command	corrected
entry					
entry					
entry					
Xtra com					
Other					

60. Place bag in Refrigerator Storage Pouch.
61. Tare 8.0 ml vial on MMMD.
62. Pull out other testis with forceps being careful not to damage testis.
63. Cut attached blood vessels, connective tissue and ducts around the testis with scissors.
64. Place clean testis in tared 8.0 ml vial.

ANOMALY
[Ctrl + 1]

Anomaly start time ________

(Start anomaly as soon as S starts to place testes in vial)

Subject started recovery with
trackball _____
trackball key ____
device - pg dn ____
device - enter _____

Subject overshot next field Y ___ N ___ If so, how many fields? _____

Subject returned with
trackball _____
trackball key ____
device - pg up ____
device - enter _____

Was there back and forth movement between fields? Y ___ N ___

Problems with next entry? Y ___ N ___

Time at correct new field __________

65. Determine testis mass on MMMD. *t p e*

Start time_______

Testis # 2 Mass [ ] **Enter**

End time ________

Problems? Y ____ N ____ *t p e*

Place lost? Y ___ N ___ Step #__________

	wrong mode	wrong number	corrected	wrong command	corrected
entry					
entry					
entry					
Xtra com					
Other					

66. Record vial ID number. *t p e*

Start time_______

Testis # 2 Vial # [   ] **Enter**

End time ________

t p e

Problems? *Y* ____ *N* ____

Place lost? Y ___ *N* ___ *Step #* _________

	wrong mode	wrong number	corrected	wrong command	corrected
entry					
entry					
entry					
Xtra com					
Other					

67. Freeze vial containing testes #2 in Quick Snap Freezer.

68. Place vial in Cryo Sample Holding Unit.

69. Record time. Place cursor on "Time Stamp" and select with middle key.

Start time _______

Time testes dissection complete ____________________________ TIME STAMP

End time ________

Problem with cursor *Y* ___ *N* ___

DUODENUM DISSECTION

70. Open up portion of abdominal wall to locate the duodenum in the abdominal cavity.

71. Cut end of the duodenum connected to stomach. Make another cut approximately 2 inches along the intestine.

72. Cut tissue sample in half (two 1 inch portions).

73. Place one portion in a fixative bag.

74. Record bag ID number. *t p e*

Start time_______

Duodenum #1 bag # [ ] **Enter**

End time ________

Problems? Y ____ N ____ *t p e*

Place lost? Y ___ N ___ *Step #* __________

	wrong mode	wrong number	corrected	wrong command	corrected
entry					
entry					
entry					
Xtra com					
Other					

75. Place bag in Refrigerator Storage Pouch.
76. Place other portion of duodenum in a 2 ml vial.
77. Record vial ID number.

t p e

Start time_______

Duodenum #2 vial # [ ] **Enter**

End time ________

Problem ? Y ___ N ___ *t p e*

Place lost? Y ___ N ___ *Step #* __________

	wrong mode	wrong number	corrected	wrong command	corrected
entry					
entry					
entry					
Xtra com					
Other					

78. Freeze vial containing duodenum in Quick/Snap Freezer.

79. Place in cryo sample holding unit.
80. Record time Place cursor on "Time Stamp" and select with middle key.

t p e

Start time _______

Time duodenum dissection complete [ ] **Time Stamp**

t p e

End time _______

Place lost? Y ___ *N* ___ *Step #* __________

ADRENAL GLANDS

81. Tare a 2 ml vial, with cap removed, on MMMD.

82. Locate right adrenal gland embedded in fat just anterior to the right kidney.

83. Using forceps, grasp adrenal and cut around it with dissecting scissors. Remove gland with some surrounding fat.

84. Place on surgery platform and remove attached fat.

85. Place adrenal gland in tared 2 ml vial and replace cap.

86. Determine mass of adrenal on MMMD.

t p e

Start time _______

Right Adrenal Mass [ ] Enter

End time ________

Problem ? Y ___ N ___ *t p e*

Place lost? Y ___ N ___ Step # __________

	wrong mode	wrong number	corrected	wrong command	corrected
entry					
entry					
entry					
Xtra com					
Other					

87. Record vial ID number. *t p e*

Start time _______

Right Adrenal Vial # [ ] Enter

End time ________

t p e

Problems? Y ___ N ___

Place lost? Y ___ N ___ Step # _________

	wrong mode	wrong number	corrected	wrong command	corrected
entry					
entry					
entry					
Xtra com					
Other					

88. Freeze adrenal in Quick/Snap Freezer.

89. Place in cryo sample holding unit.

90. Tare a 2 ml vial, with cap removed, on MMMD.

91. Locate left adrenal gland embedded in fat just anterior to the left kidney.

92. With forceps, grasp adrenal and cut around it with dissecting scissors. Remove gland with some surrounding fat.

93. Place on surgery platform and remove attached fat.

94. Place adrenal gland in tared 2 ml vial and replace cap.

95. Determine mass of adrenal on MMMD.

t p e

*Start time*______

Left Adrenal Mass [ ] **Enter**

End time _______

t p e

Problems? Y ___ N ___

Place lost? Y ___ N ___ Step # ________

	wrong mode	wrong number	corrected	wrong command	corrected
entry					
entry					
entry					
Xtra com					
Other					

96. Record vial ID number.

t p e

*Start time*______

Left Adrenal Vial # ________________

End time _______

Problems? *Y* ____ *N* ____ *t p e*

Place lost? Y ___ *N* ___ *Step #* ________

Problems? Y ____ N ____	wrong mode	wrong number	corrected	wrong command	corrected
entry					
entry					
entry					
Xtra com					
Other					

97. Freeze adrenal in Quick/Snap Freezer.

98. Place in cryo sample holding unit.

99. Place remaining carcass and towels in rodent body bag and seal.

100. Place rodent body bag next to dissection platform.

101. Record time.Place cursor on "Time Stamp" and select with middle key

t *p e*

Start time _______

Time adrenal dissection complete ________________ TIME STAMP

t p e

End time ________

Problem ? *Y* ___ *N* ___

Place lost? Y ___ *N* ___ *Step #* _____________

102. Remove gloves and place in waste bag.

103. Remove hands from glovebox gauntlets.

APPENDIX

Document 12. Voice Data Entry Observation Sheet
(No anomalies)

Observer/recorder's procedure form

Test Subject ______________________ Date of Procedure ____________

Day # ______

Handedness: R ___ L ___ Time start: _______ Time end: _________

Test Conductor ___________________ Test Observer __________________

Video Tape Number _____________ Trainer _____________________

Random Order
- pen _____
- keypad, no anomalies _____
- keypad, anomalies _____
- voice, no anomalies _____ *
- voice, anomalies _____

RECORDED NUMBERS

Specimen ID # ___ ___ ___ ___ ___

RCC ID # ___ ___ ___ ___ ___

Bag numbers	Vial numbers
Bag # ___ ___ ___ ___ ___	Vial # ___ ___ ___ ___ ___
Bag # ___ ___ ___ ___ ___	Vial # ___ ___ ___ ___ ___
Bag # ___ ___ ___ ___ ___	Vial # ___ ___ ___ ___ ___
Bag # ___ ___ ___ ___ ___	Vial # ___ ___ ___ ___ ___
	Vial # ___ ___ ___ ___ ___

Save all bags and vials until errors are checked.

1. Place hands in glovebox gauntlets and don surgical gloves.

2.. When ready, place cursor on "Time Stamp" and select with middle key.

Start time _______

TIME START _______________ TIME STAMP

End time _______

Problem with cursor? Y ___ N ___

3. Tare empty rodent restraint cone on the small mass measurement device (SMMD). Leave on SMMD until required.
4. Secure two large towels to Specimen Dissection Platform.
5. Attach head bag to dispatcher to capture head.
6. Remove one specimen from the Habitat.
7. Close and seal habitat access door.
8. Perform Health Check.

Wake up? Y ___ N ___

Use "Enter" to move through parameters

Use "x" to select the proper parameter

Start time ________

Normal Coat	☐	Enter
Hair Rough	☐	Enter
Skin Lesions	☐	Enter
Normal Eyes	☐	Enter
Discharge From Eyes	☐	Enter
Normal Respiration	☐	Enter
Labored Breathing	☐	Enter
Sneezing	☐	Enter
Nasal Discharge	☐	Enter
Abdomen Distended	☐	Enter

End time ________

Problems? *Y* ____ *N* ____

t *p* *e*

Go to sleep? Y ___ *N* ___

t=trackball p=page down e=enter

	no response to	wrong response	extra response to	wrong input by subject	corrected
number					
ERASE					
ENTER					
OTHER					

9. Record time. Place cursor on "Time Stamp" and select with middle key.

Start time _______

TIME HEALTH CHECK COMPLETE_______ **TIME STAMP**

End time _______

Problem with cursor *Y* ___ *N* ___

10. Locate and enter specimen ID number

Start time _______

Specimen ID # [ ] **Enter**

End time _______

Problems? *Y* ____ *N* ____

t *p* *e*

Go to sleep? Y ___ *N*

___

	no response to	wrong response	extra response to	wrong input by subject	corrected
number					
ERASE					
ENTER					
OTHER					

11. Obtain tared rodent restraint cone.

12. Secure specimen in cone.

13. Place specimen on SMMD.

14. Determine specimen mass (with restraint).

Wake up? Y ___ N ___

Start time_______

Specimen mass____________________ ENTER

Problems? Y ____ N ____ *End time _______*

t p e

Go to sleep? Y ___ N

___

	no response to	wrong response	extra response to	wrong input by subject	corrected
number					
ERASE					
ENTER					
OTHER					

15. Place specimen in Animal Dispatcher.

16. Decapitate specimen.

17. Discard rodent restraint cone in waste bag.

18. Secure body, ventral side up, specimen tail towards the operator, on specimen dissection platform.

19. Place head (in head bag) in Rodent Carcass Container (RCC).

Wake up? Y ___ N ___

Start time _______

RCC ID # ______________________ ENTER

End time_______

t p e

Problems? Y ____ N ____

Go to sleep? Y ___ N ___

	no response to	wrong response	extra response to	wrong input by subject	corrected
number					
ERASE					
ENTER					
OTHER					

21. Replace RCC.

22. Clean dispatcher with small towels.

23. Discard towels in waste bag.

24. Secure dispatcher away from dissection area.

25. Record time. Record time. Place cursor on "Time Stamp" and select with middle key.

Start time _______

Time specimen ID complete ____________________ TIME STAMP

End time _______

Problems? Y ____ N ____

HEART DISSECTION

26. Using forceps, pull up skin above lower abdomen.
27. With scissors, cut in a mid-ventral line forward all the way to the neck without cutting the body wall under the skin.
28. Pull skin aside and secure with hemostats.
29. Locate xiphoid cartilage. Holding cartilage with forceps, cut through body wall. Cut through diaphragm horizontally on either side of mid-line.
30. Turn scissors at right angle to incision and cut upward toward the neck through the side walls of the chest, through the ribs.
31. Repeat on other side, holding the ventral wall up to avoid injury to the heart.
32. Remove ventral wall of chest and discard in waste bag.
33. Remove thymus on cranial end of the heart and discard in waste bag.
34. Tare the 8.0 ml vial (with saline) on Micro-Mass Measurement Device (MMMD).
35. Remove heart and place carefully in saline in vial.
36. Determine mass of heart on MMMD .

Wake up? Y ___ N ___

Start time_______

Heart Mass [ ] **Enter**

End time ________

Problems? Y ____ N ____

t p e

Go to sleep? Y ___ N ___

	no response to	wrong response	extra response to	wrong input by subject	corrected
number					
ERASE					
ENTER					
OTHER					

37. With forceps, remove heart from vial and place onto towel.
38. Replace vial cap and replace vial in supply kit.

39. Remove atria with razor blade.

40. Place atria in fixative bag.

41. Record bag ID number.

Wake up? Y ___ N ___

Start time_______

Atria bag ID # [ ] **Enter**

End time ________

Problems? Y ____ N ____

t p e

Go to sleep? Y ___ N ___

	no response to	wrong response	extra response to	wrong input by subject	corrected
number					
ERASE					
ENTER					
OTHER					

42. Place bag in Refrigerator Storage Pouch.

43. Separate right and left ventricles with razor blade.

44. Place right ventricle in fixative bag.

45. Record bag ID number.

Wake up? Y ___ N ___

Start time_______

Right ventricle bag ID # [ ] **Enter**

End time ________

Problems? Y ____ N ____

t p e

Go to sleep? Y ___ N ___

	no response to	wrong response	extra response to	wrong input by subject	corrected
number					
ERASE					
ENTER					
OTHER					

46. Place bag with right ventricle in Refrigerator Storage Pouch.

47. Cut left ventricle in half and place both halves in a 2 ml vial.

48. Record vial ID number.

Wake up? Y ___ N ___

Start time_______

Left ventricle vial ID # ____________________ ENTER

End time ________

t p e

Problems? Y ____ N ____

Go to sleep? Y ___ N ___

	no response to	wrong response	extra response to	wrong input by subject	corrected
number					
ERASE					
ENTER					
OTHER					

49. Freeze vial containing left ventricle in Quick/Snap Freezer.

50. Place in cryo sample holding unit.

51. Record time. Place cursor on "Time Stamp" and select with middle key.

Start time _______

Time Heart Dissection Complete [ ] **Time Stamp**

End time _______

Problems? Y ____ N ____

TESTES DISSECTION

52. Tare a fixative bag on MMMD.
53. If testes are not visible within scrotum, apply slight pressure to the lower abdomen to push testes down.
54. Make an incision into the tip of each scrotal sac.
55. Pull out one testis with forceps, being careful not to damage testis.
56. Cut all attached blood vessels, connective tissue and ducts around the testis with scissors.
57. Place clean testis in tared fixative bag.
58. Determine testis mass on MMMD. *Wake up? Y ___ N ___*

Start time_______

Testis # 1 Mass [ ] **Enter**

End time ________

t p e

Problems? Y ____ N ____

Go to sleep? Y ___ N ___

	no response to	wrong response	extra response to	wrong input by subject	corrected
number					
ERASE					
ENTER					
OTHER					

59. Record fixative bag ID number. *Wake up? Y ___ N ___*

Start time_______

Testis # 1 Bag # [ ] **Enter**

End time ________

Problems? Y ____ N ____

t p e

Go to sleep? Y ___ N ___

	no response to	wrong response	extra response to	wrong input by subject	corrected
number					
ERASE					
ENTER					
OTHER					

60. Place bag in Refrigerator Storage Pouch.

61. Tare 8.0 ml vial on MMMD.

62. Pull out other testis with forceps being careful not to damage testis.

63. Cut attached blood vessels, connective tissue and ducts around the testis with scissors.

64. Place clean testis in tared 8.0 ml vial.

65. Determine testis mass on MMMD.

Wake up? Y ___ N ___

Start time_______

Testis # 2 Mass [ ] **Enter**

End time ________

Problems? Y ____ N ____

t p e

Go to sleep? Y ___ N ___

	no response to	wrong response	extra response to	wrong input by subject	corrected
number					
ERASE					
ENTER					
OTHER					

66.Record vial ID number.

Wake up? Y ___ N ___

Start time_______

Testis # 2 Vial # [ ] **Enter**

End time ________

t p e

Problems? Y ____ N ____

Go to sleep? Y ___ N ___

	no response to	wrong response	extra response to	wrong input by subject	corrected
number					
ERASE					
ENTER					
OTHER					

67. Freeze vial containing testes #2 in Quick Snap Freezer.

68. Place vial in Cryo Sample Holding Unit.

69. Record time. Place cursor on "Time Stamp" and select with middle key.

Start time _______

Time testes dissection complete ______________________________

TIME
STAMP

End time _______

Problems? Y ____ N ____

DUODENUM DISSECTION

70. Open up portion of abdominal wall to locate the duodenum in the abdominal cavity.

71. Cut end of the duodenum connected to stomach. Make another cut approximately 2 inches along the intestine.

72. Cut tissue sample in half (two 1 inch portions).

73. Place one portion in a fixative bag.

74. Record bag ID number.

Wake up? Y ___ N ___

Start time_______

Duodenum #1 bag # [ ] **Enter**

End time ________

t p e

Problems? Y ____ N ____

Go to sleep? Y ___ N ___

	no response to	wrong response	extra response to	wrong input by subject	corrected
number					
ERASE					
ENTER					
OTHER					

75. Place bag in Refrigerator Storage Pouch.

76. Place other portion of duodenum in a 2 ml vial.

77. Record vial ID number.

Wake up? Y ___ N ___

Start time_______

Duodenum #2 vial # [ ] **Enter**

End time ________

Problems? Y ____ N ____

t p e

Go to sleep? Y ___ N ___

	no response to	wrong response	extra response to	wrong input by subject	corrected
number					
ERASE					
ENTER					
OTHER					

78. Freeze vial containing duodenum in Quick/Snap Freezer.

79. Place in cryo sample holding unit.

80. Record time Place cursor on "Time Stamp" and select with middle key.

Start time _______

Time duodenum dissection complete [ ] **Time Stamp**

End time _______

Problems? Y ____ N ____

ADRENAL GLANDS

81. Tare a 2 ml vial, with cap removed, on MMMD.

82. Locate right adrenal gland embedded in fat just anterior to the right kidney.

83. Using forceps, grasp adrenal and cut around it with dissecting scissors. Remove gland with some surrounding fat.

84. Place on surgery platform and remove attached fat.

85. Place adrenal gland in tared 2 ml vial and replace cap.

86. Determine mass of adrenal on MMMD. *Wake up? Y ___ N ___*

*Start time*_______

Right Adrenal Mass [ ] **Enter**

End time ________

Problems? Y ____ N ____

t p e

Go to sleep? Y ___ N ___

	no response to	wrong response	extra response to	wrong input by subject	corrected
number					
ERASE					
ENTER					
OTHER					

87. Record vial ID number.

Wake up? Y ___ N ___

Start time______

Right Adrenal Vial # [ ] **Enter**

End time ________

t p e

Problems? Y ____ N ____

Go to sleep? Y ___ N ___

	no response to	wrong response	extra response to	wrong input by subject	corrected
number					
ERASE					
ENTER					
OTHER					

88. Freeze adrenal in Quick/Snap Freezer.

89. Place in cryo sample holding unit.

90. Tare a 2 ml vial, with cap removed, on MMMD.

91. Locate left adrenal gland embedded in fat just anterior to the left kidney.

92. With forceps, grasp adrenal and cut around it with dissecting scissors. Remove gland with some surrounding fat.

93. Place on surgery platform and remove attached fat.

95. Determine mass of adrenal on MMMD.

Wake up? Y ___ N ___

Start time_______

Left Adrenal Mass [ ] **Enter**

End time ________

Problems? Y ____ N ____

t p e

Go to sleep? Y ___ N ___

	no response to	wrong response	extra response to	wrong input by subject	corrected
number					
ERASE					
ENTER					
OTHER					

96. Record vial ID number.

Wake up? Y ___ N ___

Start time_______

Left Adrenal Vial # [ ] **Enter**

End time ________

Problems? Y ____ N ____

t p e

Go to sleep? Y ___ N ___

	no response to	wrong response	extra response to	wrong input by subject	corrected
number					
ERASE					
ENTER					
OTHER					

97. Freeze adrenal in Quick/Snap Freezer.

98. Place in cryo sample holding unit.

99. Place remaining carcass and towels in rodent body bag and seal.

100. Place rodent body bag next to dissection platform.

101. Record time. Place cursor on "Time Stamp" and select with middle key.

Start time _______

Time adrenal dissection complete _______________ TIME STAMP

End time ______

Problems? Y ____ *N* ____

102. Remove gloves and place in waste bag.

103. Remove hands from glovebox gauntlets.

APPENDIX

Document 13. Voice Data Entry Observation Sheet
(With anomalies)

Observer/recorder's procedure form

Test Subject ________________________ Date of Procedure ____________Day # ______

Handedness: R ___ L ___ Time start: _______ Time end: _________

Test Conductor ____________________ Test Observer ___________________

Video Tape Number _____________ Trainer ______________________

Random Order
- pen _____
- keypad, no anomalies _____
- keypad, anomalies _____
- voice, no anomalies _____ *
- voice, anomalies _____

RECORDED NUMBERS

Specimen ID # ___ ___ ___ ___ ___

RCC ID # ___ ___ ___ ___ ___

Bag numbers	Vial numbers
Bag # ___ ___ ___ ___ ___	Vial # ___ ___ ___ ___ ___
Bag # ___ ___ ___ ___ ___	Vial # ___ ___ ___ ___ ___
Bag # ___ ___ ___ ___ ___	Vial # ___ ___ ___ ___ ___
Bag # ___ ___ ___ ___ ___	Vial # ___ ___ ___ ___ ___
	Vial # ___ ___ ___ ___ ___

Save all bags and vials until errors are checked.

1. Place hands in glovebox gauntlets and don surgical gloves.

2. When ready, place cursor on "Time Stamp" and select with middle key.

Start time ______

TIME START ____________ TIME STAMP

End time ______

Problem with cursor? Y ___ *N* ___

3. Tare empty rodent restraint cone on the small mass measurement device (SMMD). Leave on SMMD until required.

4. Secure two large towels to Specimen Dissection Platform.

5. Attach head bag to dispatcher to capture head.

6. Remove one specimen from the Habitat.

7. Close and seal habitat access door.

8. Perform Health Check.

Wake up? Y ___ *N* ___

Use "Enter" to move through parameters

Use "x" to select the proper parameter

Start time ______

Normal Coat	☐	**Enter**
Hair Rough	☐	**Enter**
Skin Lesions	☐	**Enter**
Normal Eyes	☐	**Enter**
Discharge From Eyes	☐	**Enter**
Normal Respiration	☐	**Enter**
Labored Breathing	☐	**Enter**
Sneezing	☐	**Enter**
Nasal Discharge	☐	**Enter**
Abdomen Distended	☐	**Enter**

End time ______

Problems? *Y* ____ *N* ____

t *p* *e*

Go to sleep? Y ___ *N* ___

t=trackball p=page down e=enter

	no response to	wrong response	extra response to	wrong input by subject	corrected
number					
ERASE					
ENTER					
OTHER					

9. Record time. Place cursor on "Time Stamp" and select with middle key.

Wake up? Y ___ *N* ___

Start time _______

TIME HEALTH CHECK COMPLETE_______ TIME STAMP

End time _______

Problem with cursor *Y* ___ *N* ___

10. Locate and enter specimen ID number

Start time _______

Specimen ID # [ ] **Enter**

End time _______

Problems? *Y* ____ *N* ____

t *p* *e*

Go to sleep? Y ___ *N* ___

	no response to	wrong response	extra response to	wrong input by subject	corrected
number					
ERASE					
ENTER					
OTHER					

11. Obtain tared rodent restraint cone.

12. Secure specimen in cone.

13. Place specimen on SMMD.

Anomaly
[Ctrl + 1]

Anomaly start time ________
(Start anomaly as soon as specimen touches scale)

Subject started recovery with
trackball _____
trackball key ____
device - pg dn ____
device - enter _____

Subject overshot next field Y ___ N ___

If so, how many fields? _____

Subject returned with
trackball _____
trackball key ____
device - pg up ____
device - enter _____

Was there back and forth movement between fields? Y ___ N ___

Time at correct new field __________

14.Determine specimen mass (with restraint).

Wake up? Y ___ N ___

Start time_______

Specimen mass_____________________

ENTER

Problems? Y ____ N ____

End time _______

t p e

Go to sleep? Y ___ N ___

	no response to	wrong response	extra response to	wrong input by subject	corrected
number					
ERASE					
ENTER					
OTHER					

15. Place specimen in Animal Dispatcher.

16. Decapitate specimen.

17. Discard rodent restraint cone in waste bag.

18. Secure body, ventral side up, specimen tail towards the operator, on specimen dissection platform.

19. Place head (in head bag) in Rodent Carcass Container (RCC).

Wake up? Y ___ N ___

Start time _______

RCC ID # ________________________ ENTER

End time_______

t p e

Problems? Y ____ N ____

Go to sleep? Y ___ N ___

	no response to	wrong response	extra response to	wrong input by subject	corrected
number					
ERASE					
ENTER					
OTHER					

21. Replace RCC.

22. Clean dispatcher with small towels.

23. Discard towels in waste bag.

24. Secure dispatcher away from dissection area.

25. Record time. Record time. Place cursor on "Time Stamp" and select with middle key.

Start time _______

Time specimen ID complete ____________________ TIME STAMP

End time _______

Problems? *Y* ____ *N* ____

HEART DISSECTION

26. Using forceps, pull up skin above lower abdomen.

27. With scissors, cut in a mid-ventral line forward all the way to the neck without cutting the body wall under the skin.

28. Pull skin aside and secure with hemostats.

29. Locate xiphoid cartilage. Holding cartilage with forceps, cut through body wall. Cut through diaphragm horizontally on either side of mid-line.

30. Turn scissors at right angle to incision and cut upward toward the neck through the side walls of the chest, through the ribs.

31. Repeat on other side, holding the ventral wall up to avoid injury to the heart.

32. Remove ventral wall of chest and discard in waste bag.

33. Remove thymus on cranial end of the heart and discard in waste bag.

34. Tare the 8.0 ml vial (with saline) on Micro-Mass Measurement Device (MMMD).

35. Remove heart and place carefully in saline in vial.

36. Determine mass of heart on MMMD.

Wake up? *Y* ___ *N* ___

Start time _______

Heart Mass [   ] **Enter**

End time ________

Problems? *Y* ____ *N* ____

t p e

Go to sleep? *Y* ___ *N* ___

	no response to	wrong response	extra response to	wrong input by subject	corrected
number					
ERASE					
ENTER					
OTHER					

37. With forceps, remove heart from vial and place onto towel.

38. Replace vial cap and replace vial in supply kit.

39. Remove atria with razor blade.

40. Place atria in fixative bag.

41. Record bag ID number.

Wake up? Y ___ N ___

Start time_______

Atria bag ID # [ ] **Enter**

End time ________

Problems? Y ____ N ____

t p e

Go to sleep? Y ___ N ___

	no response to	wrong response	extra response to	wrong input by subject	corrected
number					
ERASE					
ENTER					
OTHER					

42. Place bag in Refrigerator Storage Pouch.

43. Separate right and left ventricles with razor blade.

44. Place right ventricle in fixative bag.

45. Record bag ID number. *Wake up? Y ___ N ___*

*Start time*_______

Right ventricle bag ID # [ ] **Enter**

End time ________

Problems? *Y* ____ *N* ____

t p e

Go to sleep? Y ___ *N* ___

	no response to	wrong response	extra response to	wrong input by subject	corrected
number					
ERASE					
ENTER					
OTHER					

46. Place bag with right ventricle in Refrigerator Storage Pouch.

47. Cut left ventricle in half and place both halves in a 2 ml vial.

48. Record vial ID number.

Wake up? Y ___ *N* ___

*Start time*_______

Left ventricle vial ID # ____________________ ENTER

End time ________

t p e

Problems? *Y* ____ *N* ____

Go to sleep? Y ___ *N* ___

	no response to	wrong response	extra response to	wrong input by subject	corrected
number					
ERASE					
ENTER					
OTHER					

49. Freeze vial containing left ventricle in Quick/Snap Freezer.

50. Place in cryo sample holding unit.

51. Record time. Place cursor on "Time Stamp" and select with middle key.

Start time _______

Time Heart Dissection Complete [ ] **Time Stamp**

End time _______

Problems? *Y* ____ *N* ____

TESTES DISSECTION

52. Tare a fixative bag on MMMD.

53. If testes are not visible within scrotum, apply slight pressure to the lower abdomen to push testes down.

54. Make an incision into the tip of each scrotal sac.

55. Pull out one testis with forceps, being careful not to damage testis.

56. Cut all attached blood vessels, connective tissue and ducts around the testis with scissors.

57. Place clean testis in tared fixative bag.

58. Determine testis mass on MMMD. *Wake up? Y* ___ *N* ___

Start time _______

Testis # 1 Mass [ ] **Enter**

End time ________

t p e

Problems? *Y* ____ *N* ____

Go to sleep? Y ___ *N* ___

	no response to	wrong response	extra response to	wrong input by subject	corrected
number					
ERASE					
ENTER					
OTHER					

59. Record fixative bag ID number. *Wake up? Y* ___ *N* ___

*Start time*_______

Testis # 1 Bag # [ ] **Enter**

End time ________

Problems? *Y* ____ *N* ____

t p e

Go to sleep? Y ___ *N* ___

	no response to	wrong response	extra response to	wrong input by subject	corrected
number					
ERASE					
ENTER					
OTHER					

60. Place bag in Refrigerator Storage Pouch.

61. Tare 8.0 ml vial on MMMD.

62. Pull out other testis with forceps being careful not to damage testis.

63. Cut attached blood vessels, connective tissue and ducts around the testis with scissors.

64. Place clean testis in tared 8.0 ml vial.

Anomaly
[Ctrl + 1]

Anomaly start time ________

(Start anomaly as soon as S starts to places testis in vial)

Subject started recovery with
trackball _____
trackball key ____
device - pg dn ____
device - enter _____

Subject overshot next field Y ___ *N* ___

If so, how many fields? _____

Subject returned with
trackball _____
trackball key ____
device - pg up ____
device - enter _____

Was there back and forth move- ment between fields? Y ___ *N* ___

Time at correct new field __________

65. Determine testis mass on MMMD.

Wake up? Y ___ N ___

Start time_______

Testis # 2 Mass [ ] **Enter**

End time ________

Problems? Y ____ N ____

t p e

Go to sleep? Y ___ N ___

	no response to	wrong response	extra response to	wrong input by subject	corrected
number					
ERASE					
ENTER					
OTHER					

66. Record vial ID number.

Wake up? Y ___ N ___

Start time_______

Testis # 2 Vial # [ ] **Enter**

End time ________

t p e

Problems? Y ____ N ____

Go to sleep? Y ___ N ___

	no response to	wrong response	extra response to	wrong input by subject	corrected
number					
ERASE					
ENTER					
OTHER					

67. Freeze vial containing testes #2 in Quick Snap Freezer.

68. Place vial in Cryo Sample Holding Unit.

69. Record time. Place cursor on "Time Stamp" and select with middle key.

Start time _______

Time testes dissection complete ______________________________ TIME STAMP

End time _______

Problems? *Y* ____ *N* ____

DUODENUM DISSECTION

70. Open up portion of abdominal wall to locate the duodenum in the abdominal cavity.

71. Cut end of the duodenum connected to stomach. Make another cut approximately 2 inches along the intestine.

72. Cut tissue sample in half (two 1 inch portions).

73. Place one portion in a fixative bag.

74. Record bag ID number.

Wake up? *Y* ___ *N* ___

Start time _______

Duodenum #1 bag # [ ] **Enter**

End time ________

t p e

Problems? *Y* ____ *N* ____

Go to sleep? *Y* ___ *N* ___

End time ______

Problems? Y ____ *N* ____

ADRENAL GLANDS

81. Tare a 2 ml vial, with cap removed, on MMMD.

82. Locate right adrenal gland embedded in fat just anterior to the right kidney.

83. Using forceps, grasp adrenal and cut around it with dissecting scissors. Remove gland with some surrounding fat.

84. Place on surgery platform and remove attached fat.

85. Place adrenal gland in tared 2 ml vial and replace cap.

86. Determine mass of adrenal on MMMD. *Wake up? Y* ___ *N* ___

Start time ______

Right Adrenal Mass [ ] **Enter**

End time ______

Problems? Y ____ *N* ____ *t p e*

Go to sleep? Y ___ *N* ___

	no response to	wrong response	extra response to	wrong input by subject	corrected
number					
ERASE					
ENTER					
OTHER					

87. Record vial ID number. *Wake up? Y* ___ *N* ___

Start time ______

Right Adrenal Vial # [ ] **Enter**

End time ______

t p e

Problems? Y ____ *N* ____

Go to sleep? Y ___ N ___

	no response to	wrong response	extra response to	wrong input by subject	corrected
number					
ERASE					
ENTER					
OTHER					

88. Freeze adrenal in Quick/Snap Freezer.

89. Place in cryo sample holding unit.

90. Tare a 2 ml vial, with cap removed, on MMMD.

91. Locate left adrenal gland embedded in fat just anterior to the left kidney.

92. With forceps, grasp adrenal and cut around it with dissecting scissors. Remove gland with some surrounding fat.

93. Place on surgery platform and remove attached fat.

95. Determine mass of adrenal on MMMD. *Wake up? Y ___ N ___*

Start time_______

Left Adrenal Mass [ ] **Enter**

End time _________

t p e

Problems? Y ____ N ____

Go to sleep? Y ___ N ___

	no response to	wrong response	extra response to	wrong input by subject	corrected
number					
ERASE					
ENTER					
OTHER					

96.Record vial ID number.

Wake up? Y ___ N ___

Start time______

Left Adrenal Vial # [   ] **Enter**

End time ________

Problems? Y ____ N ____

t p e

Go to sleep? Y ___ N ___

	no response to	wrong response	extra response to	wrong input by subject	corrected
number					
ERASE					
ENTER					
OTHER					

97. Freeze adrenal in Quick/Snap Freezer.

98. Place in cryo sample holding unit.

99. Place remaining carcass and towels in rodent body bag and seal.

100.Place rodent body bag next to dissection platform.

101. Record time.Place cursor on "Time Stamp" and select with middle key.

Start time _______

Time adrenal dissection complete ________________ TIME STAMP

End time _______

Problems? Y ____ N ____

102. Remove gloves and place in waste bag.

103. Remove hands from glovebox gauntlets.

APPENDIX

Document 14. Training and Test Day Schedule

Day 1: Training Day

Time	**Activity**
8:30	Intro with Cindy: cover study overview, schedule, equipment familiarization, mockup layout and the cuecard, paper/pen system
9:30	With Marianne: learn about transferring data recorded with pen & paper into the computer, and introduction to filemaker pro, manual input (keypad) and trackball, including instruction on recovery from system error or failure.
10:00	Voice Input Device with Gail: overview of SW/HW, demonstrate use and practice using with the trackball and procedures, instruction on recovery from system error or failure
10:45	**Break**
11:00	Dissection demonstration/hands-on with Marianne
11:45	**Lunch**
12:45	Practice Dissection by Test Subject: manual input sytem
1:40	**Break**
2:00	Practice Dissection by Test Subject: voice input system
2:45	Review Questionnaires with Gail
3:00	Training day complete!

Day 2: Test Runs

Time	**Activity**
8:30	1st Test run
9:15	**Break**
9:45	2nd Test run
10:30	**Break**
10:50	3rd Test run
11:30	**Lunch**
12:30	4th Test run
1:20	**Break**
1:40	last Test run
2:20	Complete questionnaire and debrief
3:00	Test Day complete!

APPENDIX

Document 15. Summary by Subject and by Utterance of Efficiency of Voice Data Entry System

No Anomaly	0		1		2		3		4		5		6		7
Test Subject	# of times used in data field	# of times to enter correctly	# of times used in data field	# of times to enter correctly	# of times used in data field	# of times to enter correctly	# of times used in data field	# of times to enter correctly	# of times used in data field	# of times to enter correctly	# of times used in data field	# of times to enter correctly	# of times used in data field	# of times to enter correctly	# of times used in data field
1	8	9	5	5	7	8	4	4	5	5	8	11	13	13	4
2	5	7	5	5	12	18	4	4	3	3	11	11	11	11	3
3	4	4	6	7	6	8	10	12	5	6	14	18	10	10	4
4	4	4	4	4	11	17	7	9	6	6	10	13	9	10	4
5	4	4	10	10	8	8	10	10	7	7	6	6	6	8	3
6	6	6	5	5	6	6	12	12	4	4	8	9	8	8	2
7	2	3	5	7	11	12	5	5	7	7	7	10	10	13	6
8	3	3	5	6	9	11	11	13	6	6	7	8	13	13	5
Totals	36	40	45	49	70	88	63	69	43	44	71	86	80	86	31
Efficiency = minimum entry /(# times to enter correctly)		0.90		0.92		0.80		0.91		0.98		0.83		0.93	

With Anomaly	0		1		2		3		4		5		6		7
Test Subject	# of times used in data field	# of times to enter correctly	# of times used in data field	# of times to enter correctly	# of times used in data field	# of times to enter correctly	# of times used in data field	# of times to enter correctly	# of times used in data field	# of times to enter correctly	# of times used in data field	# of times to enter correctly	# of times used in data field	# of times to enter correctly	# of times used in data field
1	4	4	7	9	9	11	5	5	5	6	10	10	8	10	6
2	6	6	5	6	9	26	2	2	6	10	11	15	8	15	5
3	7	7	9	12	10	12	7	7	6	7	11	11	8	9	3
4	6	7	5	7	10	22	4	4	6	7	15	17	11	13	6
5	5	5	6	6	10	11	6	6	9	9	8	8	9	9	6
6	5	6	8	8	8	9	5	5	7	10	6	6	10	10	7
7	8	8	5	6	7	7	7	7	0	0	14	14	10	10	3
8	3	3	9	11	10	11	7	7	4	4	8	8	11	11	5
Totals	44	46	54	65	73	109	43	43	43	53	83	89	75	87	41
Efficiency = minimum entry /(# times to enter correctly)		0.96		0.83		0.67		1.00		0.81		0.93		0.86	

No Anomaly		8		9		Point		Check Mark		Enter		Erase		Page up	
Test Subject	# of times to enter correctly	# of times used in data field	# of times to enter correctly	# of times used in data field	# of times to enter correctly	# of times used in data field	# of times to enter correctly	# of times used in data field	# of times to enter correctly	# of times used in data field	# of times to enter correctly	# of times used in data field	# of times to enter correctly	# of times used in data field	# of times to enter correctly
1	9	6	8	5	15	6	6	4	4	20	21	16	27	2	2
2	4	8	11	7	7	6	6	4	6	21	34	3	4	1	1
3	5	7	9	5	6	5	6	4	4	28	28	12	15	0	0
4	4	6	6	7	7	6	7	4	5	27	27	13	17	0	0
5	3	9	9	7	8	5	5	4	4	24	25	5	5	0	0
6	2	11	11	7	7	6	6	4	4	27	27	1	1	0	0
7	8	6	7	9	9	6	12	4	4	27	27	11	11	0	0
8	5	6	7	4	6	6	8	4	4	27	29	2	6	0	0
Totals	40	59	68	51	65	46	56	32	35	201	218	63	86	3	3
Efficiency = minimum entry /(# times to enter correctly)	0.78		0.87		0.78		0.82		0.91		0.92		0.73		1.00

With Anomaly		8		9		Point		Check Mark		Enter		Erase		Page up	
Test Subject	# of times to enter correctly	# of times used in data field	# of times to enter correctly	# of times used in data field	# of times to enter correctly	# of times used in data field	# of times to enter correctly	# of times used in data field	# of times to enter correctly	# of times used in data field	# of times to enter correctly	# of times used in data field	# of times to enter correctly	# of times used in data field	# of times to enter correctly
1	6	8	8	6	6	6	8	4	4	27	27	6	8	0	0
2	5	9	11	10	12	6	6	5	7	27	31	13	16	0	0
3	4	7	8	4	4	6	7	4	4	27	27	11	13	0	0
4	9	8	10	9	11	7	7	4	4	25	25	13	16	0	0
5	6	11	11	4	4	6	6	4	4	26	30	3	5	0	0
6	7	9	11	4	5	5	6	4	4	27	28	9	12	0	0
7	3	10	11	5	6	6	7	4	4	27	27	7	8	0	0
8	5	7	7	6	6	6	6	4	5	27	28	9	11	0	0
Totals	45	69	77	48	54	48	53	33	36	213	223	71	89	0	0
Efficiency = minimum entry /(# times to enter correctly)	0.91		0.90		0.89		0.91		0.92		0.96		0.80		0.00

No Anomaly	Page down		Go to sleep		Wake up		
Test Subject	# of times used in data field	# of times to enter correctly	# of times used in data field	# of times to enter correctly	# of times used in data field	# of times to enter correctly	Overall Efficiency
1	1	1	14	18	15	26	
2	1	2	11	13	12	19	
3	0	0	12	12	14	18	
4	1	1	16	19	16	18	
5	0	0	16	18	16	22	
6	1	1	14	14	14	20	
7	5	7	17	18	17	18	
8	1	2	14	16	14	17	
Totals	10	14	114	128	118	158	
Efficiency = minimum entry /(# times to enter correctly)		0.71		0.89		0.75	0.85

With Anomaly	Page down		Go to sleep		Wake up		
Test Subject	# of times used in data field	# of times to enter correctly	# of times used in data field	# of times to enter correctly	# of times used in data field	# of times to enter correctly	Overall Efficiency
1	12	12	17	22	17	22	
2	8	10	18	36	13	18	
3	3	3	16	16	16	17	
4	0	0	16	20	16	20	
5	2	2	14	17	13	21	
6	6	7	16	16	16	22	
7	11	16	17	18	17	17	
8	2	2	18	23	18	25	
Totals	44	52	132	168	126	162	
Efficiency = minimum entry /(# times to enter correctly)		0.85		0.79		0.78	0.87

APPENDIX

Document 16. Glovebox Data Entry and Display Study Questionnaire

Think about the tasks you have just completed and the devices you used. For each characteristic, circle one of the two devices in each pair you think was better. Even if you feel the choice is difficult, you must choose one or the other. (Please note: "Pen only" includes electronic data transcription).

Characteristic	Paired Comparison
1. Ease of learning the system	pen only or keypad voice system or keypad voice system or pen only
2. Ease of entering data	pen only or voice system keypad or voice system keypad or pen only
3. Ease of entering commands (Page up, page down, erase/delete, enter)	keypad or voice system
4. Ease of correcting wrong numbers entered in the correct field	keypad or voice system voice system or pen only keypad or pen only
5. Ease of correcting an entry entered in the wrong field	keypad or pen only voice system or pen only voice system or keypad
6. Ease in dealing with anomalies, e.g., cursor moving to another field, inadvertent page up, etc.	keypad or voice system

7. Ease of keeping track of your place in the procedure	pen only or voice system keypad or voice system keypad or pen only
8. Ease of knowing which commands to enter	voice system or keypad
9. Efficiency of performing dissection procedure (minimal disruption by data entry)	pen only or voice system keypad or voice system pen only or keypad
10. Overall preference	pen only or voice system keypad or pen only keypad or voice system

Please rate each method of data entry by circling the appropriate number:

Pen and paper:	Most preferred	1	2	3	4	5	6	7	Least preferred
Keypad:	Most preferred	1	2	3	4	5	6	7	Least preferred
Voice system:	Most preferred	1	2	3	4	5	6	7	Least preferred

APPENDIX

Document 17. Follow-up Questions Regarding the Voice Input System

Please think back to your experience using the voice input system.

1. What did you like about using the voice system?

2. Which functional capabilities did you like to use the voice system for? navigation (page/up & down)? numerical data input?

3. What changes can you think of that would make the voice system more user friendly?

4. If these changes were made to the voice system, do you think you would prefer the voice system over a keypad or pen and paper (if you didn't before)?

5. Some aspects of the user interface could be changed relatively easily, such as:

   - Having the system automatically "Go to Sleep" everytime data was entered
   - Having the system turn on with the recognition of a keyword
   - Changing some of the vocabulary
   - Having a visual verification of the current operating mode (on/off)
   - Having an audible cue as well as the visual cue "###" to alert the operator when the system doesn't understand a command or data

   Do you think these changes would make the voice input system significantly easier to use?

6. Please indicate whether you "agree" or "disagree" with the following comments about the voice system:

   - I felt I needed a lot of time to really get comfortable with the system: agree or disagree

   - I could easily tell whether the system was "asleep" or "awake": agree or disagree

   - It was not a problem to remember correct pronounciations of words or numbers: agree or disagree

   - Using the voice system for navigation was efficient because I didn't have to stop what I was doing with my hands: agree or disagree

- The command phrases were easy to remember: agree or disagree

- I had as much confidence that data would be recorded accurately with the voice system as with the other methods: agree or disagree

- I did not mind wearing the headset while working : agree or disagree

7. How would having more training and practice working with the voice system affected your impressions?

8. How would it affect your impression of the voice system if additional commands were available (such as time stamp, move to the next or previous field, and select entire field) which would minimize or eliminate the need for a trackball?

9. Do you think that the current recognition technology is mature enough to judge?

10. Any other comments about your experience using the voice system?

APPENDIX

Document 18

The Glovebox I Risk Reduction Study: An Analysis of Two Data Input Systems for Scientific Procedures within a Closed Workstation

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SUMMARY

The present study examined the human-computer interface for data entry and performing procedures within a glovebox work volume. Test subjects entered data using either manual manipulation of a touchpad, the UnMouse, located within the glovebox, or voice input using Voice Navigator and a headset. Data, such as sample vial identification numbers, sample tissue weights, and health check parameters of the specimen were entered directly into procedures that were electronically displayed on a video monitor within the glovebox. Procedures were performed with either one or two operators. However, test subjects were always responsible for data entry.

The results of the study clearly show that operations were performed faster with two operators than with one. There was no difference in total operation time between the entry devices for either one or two person procedures. Comparison of the data entry devices revealed that the time required to enter a command was less with voice input, while the time to enter data (sample vial identification number) was less with the UnMouse. Data entries were characterized as: "correct responses" (by the device), "no response" (by the device), "wrong response" (by the device) or "wrong data" (entered by the test subject). There were more "correct responses" but also more "wrong data" entered using the UnMouse compared to voice input. In addition, there were fewer "no responses" and "wrong responses" associated with use of the UnMouse. The level of voice input system technology used in this study resulted in a large percentage of responses where the device either did not respond or gave the wrong response to correct input by the test subject.

Taken together, the data suggest that, at the technology level of the data entry devices used, manual input of data may be more efficient than voice input due to the increased percentage of correct responses and decreased percentage of no or wrong responses with the manual input device.

The continuation of this study, (Glovebox II), will address the question of device technology impacts on data entry systems by comparing manual and voice systems, using a state of the art, speaker-independent voice input system. Furthermore, the study will assess these issues in the context of the computer operations system currently envisioned for use on space station.

INTRODUCTION

International Space Station Alpha marks the beginning of the next phase of non-human life sciences research in space. Experiments will be conducted that will more fully investigate the influence of gravity on living organisms. Activities to support this research will require the use of a glovebox within which specimens, including plants and animals, can be manipulated, procedures performed, and experimental data collected and recorded. The glovebox provides an isolated work area within which these activities can take place.

For life sciences research currently being conducted on the space shuttle, experiment procedures are displayed in procedure books or on cue cards and data recorded by hand, using paper and pencil. However, this simple system has many drawbacks when long-duration flights such as the space station are considered. The protocols used and data collected would require a considerable volume of procedure books and data sheets. Recognizing this, the space station is evolving to a "paperless" environment where procedures will be displayed on video display terminals and experimental data recorded electronically.

Studies have been conducted by the Man-Systems Division at NASA-Johnson Space Center to evaluate cursor control devices as a means of cursor navigation on video display terminals within a microgravity environment on both the KC-135 and the space shuttle (1). However, presentation of experimental procedures and recording of data efficiently within an isolated work volume provides unique design challenges that have not been adequately identified and defined.

The purpose of the present study was to examine the human-computer interface for communication with a glovebox data system requiring data input while performing procedures presented on an electronic display located within the glovebox work volume.

METHODS

Test Plan/Approach

The utility and efficiency of two data entry devices (manual and voice) were evaluated for their ability to enter and correct data input into procedures displayed on a monitor within a glovebox work volume. The manual data entry system required manipulation of a touchpad, the UnMouse, located within the glovebox. The voice data entry system required entering the data using voice commands through a headset which was connected to a voice recognition system, Voice Navigator, installed on the computer. Four test subjects entered data directly into fields located within electronically displayed surgical procedures. The test subjects used each device twice, working either alone or with a second person at the glovebox. Procedures were modified from experimental operations with rodents defined in the "Characterization of Flight Verification Increments for the Centrifuge Facility."

Input Device Selection

Manual Input Devices

Several input devices were evaluated as candidate manual data entry devices. Each device was judged for its ability to support numerical input, to provide cursor control, the volume and surface area required within the glovebox, accessibility of the input device, and device maintenance (Table 1). Of the input devices that were examined, only the UnMouse was able to uniquely provide both numerical input and cursor control within a small, cleanable package.

Input Device	Numerical Input	Cursor Control	Volume/ Surface Area Cost	Accessibility	Maintenance
Keyboard	Yes	**Limited**	**High**	Easy, movable	Difficult to keep clean.
Mouse	**No**	Yes	Low	Easy, movable	Difficult to keep clean.
Trackball	**No**	Yes	Low	Easy, movable	Difficult to keep clean.
Joystick	**No**	Yes	Low	Easy, movable	Not evaluated.
UnMouse	Yes	Yes	Low	Easy, movable	Not perceived as an issue.
Touchscreen	**No**	Yes	Low	Fixed location, presents reach problems for smaller users if screen is placed on the rear surface of the glovebox	Not perceived as an issue.

Table 1. Evaluation of Candidate Manual Data Entry Devices

The UnMouse™ (Figure 1, MicroTouch Systems, Inc., Methuen, MA) is a small, flat, touch tablet. Cursor control is provided by sliding a finger over the surface of the UnMouse. The UnMouse is based on analog capacitive sensing technology. The surface is coated so that the device can sense changes when a conductive item such as a finger or conductive stylus touches the surface. The UnMouse interfaces with the computer on the Apple Desktop Bus and requires 60 K of RAM. The unit is easily cleaned (water, alcohol or glass cleaner) and is impermeable to water and particles. Input, equivalent to mouse clicking, is performed by applying sufficient pressure to depresses the surface of the plate downward. User defined function keys can be programmed to execute commands which can be identified by a template under the surface of the UnMouse. A numerical "keypad" and selected function keys were programmed for the study. In order to use the UnMouse for both cursor control and as a keypad, the unit must be used in the "Red Button Mode". That is, to activate the keypad, the red button at the left of the unit must be pressed prior to making selections indicated on the template. For example, to enter the command "Time Stamp", the red button must be pressed prior to pressing down on the "Time Stamp" portion of the UnMouse surface.

During preliminary testing with the UnMouse, it was found that the sensitivity of the unit was significantly reduced when used in conjunction with latex surgical gloves. However, use of vinyl gloves provided acceptable performance and were used in all procedures with the UnMouse.

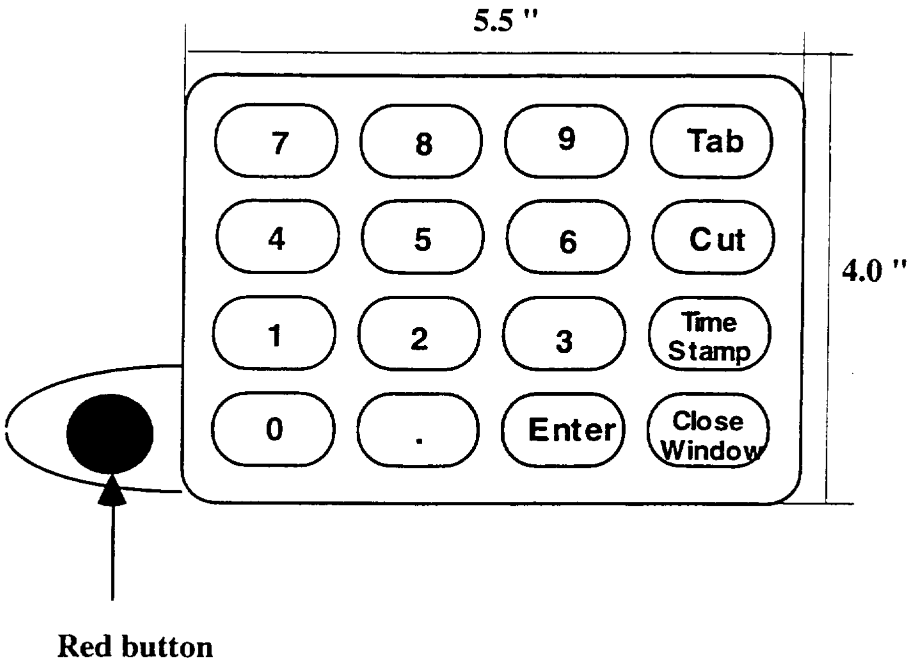


Figure 1. UnMouse Data Entry Device

Voice System

The voice recognition system used in this study was Voice Navigator II (Articulate Systems, Inc. Worburn, MA). Voice Navigator is a Macintosh compatible, speaker dependent, voice recognition system that may be linked to any application. The speaker dependent nature of the system requires each user to pre-train the words/commands to be included in the active vocabulary. Spoken commands are compared against the set of words in the user's voice file (a set of user specific voice recordings) and the corresponding command executed by Voice Navigator. The system includes the Navigator unit (5.5" x 6.3" x 1") which was mounted to the exterior of the glovebox, software (requiring 2 MB of RAM) and a desktop microphone. Voice Navigator runs "behind" the primary program (for this study, Double Helix) and can be used to control the position of the cursor, to execute commands (like function keys), and to input any of the words in the active vocabulary. The Navigator interfaces with the computer through the Small Computer Systems Interface port. The system can support multiple users, each of which has an individual voice file that can be accessed from the Macintosh control panel.

The microphone selected for this study was a Gentex 1000 headset (Derry, NH) which was connected directly into the Voice Navigator system. This headset/microphone was selected over the desktop model provided with Voice Navigator for its background noise reduction capability and ease of use. During test development, it was determined that a headset/microphone was less restricting than the desktop microphone, permitting users to work and move more naturally while performing the procedures. In addition, the headset system keeps the location and distance between the microphone and the speaker's mouth fixed, thereby improving the efficiency of voice recognition.

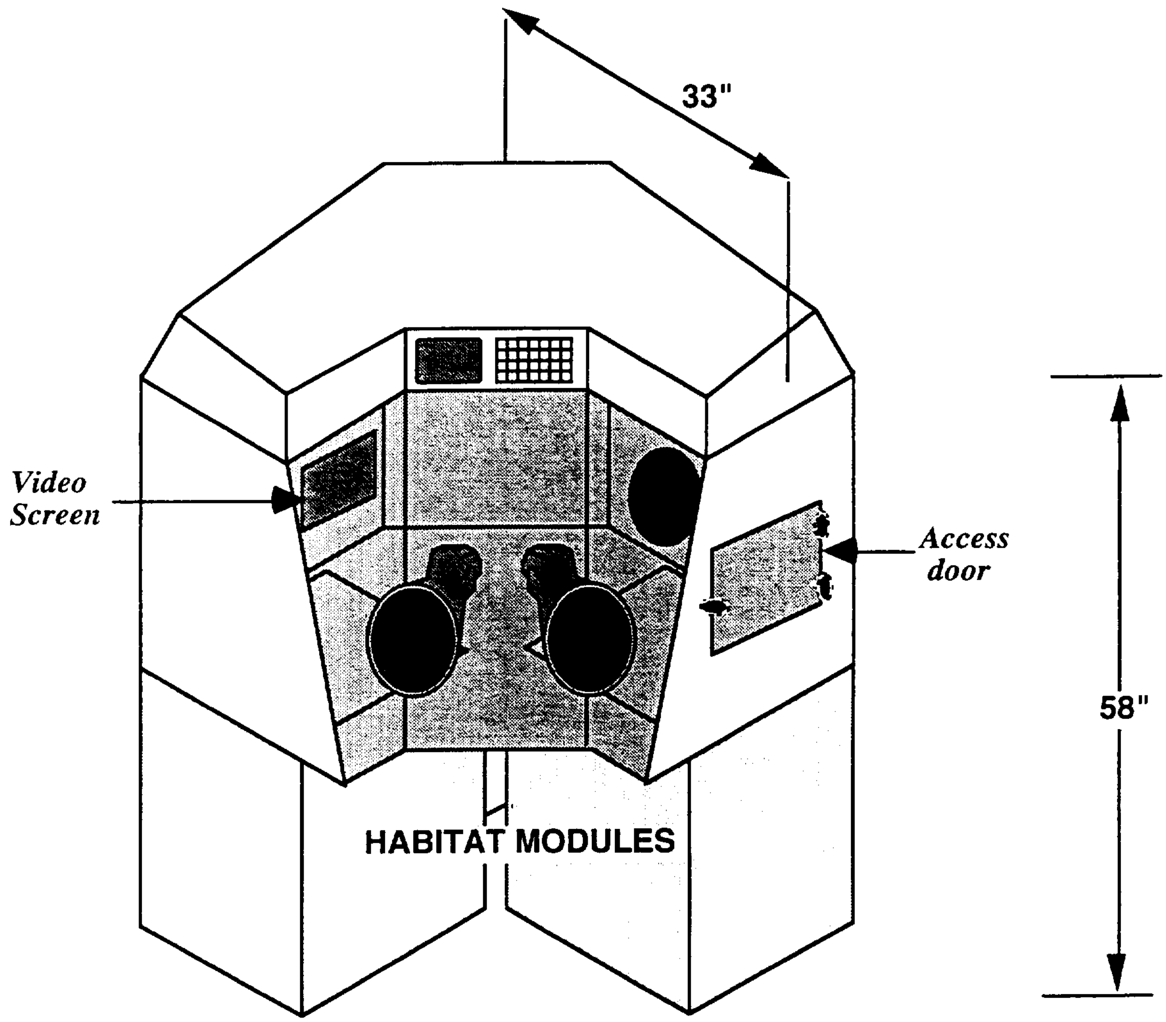
The confidence level (the point at which the system will not recognize or execute a command) was set at 75%. The confidence level establishes how closely a spoken word or phrase must match the model in the user's voice file before the system will execute the corresponding command. Lower confidence levels require a less accurate match between the spoken command and the model in the voice file, increasing the potential for the system to incorrectly identify the spoken command (false positive).

Visual feedback is provided to the user so that when the voice system is "on", a headset icon surrounding the apple symbol in the upper left portion of the video screen is bolded in black. When the system is "off", the headset is lightened to gray. Additionally, the last recognized spoken command is displayed in the upper right hand corner of the menu bar.

Test Environment

All training sessions and experimental runs were conducted within a single room of a dedicated trailer. No special acoustical isolation was provided by the trailer. The background noise in the room was not controlled or measured. The test room contained the glovebox mock-up, a video camera mounted on a tripod to record test subject body position and posture, the Macintosh computer, and miscellaneous furniture, including a table for demonstrations. A video display terminal and VCR connected to the internal camera, resided in the adjacent room.

The glovebox used for this study was based on the "wrap-around work volume" concept conceived by the Centrifuge Facility Project Office (Figure 2). Previous work (2) indicated that this design provided users with accessible surfaces and work areas where operations can be efficiently performed. The glovebox was constructed of aluminum and lexan. It can accommodate two operators, one at the front and another along the right-back wall. Access doors on the floor of the work volume permit attachment of up to two habitats or equipment modules. Equipment and specimens may be retrieved through either of these access doors.



Italicized items indicate modifications resulting from observations made during procedure development.

Figure 2. Wrap-Around Glovebox Mock-Up

Several modifications were made to the existing mock-up based on observations made during procedure development. Metal sheets (0.030 inch mild steel) were attached to the surface of the interior walls so that instruments and supplies could be attached with magnetic strips. A door was added to the right side panel to permit access to the interior volume for transferring items in and out of the work area without disturbing equipment set-up on the work surface (which doubles as the habitat/equipment access doors). Two fluorescent lamps (15 watts each) were placed on top of the glovebox to provid illumination of the work volume. Room lights were turned off during test runs because they produced reflective glare on the front panel of the work volume and impeded visibility into the interior. Finally, a shelf and cut-out were added to the left rear of the exterior work volume to mount the video monitor used to display procedures.

Equipment and Supplies

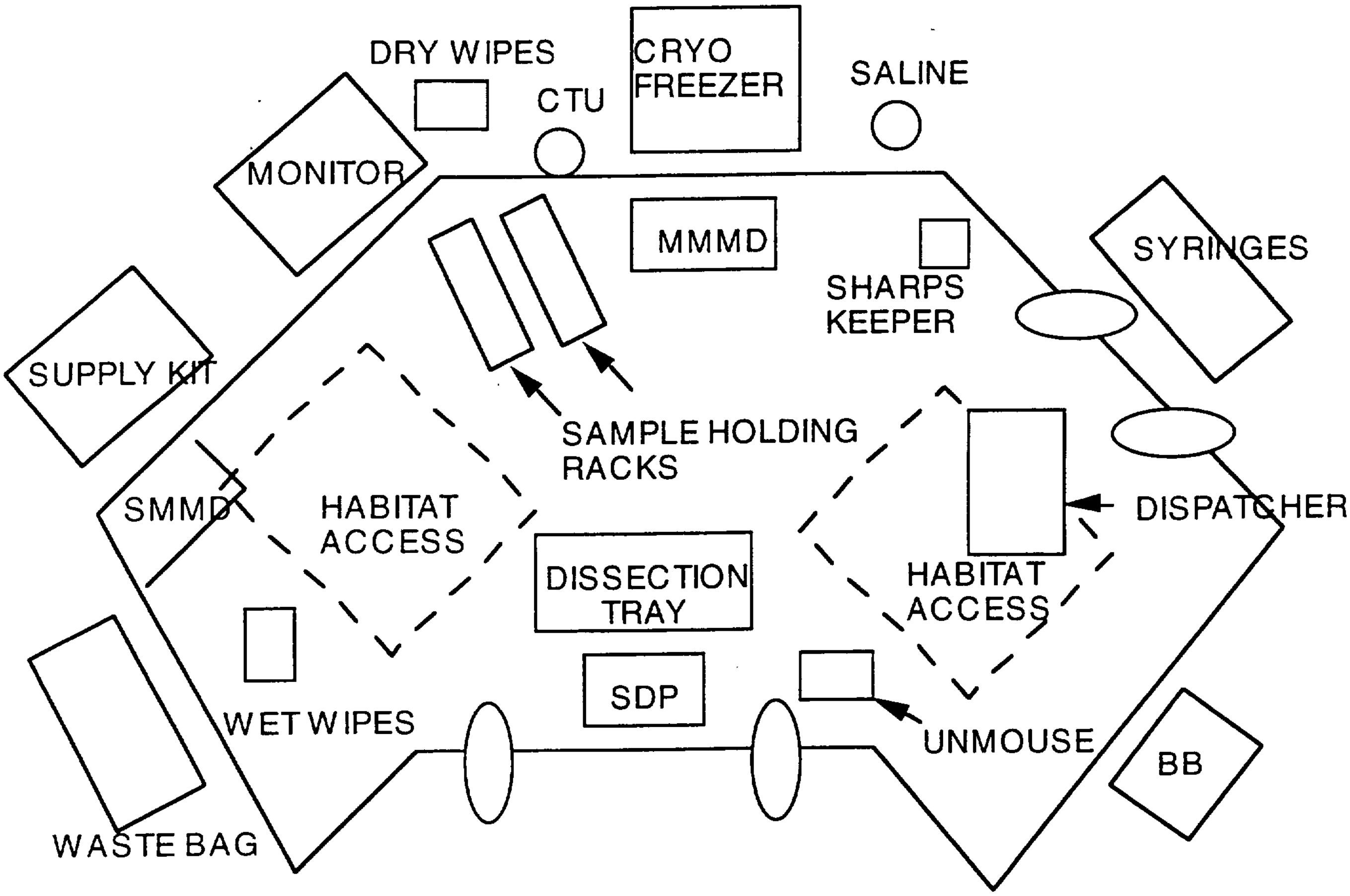
Standard laboratory supplies (e.g., surgical gloves, lab coats, test tubes and racks) and some equipment (e.g., surgical instruments and tray, dissecting platform) were purchased for this study. A tissue weighing scale and animal guillotine were borrowed from a biological laboratory. Other equipment such as an animal weighing scale, a cryofreezer and a cryofreezer holding unit were fabricated from foam core. Specimens for dissection were preserved adult, rats, weighing approximately 400 grams (Wards Natural Science, Rochester, NY).

Test Development

The initial development of the test concentrated on evaluation and acquisition of the data entry devices, procurement of the equipment and supplies and a workspace for a laboratory, modification of the glovebox mock-up (all described above) and development of the electronic displays for the surgical procedures.

The surgical procedures were modified from four reference experiments described in the "Characterization of Flight Verification Increments for the Centrifuge Facility." The procedures outlined in detail the operations required to remove the following tissue samples from a rat: heart (further divided into numerous samples), testes, duodenum and adrenals. The procedures were expanded to include turning on the glovebox power, checking the layout of the equipment and supplies in the glovebox work volume, removal of the specimen from the holding tray below the glovebox, entering mass and health check parameters, decapitation of the specimen, removal of tissues and either preserving or freezing them, data entry of vial identification numbers and some tissue weights, cleaning of the work space and turning the glovebox power off. Fixation and freezing of tissues and glovebox power manipulations were simulated. Copies of the one and two person procedures are attached in the Appendix.

The procedures were incorporated in a relational database (Double Helix Express, Helix Technologies, Northbrook, IL), where data such as specimen or tissue mass, sample vial identification number or health check parameters could be entered directly into fields displayed within the procedures. Specimen identification number, mass and health check parameters were listed on a cue card attached to the specimen. The procedures were extensively modified during numerous dry runs and wet runs conducted by the test developers. During "dry runs," the procedures were performed with a dummy specimen; during "wet runs," a preserved rat specimen was used. The original protocols included a requirement for the test subjects to transport the equipment and supplies to the glovebox and set up the material for the procedures and to remove the materials when the test session was complete. During the dry runs, this requirement was deleted because it added considerable time to the total operation and was not related to the primary purpose of this study, an evaluation of data input devices. Prior to the start of each experimental run, the glovebox was set up to contain all required equipment and supplies. The layout used for a one person operation is shown in Figure 3.



View from the top of the work volume. Equipment outside of the work volume footprint was mounted on the wall. Drawing is not to scale.

ACRONYMS

BB - Biomaterials Bag

CTU - Cryotransfer Unit

MMMD - Micro Mass Measurement Device

SDP - Specimen Dissection Platform

SMMD - Small Mass Measurement Device

Figure 3. Layout of Equipment/Supplies in the Glovebox for the One Person Procedure

Personnel

Various roles and responsibilities were assigned to the particular test developers:

The Test Conductor prompted the test subject, when necessary, during the sessions to read and follow the procedures and answered questions and clarified issues.

The Trainer compiled the training manual for each test subject and was responsible for coordinating the training and practice sessions in the use of each data entry device and performance of the procedures (See Training).

The Test Observer recorded data on the observation sheets documenting the types of data entry errors and any other problems which occurred during the test session. The format of the observation sheets closely followed the format of the one person and two person procedures. Separate observation sheets were developed for voice and UnMouse data entry. Examples extracted from the observation sheets for the UnMouse and voice are shown below.

Data collected for each data entry attempt with the UnMouse:

Any Problems (Y/N?): ________________

If Yes:

Problems in Unmouse response: [ ]

Problem in locating cursor: [ ]

Problem in timing:
(red button)/(enter) : [ ]
(red button/(number(s)) : [ ]

Cleaning required: [ ]

Wizard intervention required: [ ]

Other:

Data collected for each data entry attempt with the voice system:

What was said ?	*What was displayed (or what the computer did) ?*	Wizard Intervention required?	"Enter" Command	Notes

The Wizard operated "behind the scenes" during the test sessions, with a keyboard and mouse connected to the computer display. It became apparent during the dry runs that certain problems with data entry would be encountered by the test subjects. For example, the cursor movements with the UnMouse were occasionally erratic and the cursor jumped from one entry field to another for no obvious reason. When this occurred, the wizard returned the cursor to the proper field. With the voice input system, the test subjects occasionally had problems with the system recognizing the data entries. After three attempts with no recognition, the wizard entered the data.

The Dissector performed the surgical procedures during the two person operations; the test subject was responsible for assisting with the procedures but was solely responsible for data entry. During the one person procedures, the test subject performed both the surgical procedures and the data entry.

Questionnaires were developed during the dry runs to evaluate the usefulness and "user-friendliness" of the data entry devices by the test subject. Separate questionnaires were developed for the UnMouse and for the voice system. At the end of all eight test sessions, the test subject completed a general questionnaire assessing the general test environment and ranking the entry devices. Copies of the questionnaires are included in the Appendix.

Test subjects

Two women and two men, ranging from 45-55 years of age, were recruited as test subjects. All test subjects had some experience in surgical procedures. The test developers felt that by imposing this requirement, the test subjects could focus on becoming proficient with the input devices and not on the dissection procedures.

Experiment Design

Training

Prior to the start of test runs, each subject was provided with a training manual containing an outline of the study, general descriptions of each of the input devices, the voice vocabulary, procedures for 1 and 2 person operations, schematics of the equipment layout and copies of the questionnaires. On the first day of each test week, subjects were introduced to the objectives of the study and staff, familiarized with the test schedule, given an overview of the glovebox and equipment, and trained on each of the input devices and glovebox procedures. Additionally, subjects created their own personal voice file. The vocabulary used in this study is listed in the Appendix. Each subject was given a bench-top demonstration of the experimental procedures and was required to perform the procedures with each of the input devices within the glovebox. The schedule for the training day is shown in the Appendix.

Test Runs

Test runs began on the day following training. Each test subject performed eight procedures over two or three days: four using Voice Navigator and four using the UnMouse. Under each device condition, two runs were performed by the test subject alone, doing both the surgical procedures and the data entry; and two runs with a second operator, who performed the surgical procedures while the test subject was primarily responsible for data entry. The test runs were arranged in a Latin squares configuration to ensure a counterbalanced design and eliminate any order effects. Test subjects performed three or four procedures per day with rest periods (one half hour) between test runs and an hour lunch break.

Data

During the test runs, elapsed time and postural and hand movements were recorded on the video cameras located outside and inside the Glovebox, respectively. In addition, voice comments by the test subjects and study investigators were recorded on the audio file of the interior camera. Errors and problems during data input or procedure operations were recorded on the observation data sheets by the Test Observer. At the end of each test run, the test subject completed a questionnaire applicable to the particular input device. Upon completion of all eight test runs, the test subject was asked to fill out a general questionnaire evaluating the test environment within the Glovebox and comparing the input devices.

After the completion of the test runs for all subjects, the internal video recordings were viewed to determine the time required to perform data entry (e.g. seconds to enter each number in the sample vial identification numbers, specimen weight, sample weight) or command entry ("close window", "time stamp", "turn glovebox fan on"). In addition, the total time to complete the experimental operations for one and two persons for each input device was determined.

The characteristics of the data entries were determined from the observation sheets. If there was any uncertainty in the data entry categorization from the observation sheet, the internal Glovebox videos were reviewed. Data entry was categorized as shown in Table 2.

Data Entry	
Correct Responses	The correct data entry was made and the input device responded appropriately
No Responses	The correct data entry was made but the input device did not respond
Wrong Responses	The correct data entry was made but the input device entered the wrong data
Wrong Data	An incorrect data entry was made by the test subject

Table 2. Data Entry Categories

For data analysis and presentation in this report, the above entry characterizations are presented as a percent of the total number of entries required to enter the data during a test session. These categories were then compared between the two data entry devices. In addition, the percentage of "Wrong Data" entered was compared between one and two person operations.

Finally, an Efficiency of Performance Index was calculated for the input devices: the total number of entry attempts was divided by the minimum number of entries that would have been required to enter the data had all entries been made without problems. For example, if a test subject required 181 attempts to enter the data that would have required a minimum of 130 entries, the Efficiency of Performance Index would be 1.39. The closer this value is to 1.0, the more efficient was the operation of the device. These values were then compared between devices.

Statistical analysis

Data were analyzed by two-way analysis of variance using StatView (Abacus Concepts Inc., Berkeley, CA, 1992).

RESULTS

As can be seen in Figure 4, the total time required to complete each test session was significantly less ($p<0.01$) when two people were performing the procedures compared to one person. There was no difference between the entry devices in time required, for either one person or two person operations.

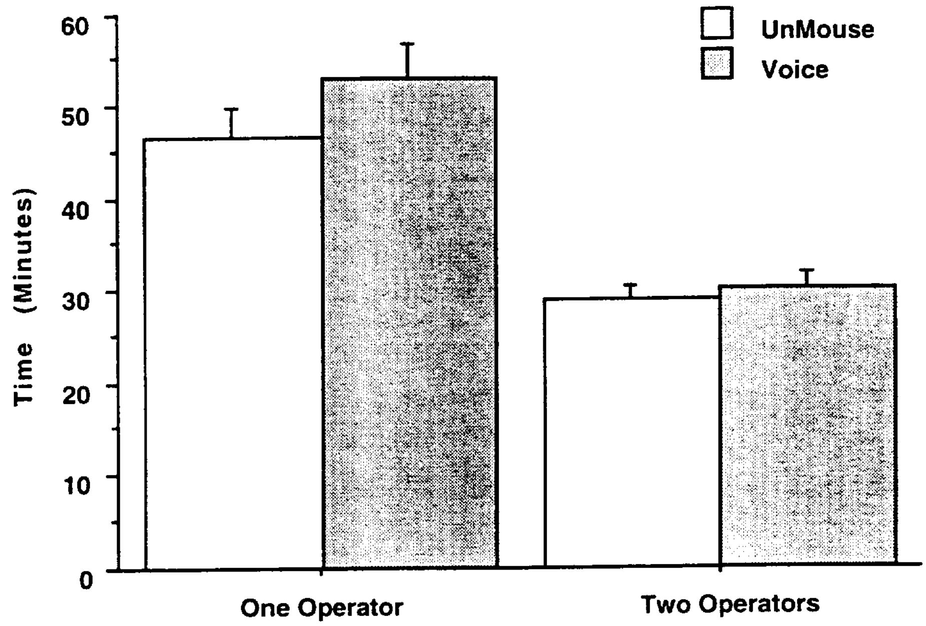


Figure 4

The time (seconds) to enter commands such as "close window," "time stamp" or "turn glovebox fan on" (Command Time) was significantly less ($p<0.01$) with the voice system than with the UnMouse. Conversely, the time required to enter data such as each number in the sample vial identification numbers, specimen weight or sample weight (Entry Time) was less ($p<0.01$) with the UnMouse than with voice input (See Figure 5).

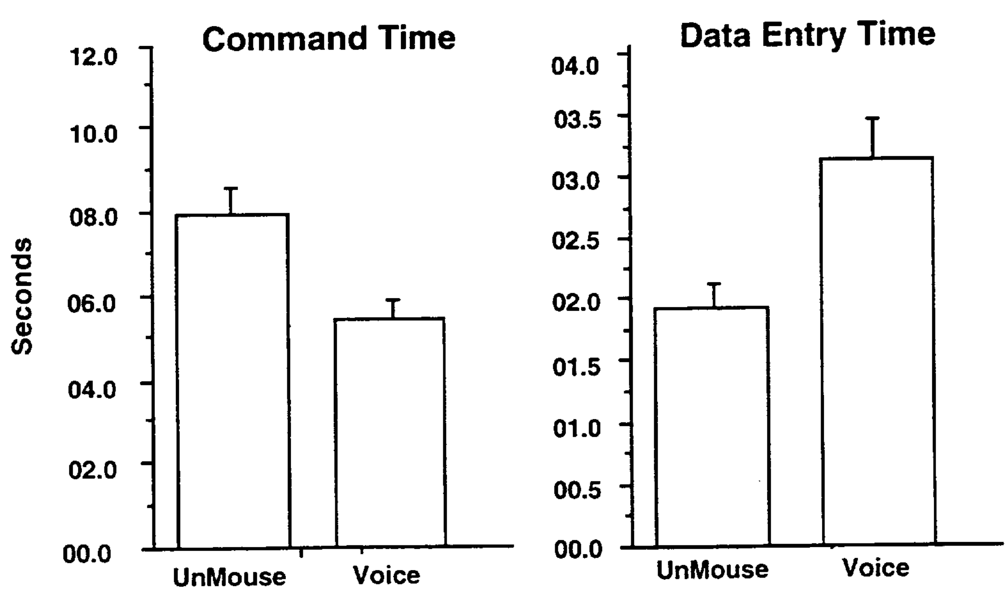


Figure 5

The results from data entry characterization are shown below in Table 3. There was a significantly greater percentage of correct data entries when test subjects used the UnMouse compared to the voice system (96.69% versus 64.03%). However, there was also a greater percentage of wrong data entered with the UnMouse than with the voice system (1.88% versus 0.06%). There was no difference in the percentage of wrong data entered between one and two person operations (data not shown). The per cent of entries that elicited either no response or a wrong response was greater with voice input than with the UnMouse. Overall, the UnMouse had a better Efficiency of Performance Index than the voice system.

	% Correct Responses	% No Response	% Wrong Response	% Wrong Data	Efficiency of Performance Index
Voice	64.03	33.52	2.39	0.06	1.46
Unmouse	96.69	1.39	0.14	1.88	1.03

Devices are significantly different from each other in every category

Table 3. Data Entry Characterization

Data entry with the voice system resulted in a large percentage of trials on which there was "no response" (see above, Table 3), sometimes requiring many repetitions of the entry and may be the cause of the significant difference in data entry times between voice and UnMouse (Figure 5). Therefore, a second analysis was performed in which trials with "no response" were removed from the analysis. This analysis showed that, while the advantage of the voice system in command time remained intact (there were few "no response" problems in commands), no significant difference (p>.05) was now observed between voice and UnMouse in data entry time. These results are shown in Figure 6. If it were possible to eliminate the device problems with the voice system, the Efficiency of Performance Index for voice would probably drop close to 1.0, similar to the UnMouse index.

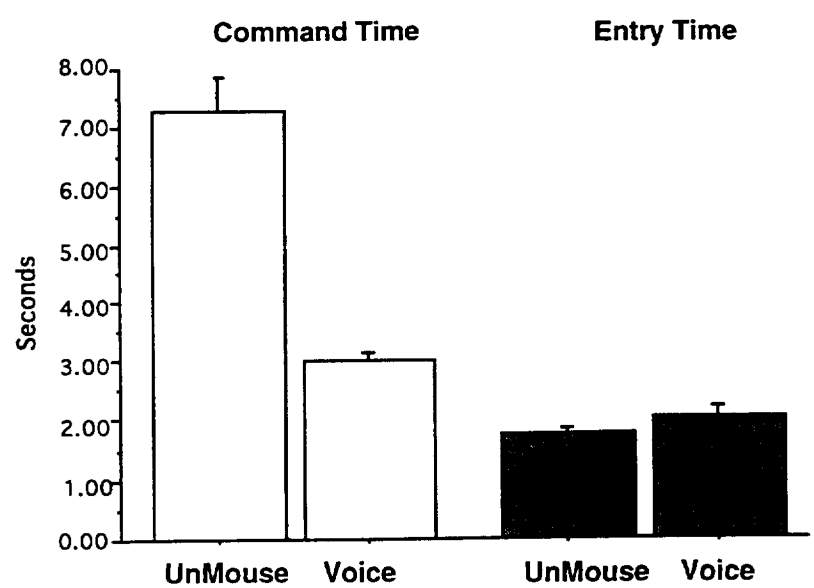


Figure 6

Although the overall time to perform the entire glovebox procedure was not affected by the input device (Figure 4), it was possible that the time to perform a particular subtask might be. Thus, the glovebox tasks were divided into six subtasks: health check, dissection layout and dissections of the heart, testes, duodenum and adrenal. A time was obtained for each subtask under each condition with time for commands and data entry removed. In this way, the effect of the device on performance of the primary subtask could be gauged.

As expected, subtasks differed from one another in the time it took to perform them ($p<.0001$), since some were more complex than others. The finding of interest, however, was that the device also had an effect on primary subtask performance ($p=.0055$) and that the effect varied for different subtasks ($p=.03$). These effects are shown in Figure 7.

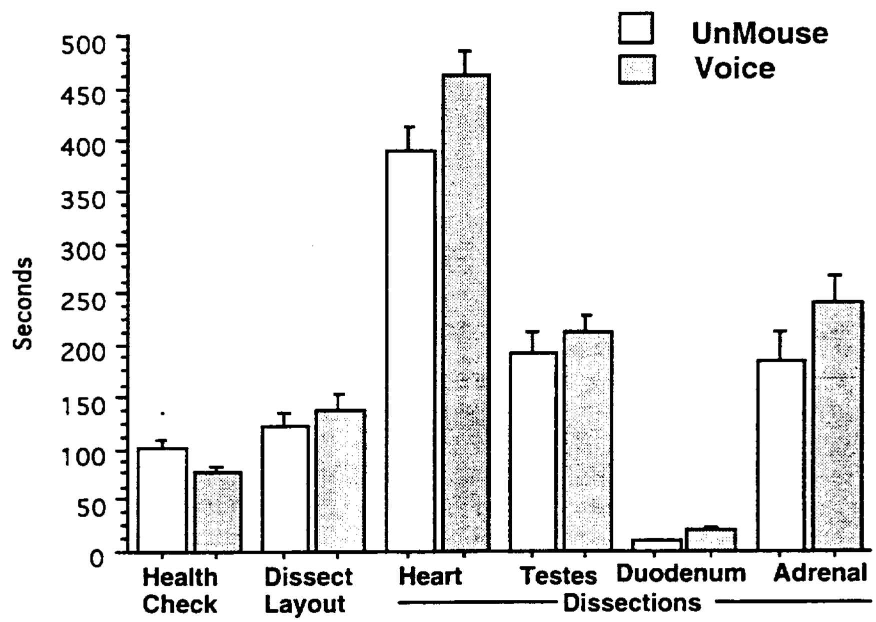


Figure 7

Overall, the total time spent on the primary subtasks is shorter for the UnMouse than for the voice system. Post hoc tests (Scheffe) indicated that this is not true, however, for the dissection layout and for dissection of testes and adrenal. Here, the two devices produce statistically equal performance in terms of time. Furthermore, time spent on the Health Check was longer with the UnMouse. The health check and dissection layout subtasks had relatively few instances in which there were significant numbers of "no response" trials, where problems with voice recognition would have increased the time; most of the "no responses" were found in the other subtasks.

Test subjects evaluated the data entry devices for performing certain cursor movements such as moving the cursor short or long distances, positioning the cursor for correcting erroneous input, and scrolling procedures up or down on the video screen. There were no significant differences between devices in these evaluations. Both devices received a numerical score which corresponded to "reasonably acceptable." In addition, there were no significant differences in the means of these ratings.

Test subjects were also asked to provide an overall ranking of the entry devices. The rankings are shown below in Table 4. Three out of four test subjects ranked the UnMouse better than voice for entering data and moving through the electronically displayed procedures. One of these subjects clearly disliked the voice input system; while another mildly preferred it.

Test Subject	UnMouse	Voice
1	3	4
2	1	10
3	5	3
4	3	4

1 = best; 10 = worst

Table 4. Ranking of the Data Entry Devices

Examination of the tapes from the external camera did not reveal any additional information pertinent to this study.

DISCUSSION

The primary purpose of this study was to examine the utility and efficiency of two types of systems for entering data directly into electronically displayed experimental procedures inside a glovebox work volume. The results of the study indicate that there was no effect of device type on the total time required to perform the experimental procedures, independent of the number of operators performing the procedures (Figure 4). However, there was an effect of input device when individual subtasks were considered (Figure 7). The effect of the device on time to perform the subtasks was not consistent: the UnMouse was better for some (Heart Dissection); the voice system was better for others (Health Check); and some tasks were unaffected by the device. The randomness of the device effects argues against a relationship to specific problems with the voice system, since the number of "no response" trials is small on some tasks where there is a significant effect and large on others. This may also suggest that the effect of input device on subtasks may be much larger when such variables as type of measurement taken or species being investigated are considered. Dissection of a preserved specimen is a relatively routine task. Other tasks, especially if they involve more complex producures or data and/or live animals of a species which is difficult to handle, may be much more affected by particular input devices.

There were small, but significant, differences between the devices for particular entry times: voice was slightly faster than the UnMouse for entering commands, while the UnMouse was slightly faster than voice for entering data. The faster time for command entry with voice could be due to differences in programming between the two systems. For example, for the command "Turn Glovebox Fan On" using the voice system, after the test subject spoke the command, the window displaying the glovebox power displays automatically appeared and the correct box was "checked." When using the UnMouse, the test subject was required to find the window label in a menu, double click on it to open and then use the UnMouse to "check" the correct box. While most command operations were similar between the systems, the difference in operations in just a few commands could explain the slight advantage the voice system displayed in this data parameter. In contrast, the UnMouse was slightly faster than voice when data entry time was compared. We attribute this advantage to the greater number of either "no responses" or "wrong responses" by the voice system: the test subject often had to repeat the entry a number of times or correct a wrong response before ultimately achieving a correct data entry. This conclusion is substantiated by the analysis of the data entry times showing no difference between input devices when trials which required data entry repetitions were removed (Figure 6). Taken together, these results indicate that the relative advantage of different input devices depends substantially on differences in device characteristics and in programming.

While a greater percentage of correct responses was seen with the UnMouse compared with voice input, there was also a greater percentage of wrong data entered with the UnMouse. This observation is of concern since it is extremely important for correct data to be entered during experimental procedures. Even though these entries were eventually corrected by the test subjects, the time required for correction may take valuable time away from procedural operations.

In the course of developing this study, a better understanding of the requirements for data input devices to be used within a glovebox work volume was achieved. Certain characteristics were identified early for selection of the UnMouse as the manual input device: i.e. ability to enter numerical input, cursor control, small volume/surface area, accessibility and maintenance (see Table 1). Additional characteristics which are of high priority in the selection of a data input system are presented in Table 5. These characteristics apply to both the manual and voice systems.

Characteristic	Rationale
Ease of error correction	Uncorrected errors will severely impact the experimental results. The data input system must accommodate quick and easy correction of data entry errors
Training	The time required to learn the data input system must be as short as possible since available time for crew training is limited, i.e.the system must be easy to learn.
Ability to program "function keys"	The use of function keys for frequently used keystroke sequences will reduce the time required to perform the glovebox procedures.
High Effeciency of Performance Index	The system must have a high rate of data input recognition. If the efficiency of the device is less than optimal, the time required to enter data, as well as the potential for making errors, will increase proportionately.
Operate in a microgravity environment	Data entry device training will be conducted in a 1-g environment. However, the device will be used in microgravity and must operate efficiently under this latter condition.

Table 5. Additional Characteristics of Data Entry Systems.

The work volume of the wrap-around glovebox design is approximately 17 cubic feet. As can be seen in Figure 3, the equipment and supplies necessary for the experimental procedures occupied a significant proportion of the available space. The addition of magnetic sheets to the sides of the glovebox was extremely useful in providing a larger work area. Magnetic strips were attached to various "kits," a holder for the syringes and even to the foam mock-up of the cryo-freezer so that they could be held in place on the glovebox walls. In addition, the dissection tray was metal and readily attached to the walls while the surgical instruments were secured with additional magnetic strips. Test subjects approved of the use of magnets and found they could easily "throw" kits against the walls to get them out of the way. Nevertheless, actual work space for the procedures was limited and this required the test subjects to rearrange various pieces of equipment during the procedures. One might think that an advantage of a voice data input system would be that no work space is required for this device inside the work volume. However, it is also clear that a voice system, regardless of how highly advanced, must always have a manual data entry system available as a back-up in case of system failure or other emergency. One of the lessons learned in this study is the requirement for creativity in designing experiments, organizing equipment and supplies and performing procedures within a confined, enclosed work space.

This study also evaluated the efficiency of one or two persons to perform the procedural operations. Clearly, with the division of labor between a primary dissector of tissue versus a dedicated data entry person, a two person procedure was shorter than when one person performed both operations. However, this shorter time period may not be more efficient. In space, crew time is extremely limited and valuable. In this study, two person procedures took an average of 30 minutes while one person procedures took an average of 50 minutes. In reality, the two person procedures required 60 minutes of crew time (30 minutes x two crew members). Given the number of activities required of the crew, this saving of 10 minutes (50 minutes versus 60 minutes) may not be the most effective use of crew time. This is particularly true since there was no difference in the amount of wrong data entered between the one and two person procedures. On the other hand, two operators may be able to perform the scientific procedures within a two day period rather than spread out over almost four days. This factor needs to be considered, not only from the perspective of efficient use of crew time, but also in terms of completing laboratory protocols in a timely manner to increase scientific validity and reliability. Finally, it must be noted that the distribution of work in the two person procedures used in this study were heavily weighted to one individual (the dissector), allowing the test subject to focus on the input device. Additional work in this area is required to determine the most effective use of crew time.

At the conception of this study, the test developers hypothesized that the voice input system would be a more efficient system for data entry, facilitating procedure operation by leaving the operator's hands free and would be preferred by the test subjects. The results of the study do not support this hypothesis: time of operation was not different between the devices and, when asked to rank their preference for the devices, the two of the test subjects slightly preferred the UnMouse, while one clearly disliked the voice system. In the general questionnaires at the end of the test, subjects stated that, had the voice system been "better", i.e. more accurate in responding to their input, they would have ranked it higher than the UnMouse.

CONCLUSION

Taken together, the data suggest that, at the technology level of the data entry devices used, manual input of data may be more efficient than voice input due to the increased percentage of correct responses and decreased percentage of no or wrong responses.

REFERENCES

1 Adam, S., Hoden, K., Gillan D., Rudisill M., "Microgravity Cursor Control Device Evaluation for Space Station Freedom Workstations" NASA Lyndon B. Johnson Space Center, Houston, TX

2 Sun, S.C., Goulart C.V., "The Centrifuge Facility Life Sciences Glovebox Configuration Study", SAE Paper #921158, presented at the 22nd International Conference on Environmental Systems, Seattle, Washington, July, 1992.

APPENDIX

Contents

One Person Procedure

1. **Using external display, Check Glovebox Parameters:**

   √ **GB PWR sw - ON**
   √ **Temp. - 22.0°C**
   √ **Airflow - 400 cfm**
   √ **Overhead Light - 400 lx**
   √ **Spotlight - 400 lx**
   √ **Fan PWR sw - OFF**

2 √ **Hab secured to GB**

3. **Place hands in gauntlets and don Surgical Gloves**

4. **Using internal display/input device:**

   GB Fan PWR sw - ON

   UnMouse: Select "GB Controls" window, position cursor over box next to "Fan Power: and select.

   Voice script: "Turn Glovebox Fan On"

5. **Tare empty rodent restraint cone on SMMD, leaving it on the SMMD until required in step 11.**

6. **Secure two towels to Specimen Dissection Platform (SDP).**

7. **Attach 4 x 4 ziplock bag to dispatcher to capture head. Clean dispatcher blade with disinfectant wipe.**

8. **Remove one specimen from Hab 1. Close and seal hab cover.**

   √ **Hab cover sealed**

9. **Locate and enter specimen ID ______________ [√]**

   UnMouse: Press red button prior to pressing each number. Then press red button followed by "Enter" OR select "√" button when finished.

   Voice Script: Read each number, followed by "Enter" when finished

   Time: ________________ (recorded automatically)

10. **Examine specimen health. [Health Check]**

   UnMouse: Select Health Check Button

   Voice Script: "Perform Health Check"

Health Check Window:

- [ ] Normal Coat
- [ ] Haircoat Rough
- [ ] Haircoat Soiled
- [ ] Hair Loss
- [ ] Awake
- [ ] Asleep
- [ ] Feces Soft
- [ ] Feces Bloody
- [ ] Feces Loose/Smeared

- [ ] Normal Eyes
- [ ] One eye closed
- [ ] Both eyes closed
- [ ] Discharge from Eyes
- [ ] Nose Discharge
- [ ] Pawing at Nose
- [ ] Paw/Tail Lesions
- [ ] Paw/Tail Abnormal Color

- [ ] Normal Respiration
- [ ] Labored Breathing
- [ ] Sneezing

- [ ] Abdomen Distended
- [ ] Abdomen Tucked Up

Health Check Complete: _______ (Time recorded automatically)

UnMouse: Position cursor in time field and select "Health Check Complete" button:

Voice Script: "Health Check Complete".

11. Obtain tarred rodent restraint cone and secure specimen in cone.

12. Determine specimen mass (with restraint). _______ g [√]

UnMouse: Read mass from specimen cue card. Press red button prior to pressing each number, followed by "Enter" OR Select "√" button when finished

Voice Script: read numbers from cue card, including "Decimal Point" followed by "Enter" when finished.

Time: ____________ (recorded automatically)

13. Leaving specimen on SMMD, arrange equipment as indicated in "Dissection Layout".

[Dissection Layout]

UnMouse: Select "Dissection Layout" button

Voice Script: "Dissection Layout"

14. Place specimen in Animal Dispatcher with head inside 4 x 4 ziplock bag.

15. Decapitate specimen. Record Time: _______ **[Time Stamp]**

UnMouse: Make sure cursor is in box and select "Time Stamp" button, or hit red button, then "Time-Stamp" button on UnMouse:

Voice Script: Make sure cursor is in box, then say "Time-Stamp".

16. Secure body, ventral side up and specimen tail towards the operator to Specimen Dissection Platform (SDP).

	no response to	wrong response	extra response to	wrong input by subject	corrected
number					
ERASE					
ENTER					
OTHER					

75. Place bag in Refrigerator Storage Pouch.

76. Place other portion of duodenum in a 2 ml vial.

77. Record vial ID number.

Wake up? Y ___ N ___

Start time_______

Duodenum #2 vial # [ ] **Enter**

End time ________

Problems? Y ____ N ____

t p e

Go to sleep? Y ___ N ___

	no response to	wrong response	extra response to	wrong input by subject	corrected
number					
ERASE					
ENTER					
OTHER					

78. Freeze vial containing duodenum in Quick/Snap Freezer.

79. Place in cryo sample holding unit.

80. Record time Place cursor on "Time Stamp" and select with middle key.

Start time _______

Time duodenum dissection complete [ ] **Time Stamp**

17. Remove head (in bag) from dispatcher and place on 4°SHR.

18. Clean dispatcher blade with wet wipe and secure away from main dissection area.

HEART DISSECTION

NOTE: All heart tissue must be fixed within 3 minutes of specimen sacrifice.

19 Using cleaned forceps, pull skin above lower abdomen and slit along mid-ventral line with scissors or scalpel. Cut forward toward all the way to the neck without cutting the body wall under the skin.

20. Pull skin aside and secure with hemostats.

21. Locate xiphoid cartilage. Holding cartilage with forceps, cut through body wall. Then cut through diaphragm horizontally on either side of mid-line.

22. Turn scissors at right angle to incision and cut upward toward the neck through the side walls of thorax. Repeat on other side, pulling ventral wall up to avoid injury to heart.

23. Remove ventral wall of thorax and discard in waste bag.

24. Remove thymus (on cranial end of the heart) and discard in waste bag.

25. Cut through and peel away the parietal pericardium.

26. Cut through aorta, vena cava, pulmonary artery, and pulmonary vein .

27. Tare centrifuge tube on MMMD. (without cap)

28. Carefully and quickly remove heart, blot excess blood on towel, and place heart in tarred centrifuge tube.

29. Measure mass of heart: __________ g [√]

    UnMouse: Press red button prior to pressing each number. Then press red button followed by "Enter" OR select "√" button when finished.

    Voice Script: read numbers from scale, including "Decimal Point" followed by "Enter" when finished.

    Time: ________________ (recorded automatically)

30. Fill tube with cold saline. Dump heart and saline onto towel. Discard centrifuge tube. Remove atria with sharp scalpel or razor blade.

31. Place atria in 5 mL vial . Inject Triple Fix from cc syringe.

    Record vial ID: ___________ [√]

UnMouse: Press red button prior to pressing each number. . Then press red button followed by "Enter" OR select "√" button when finished.

Voice Script: Read each number, followed by "Enter" when finished

Time: ____________ (recorded automatically)

32. Place vial in 4°SHR.

33. Grasp right ventricular wall with forceps. Using scissors, cut away the left ventricular wall, leaving the septum and right ventricle.

34. Place septum and right ventricle in a 5 mL vial. Inject Triple Fix from 5 cc syringe.

Record vial ID: __________ [√]

UnMouse: Press red button prior to pressing each number. Then press red button followed by "Enter" OR select "√" button when finished.

Voice Script: Read each number, followed by "Enter" when finished

Time: ______________ (recorded automatically)

35. Place vial in 4°SHR.

36. Cut left ventricle into 4 sections. Put 2 sections each in separate 2 mL vials. Inject Triple Fix, equally distributing the contents of one 5 cc syringe. Record vial IDs
:

Vial 1 ID: ____________ [√]

UnMouse: Press red button prior to pressing each number. Then press red button followed by "Enter" OR select "√" button when finished.

Voice Script: Read each number, followed by "Enter" when finished

Time: __________ (recorded automatically)

Vial 2 ID: ________ [√]
Time: __________ (recorded automatically)

37. Place vials in 4°SHR.

38. Put 2 remaining sections of left ventricle each into separate 2 mL vials. Record vial IDs

Vial 1 ID: ____________ [√]

UnMouse: Press red button prior to pressing each number. Then press red button followed by "Enter" OR select "√" button when finished.

Voice Script: Read each number, followed by "Enter" when finished

Time: ______________ (recorded automatically)

Vial 2 ID: _____________ [√]
Time: ______________ (recorded automatically)

39. Quick freeze vials in Quick/Snap Freezer and place in cryo sample transfer unit (CSTU).

40. Obtain head (in bag) from 4°SHR and place in Biomaterials Bag (BB).

Record container ID: ______ [√]

UnMouse: Press red button prior to pressing each number. Then press red button followed by "Enter" OR select "√" button when finished.

Voice Script: Read each number, followed by "Enter" when finished

Time: __________ (recorded automatically)

41. Place BB on 4°SHR.

TESTES DISSECTION

42. Tare centrifuge tube. (without cap)

43. If the testes are not easily visible within scrotum, apply slight pressure to the lower abdomen. This should push testes down, making subsequent steps easier.

44. Make small incision into the tip of each scrotal sac.

45. Pull out one testis with forceps being careful not to damage testis.

46. Cut all the attached blood vessels, connective tissue, and ducts around the testis with iris scissors.

47. Place clean testis in tarred centrifuge tube and determine testis mass on MMMD.
Record mass: ____________ g [√]

UnMouse: Press red button prior to pressing each number. Then press red button followed by "Enter" OR select"√" button when finished.

Voice Script: read numbers from scale, including "Decimal Point" followed by "Enter" when finished.

Time: __________ (recorded automatically)

48. Inject Triple Fix using 5 cc syringe. Record tube ID:

Tube ID:________ [√]

UnMouse: Press red button prior to pressing each number. Then press red button followed by "Enter" OR select "√" button when finished.

Voice Script: Read each number, followed by "Enter" when finished

Time: ___________ (recorded automatically)

49. Place tube in 4°SHR.

50. Tare centrifuge tube. (without cap)

51 Pull out other testis with forceps being careful not to damage testis.

52. Cut all the attached blood vessels, connective tissue, and ducts around the testis with iris scissors.

53. Place clean testis in tarred centrifuge tube.

54. Determine testis mass on MMMD.
Record mass: ___________ g $\boxed{\surd}$

UnMouse: Press red button prior to pressing each number. Then press red button followed by "Enter" OR Select the "√" button when finished.

Voice Script: read numbers from scale, including "Decimal Point" followed by "Enter" when finished.

Time: __________ (recorded automatically)

55. Inject Triple Fix using 5 cc syringe.

Record tube ID: ________ $\boxed{\surd}$

UnMouse: Press red button prior to pressing each number. Then press red button followed by "Enter" OR select "√" button when finished.

Voice Script: Read each number, followed by "Enter" when finished

Time: ___________ (recorded automatically)

56. Place vial in 4°SHR.

DUODENUM DISSECTION

57. Locate the duodenum in the abdominal cavity.

58. Carefully cut end of the duodenum connected to stomach and then make another cut approximately 4 inches along the intestine.

59. Attach saline container to end of duodenum and rinse duodenum with saline to remove contents. Collect contents on towel.

60. **Place duodenum in 5 mL vial, inject Triple Fix from 5 cc syringe.**

Record vial ID: __________ [√]

UnMouse: Press red button prior to pressing each number. Then press red button followed by "Enter" OR select "√" button when finished.

Voice Script: Read each number, followed by "Enter" when finished

Time: __________ (recorded automatically)

61. **Place vial in 4°SHR.**

ADRENAL GLANDS

62. **Tare a 2 mL vial. (without cap)**

63. **If necessary, move intestines to the left out of body cavity and locate right kidney.**

64. **Using a pair of dissecting forceps, locate right adrenal gland, just anterior to kidney, embedded in fat.**

65. **Hold onto adrenal with the forceps and cut around it with dissecting scissors. Remove gland with some surrounding fat.**

66. **Place on surgery platform and remove attached fat.**

67. **Place right adrenal gland in vial and determine mass on MMMD:**
Record Mass: __________ g [√]

UnMouse: Press red button prior to pressing each number. Then press red button followed by "Enter" OR select "√" button when finished.

Voice Script: read numbers from scale, including "Decimal Point" followed by "Enter" when finished.

Time: ___________ (recorded automatically)

68. **Record vial ID: ___________** [√]

UnMouse: Press red button prior to pressing each number. Then press red button followed by "Enter" OR select "√" button when finished.

Voice Script: Read each number, followed by "Enter" when finished

Time: ______________ (recorded automatically)

69. **Quick freeze adrenal in Quick/Snap freezer. Place in CSTU.**

70. **Tare a 2 mL vial. (without cap)**

71. **If necessary, move intestines to the right out of the body cavity and locate left kidney.**

72. **Using a pair of dissecting forceps, locate adrenal gland, just anterior to kidney, embedded in fat.**

73. **Hold onto adrenal with the forceps and cut around it with dissecting scissors. Remove gland with some surrounding fat.**

74. **Place on surgery platform and remove attached fat.**

75. **Place left adrenal gland in vial and determine mass on MMMD:**
    Record Mass: __________ g [√]

    UnMouse:Press red button prior to pressing each number. Then press red button followed by "Enter" OR select the "√" button when finished.

    Voice Script: read numbers from scale, including "Decimal Point" followed by "Enter" when finished

    Time: ____________ (recorded automatically)

76. **Record vial ID: __________** [√]

    UnMouse: Press red button prior to pressing each number. Then press red button followed by "Enter" OR select "√" button when finished.

    Voice Script: Read each number, followed by "Enter" when finished

    Time: __________ (recorded automatically)

77. **Quick freeze adrenal in Quick/Snap freezer. Place in CSTU.**

78. **Bag remaining carcass in rodent body bag, place in Biomaterials Bag.**

    √ **BB ID = XXXX (displays number previously entered)**

79. **GB PWR sw - OFF**

    UnMouse: Select "GB Controls" window from menu then select box next to "Power" Close window.

    Voice script: "Glovebox Power Off"

80. **Enter Time Procedure completed: __________** [Time Stamp]

    UnMouse: Make sure cursor is positioned in box and select "Time Stamp" button, or hit red button, followed by "Time-Stamp" button on UnMouse:

    Voice Script: Make sure cursor is positioned in box and say "Time-Stamp".

Two Person Procedure

PERSON 1 (Side)

1 √ Hab secured to GB

2. Place hands in gauntlets and don Surgical Gloves

3. Secure two towels to Specimen Dissection Platform (SDP).

4. Attach 4 x 4 ziplock bag to dispatcher to capture head. Clean dispatcher blade with disinfectant wipe.

5. Remove one specimen from Hab 1. Close and seal hab cover.

   √ Hab cover sealed

6. Locate and read specimen ID # to operator 2.

PERSON 2 (Front)

1. Using external display, Check Glovebox Parameters:

   √ GB PWR sw - ON
   √ Temp. - 22.0°C
   √ Airflow - 400 cfm
   √ Overhead Light - 400 lx
   √ Spotlight - 400 lx
   √ Fan PWR sw - OFF

2. Place hands in gauntlets and don Surgical Gloves

3. Using internal display/input device:

   GB Fan PWR sw - ON

   UnMouse: Select "GB Controls" window from menu, position cursor over box next to "Fan Power: and select.

   Voice script: "Turn Glovebox Fan On".

4. Tare empty specimen restraint on SMMD. Assist Operator 1 with specimen removal.

5. Locate and enter specimen ID ________

   $\boxed{\surd}$

   UnMouse: Press red button prior to pressing each number. Then press red button followed by "Enter" OR select "√" button when finished

   Voice Script: Repeat each number, followed by "Enter" when finished

   Time: ____________
   (Recorded automatically)

6. **Enter health check information \X(Health Check)**

   UnMouse: Select "Health Check" button

   Voice Script: "Perform Health Check

7. **Examine specimen health. Read observations from cue card to Operator 2**

Health Check Window:

- ☐ Normal Coat
- ☐ Haircoat Rough
- ☐ Haircoat Soiled
- ☐ Hair Loss
- ☐ Awake
- ☐ Asleep
- ☐ Feces Soft
- ☐ Feces Bloody
- ☐ Feces Loose/Smeared

- ☐ Normal Eyes
- ☐ One eye closed
- ☐ Both eyes closed
- ☐ Discharge from Eyes
- ☐ Nose Discharge
- ☐ Pawing at Nose
- ☐ Paw/Tail Lesions
- ☐ Paw/Tail Abnormal Color

- ☐ Normal Respiration
- ☐ Labored Breathing
- ☐ Sneezing

- ☐ Abdomen Distended
- ☐ Abdomen Tucked Up

Health Check Complete: ______________

UnMouse: Position cursor in time field and select "Health Check Complete" button,:

Voice Script: "Health Check Complete"

8. **Secure specimen in Rodent Restraint Cone**

9. **Hand restrained specimen to Operator 2**

10. **Position dispatcher for decapitation.**

7. **Determine specimen mass (with restraint).**

8. **Record specimen mass**

   Mass: _______ **g** [√]

   UnMouse: Read mass from cue card. Press red button prior to pressing each number. Then press red button followed by "Enter" OR select "√" button when finished.

   Voice Script: read numbers from cue card, including "Decimal Point" followed by "Enter"

   Time: ___________
   (recorded automatically)

11. **Arrange equipment as indicated in "Dissection Layout 2".**

12. **Position specimen in dispatcher.**

13. **Decapitate specimen.**

14. **Remove body from dispatcher.**

15. **Secure body, ventral side up, with specimen tail towards operator, to specimen dissection platform.**

HEART DISSECTION

NOTE: All heart tissue must be fixed within 3 minutes of specimen sacrifice.

16. **Using cleaned forceps, pull skin above abdomen and slit along mid-ventral line with scissors or scalpel. Cut forward toward the neck without cutting the body wall under the skin.**

9. **Arrange equipment as indicated in "Dissection Layout 2".**

   Dissection Layout 2

   UnMouse: Select "Dissection Layout 2" button

   Voice Script: "Dissection Layout 2"

10. **Return specimen to Operator 1.**

11. **Record decapitation time: __________**

    Time Stamp

    UnMouse: Make sure cursor is in box and select "Time Stamp" button, or hit red button, then "Time-Stamp" button on UnMouse:

    Voice Script: Make sure cursor is in box, then say "Time-Stamp".

12. **Remove head from dispatcher. Clean dispatcher blade with wet wipe and secure away from main dissection area.**

13. **Place head in 4 x 4 ziplock bag and place in Biomaterials Bag (BB)**

    Record container ID:

    ____________ √

    UnMouse: Press red button prior to pressing each number. Then press red button followed by "Enter" OR select "√" button when finished.

    Voice Script: Read each number, followed by "Enter" when finished

    Time: ________(automatic)

17. Pull skin aside and secure with hemostats.

18. Locate xiphoid cartilage. Holding cartilage with forceps, cut through body wall. Then cut through diaphragm horizontally on either side of mid-line.

19. Turn scissors at right angle to incision and cut upwards toward the neck through the side walls of thorax. Repeat on other side, pulling ventral wall up to avoid injury to heart.

20. Remove ventral wall of thorax and discard.

21. Remove thymus (on cranial end of the heart) and discard.

22. Cut through and peel away the parietal pericardium.

23. Cut through aorta, vena cava, pulmonary artery, and pulmonary vein .

24. Carefully and quickly remove heart, blot excess blood on towel and place in centrifuge tube held by operator 2.

14. Place BB on 4°SHR.

15. Tare centrifuge tube on MMMD. (without cap)

16. Assist Operator 1 with dissection.

17. Hold out tube for Operator 1.

18. Measure mass of heart.
    Mass: _______ g $\boxed{\surd}$

    UnMouse: Press red button prior to pressing each number. Then press red button followed by "Enter" OR select the "√" button when finished.

    Voice Script: read numbers from scale, including "Decimal Point" followed by "Enter" when finished.

    Time: ___________
    (recorded automatically).

25. Fill tube with cold saline. Dump heart and saline onto towel. Discard tube. Remove atria with sharp scalpel or razor blade.

26. Place atria in 5 mL vial held out by Operator 2.

27. Grasp right ventricular wall with forceps. Using scissors, cut away the left ventricular wall, leaving the septum and right ventricle

28. Place septum and right ventricle in 5 mL vial held out by Operator 2.

29. Cut left ventricle into 4 sections. Put 2 sections each into separate 2 mL vials held out by Operator 2.

19. Return tube to operator 1.

20. Hold out 5 mL vial for Operator 1.

21. Inject Triple Fix into 5 mL vial from 5cc syringe.

Record vial ID: ________ $\boxed{\surd}$

UnMouse: Press red button prior to pressing each number. Then press red button followed by "Enter" OR select "√" button when finished.

Voice Script: Read each number, followed by "Enter" when finished

Time: ________(automatic)

22. Place in 4°SHR.

23. Hold out 5 mL vial for Operator 1.

24. Inject Triple Fix from 5cc syringe and record vial ID: __________ $\boxed{\surd}$

UnMouse: Press red button prior to pressing each number. Then press red button followed by "Enter" OR select "√" button when finished.

Voice Script: Read each number, followed by "Enter" when finished

Time: ________(automatic)

25. Place vial in 4°SHR.

26. Hold out two 2 mL vials for Operator 1.

27. Inject Triple Fix, equally distributing the contents of one 5cc syringe. Record vial IDs:

Vial 1 ID: ________ √

UnMouse: Press red button prior to pressing each number. Then press red button followed by "Enter" OR select "√" button when finished.

Voice Script: Read each number, followed by "Enter" when finished

Time: ________(automatic)

28. Place vial in 4°SHR.

29. Record vial 2 ID: _____ √ Time: ________(automatic)

30. Place vial in 4°SHR.

30. Put 2 remaining sections each into separate 2 mL vials held out by Operator 2.

31. Hold out two 2 mL vials for Operator 1.

32. Record vial IDs:

vial 1 ID: _________ √

UnMouse: Press red button prior to pressing each number. Then press red button followed by "Enter" OR select "√" button when finished.

Voice Script: Read each number, followed by "Enter" when finished

Time: _________(automatic)

33. Quick freeze vial in Quick/Snap freezer.

34. Record vial 2 ID: ______ √
Time: _________(automatic)

35. Remove vial 1 and place in CSTU.

36. Quick freeze vial 2 in Quick/Snap Freezer and place in cryo sample transfer unit (CSTU).

TESTES DISSECTION

31. If the testes are not easily visible within the scrotum, apply slight pressure to the lower abdomen. This should push the testes down, making subsequent steps easier.

32. Make a small incision into the tip of scrotal sac.

33. Pull out testis with the forceps being careful not to damage the testis.

34. Cut all the attached blood vessels, connective tissue, and ducts around testis with the iris scissors.

35. Place the clean testis in tarred centrifuge tube.

36. Pull out remaining testis with the forceps being careful not to damage the testis.

37. Cut all the attached blood vessels, connective tissue, and ducts around testis with the iris scissors.

37. Tare centrifuge tube. (without Cap)

38. Hold out tube for Operator 1.

39. Determine testis mass on MMMD.
Record:

Mass: __________ g $\boxed{\surd}$

UnMouse: Press red button prior to pressing each number. Then press red button followed by "Enter" OR select "√" button when finished.

Voice Script: read numbers from scale, including "Decimal Point" followed by "Enter" when finished.

Time: __________
(recorded automatically)

40. Inject Triple Fix from 5cc syringe.
Record tube ID:

Tube ID: ________ $\boxed{\surd}$

UnMouse: Press red button prior to pressing each number. Then press red button followed by "Enter" OR select "√" button when finished.

Voice Script: Read each number, followed by "Enter" when finished

Time: ________(automatic)

41. Place vial in 4°SHR.

42. Tare another centrifuge tube. (without cap)

38. Place the clean testis in tarred centrifuge tube.

DUODENUM DISSECTION

39. Locate the duodenum in abdominal cavity.

40. Carefully cut end of the duodenum connected to stomach and then make another cut approximately 4 inches along the intestine.

41. Attach saline container to end of duodenum and rinse duodenum with saline to remove contents. Collect contents on towel.

42. Place the duodenum into 5 mL vial held out by Operator 2.

43. Hold out tube for Operator 1.

44. Determine testis mass on MMMD. Record:

Mass: __________ g $\boxed{\surd}$

UnMouse: Press red button prior to pressing each number. Then press red button followed by "Enter" OR select "√" button when finished.

Voice Script: read numbers from scale, including "Decimal Point" followed by "Enter" when finished.

Time: __________
(recorded automatically)

45. Inject Triple Fix from 5cc syringe.
Record tube ID: __________ $\boxed{\surd}$

UnMouse: Press red button prior to pressing each number. Then press red button followed by "Enter" OR select "√" button when finished.

Voice Script: Read each number, followed by "Enter" when finished

Time: ________(automatic)

46. Place tube in 4°SHR.

47. Hold out 5 mL vial for Operator 1.

ADRENAL GLANDS DISSECTION

43. If necessary, move the intestines to the left out of the body cavity.

44. Using a pair of dissecting forceps, locate the adrenal gland, just anterior to the kidney imbedded in the fat.

45. Hold onto the adrenal gland with the forceps and cut around it with a dissecting scissors. Remove the gland with some surrounding fat.

46. Place the adrenal on the surgery platform and clean off the attached fat.

47. Place right adrenal gland in tarred 2 mL vial.

48. If necessary, move the intestines to the right out of the body cavity.

49. Hold onto left adrenal with forceps and cut around it with dissecting scissors. Remove gland with some surrounding fat.

48. Inject Triple Fix from 5cc syringe. Record vial ID:

Vial ID: ______ [√]

UnMouse: Press red button prior to pressing each number. Then press red button followed by "Enter" OR select "√" button when finished.

Voice Script: Read each number, followed by "Enter" when finished

Time: ________(automatic)

49. Place vial in 4°SHR.

50. Tare a 2 mL vial. (without Cap)

51. Hold out vial for Operator 1.

52. Determine mass on MMMD:
Mass: _________ g [√]

UnMouse: Press red button prior to pressing each number. Then press red button followed by "Enter" OR select "√" button when finished.

Voice Script: read numbers from scale, including "Decimal Point" followed by "Enter" when finished

Time: __________
(recorded automatically)

50. **Place adrenal on surgery platform and remove attached fat.**

51. **Place left adrenal gland in tarred 2 mL vial.**

52. **Bag remaining carcass, place in Biomaterials Bag on 4 °C SHR.**

√ **BB ID: __________**

53. **Record vial ID: _______ √**

UnMouse: Press red button prior to pressing each number. Then press red button followed by "Enter" OR select "√" button when finished.

Voice Script: Read each number, followed by "Enter" when finished

Time: __________(automatic)

54 **Quick freeze adrenal in Quick/Snap freezer.**

55. **Tare another 2 mL vial. (without cap)**

56. **Hold out vial for Operator 1.**

57. **Determine mass on MMMD:**
__________ g √

UnMouse: Press red button prior to pressing each number. Then press red button followed by "Enter" OR select "√" button when finished.

Voice Script: read numbers from scale, including "Decimal Point" followed by "Enter" when finished.

Time: ___________
(recorded automatically)

58. **Record vial ID: _______ √**

UnMouse: Press red button prior to pressing each number. Then press red button followed by "Enter" OR select "√" button when finished.

Voice Script: Read each number, followed by "Enter" when finished

Time: __________(automatic)

59. **Remove vial 1 from freezer and place in CSTU. Quick freeze left adrenal in Quick/Snap freezer. Place in CSTU.**

60. GB PWR sw - OFF

UnMouse: Select "GB Controls" window from menu then select box next to "Power". Close Window

Voice script: "Glovebox Power Off".

61. Enter Time Procedure completed:

____

Time Stamp

UnMouse: Make sure cursor is positioned in time field and select "√" button, or hit red button, then "Time-Stamp" button on UnMouse:

Voice Script: Make sure cursor is positioned in box and say "Time-Stamp".

Glovebox Data Input and Display Study Questionnaire
UnMouse

Name:________________ Date: ______________ 1 or 2 person

Please rate the device for questions 1-11 using the following scale as reference.				
1	2	3	4	5
Completely Unacceptable	Reasonably Unacceptable	Borderline	Reasonably Acceptable	Completely Acceptable

How acceptable was:

1. the correspondence of your use of the UnMouse cursor movement to the cursor movement on the screen? ☐
2. the UnMouse for moving the cursor short distances (< 1/2 screen)? ☐
3. the UnMouse for moving the cursor long distances (> 1/2 screen)? ☐
4. the UnMouse for exact positioning of the cursor on data entry fields? ☐
5. the UnMouse for exact positioning of the cursor on the scroll bars? ☐
6. the UnMouse for exact positioning of the cursor on the menus? ☐
7. the size and shape of the UnMouse for use inside the work volume? ☐
8. the pressure applied to the select and numerical/command buttons? ☐
9. the UnMouse for correcting erroneous text/numerical values? ☐
10. the UnMouse for scrolling the procedures up or down? ☐
11. the numerical input sequences for the UnMouse? ☐
12. If the response to question 11 was ≤ 3, was this due to:
    Lack of proper training? ______________________
    Lack of familiarity with device? ______________________
    Other:______________________
13. What, if anything, could be done to improve the rating in question 11?
    ____
    ____
    ____
    ____
    ____

Additional Comments:
____
____
____
____
____

Please rate the device for the questions 14-16 using this scale as reference.				
1	2	3	4	5
Never	Rarely	Sometimes	Frequently	Always

14. Did the cursor ever disappear and reappear on the screen and/or show sporadic movement or jumps? ☐

15. Did you experience any discomfort in using the UnMouse? ☐

    Please specify:____

16. Did you experience any visibility problems on the screen or the UnMouse during the experiment? ☐

17. If you experienced any discomfort or visibility problems, briefly describe where and why the discomfort or visibility problems were encountered.

Glovebox Data Input and Display Study Questionnaire
VOICE

Name:________________ Date: ______________ 1 or 2 person

Please rate the device for questions 1-11 using the following scale as reference.

1	2	3	4	5
Completely Unacceptable	Reasonably Unacceptable	Borderline	Reasonably Acceptable	Completely Acceptable

How acceptable was:

1. the voice training required to establish a user voice file (at setup)? ☐
2. the headset? ☐
3. voice for moving the cursor short distances (< 1/2 screen)? ☐
4. voice for moving the cursor long distances (> 1/2 screen)? ☐
5. voice for exact positioning of the cursor on data entry fields? ☐
6. voice for exact positioning of the cursor on the scroll bars? ☐
7. voice for accessing other windows (GB Control)? ☐
8. voice for correcting erroneous text/numerical values? ☐
9. voice for scrolling the procedures up or down? ☐
10. the response of the system to your commands? ☐
11. the voice command sequences? ☐
12. If the response to question 11 was ≤ 3, was this due to:
    Lack of proper training on the commands? ________________
    Lack of familiarity with commands? ________________
    Other:________________
13. What, if anything, could be done to improve the rating in question 11?
    ____
    ____
    ____
    ____
    ____

Additional Comments:
____
____
____
____
____

Please rate the device for the questions 14-16 using this scale as reference.				
1	2	3	4	5
Never	Rarely	Sometimes	Frequently	Always

14. Did the cursor ever disappear and reappear on the screen and/or show sporadic movement or jumps? ☐

15. Did you experience any discomfort in using the headset or voice commanding? ☐

    Please specify:______________________________

16. Did you experience any visibility problems on the screen during the experiment? ☐

17. If you experienced any discomfort or visibility problems, briefly describe where and why the discomfort or visibility problems were encountered.

Glovebox Data Input and Display Study Questionnaire
GENERAL

Name:____________________ Date: ________________ 1 or 2 person

Please rate each response for questions 1-5 using this scale as reference.

1	2	3	4	5
Completely Unacceptable	Reasonably Unacceptable	Borderline	Reasonably Acceptable	Completely Acceptable

1. How acceptable was the visual verification of data input? [ ]
2. How acceptable was the font type and size used in the procedure display? [ ]
3. How acceptable was the lighting during the experiment? [ ]
4. How acceptable was the ambient noise/vibration during the experiment? [ ]
5. How acceptable was the internal environment (moisture, workspace, gloves/gauntlets, communication with others, etc.) of the glovebox during the experiment? [ ]
6. How did the Glovebox environment affect the performance of the input device?

   ____
   ____
   ____
   ____
   ____

7. How did the addition of a second person affect the performance of the experiment?

   ____
   ____
   ____
   ____
   ____

8. Considering all the device characteristics, please rank the devices on a scale from 1-10 with ties allowed (Best=1, Worst=10)

   A (UnMouse): [ ] B (Voice): [ ]

9. Would the rating in question 8 be different for one and two person operations?___
Please Explain: ____

10. Overall comments: Regarding the characteristics of the input devices considered in this experiment, what are their strong and weak points?

A (UnMouse): ____

B (Voice): ____

C (Bar Code Reader): ____

11. Additional comments about the experiment:

Voice Commands

Voice Command:	Explanation:
Abdomen Distended	Moves cursor to "Abdomen Distended" box in Health Check window and selects
Abdomen Tucked Up	Moves cursor to "Abdomen Tucked Up" box in Health Check window and selects
Activate	Activates voice commanding
Asleep	Moves cursor to "Asleep" box in Health Check window and selects
Awake	Moves cursor to "Awake" box in Health Check window and selects
Both Eyes Closed	Moves cursor to "Both Eyes Closed" box in Health Check window and selects
Close Window	Closes uppermost window on screen
Deactivate	Deactivates voice commanding
Decimal Point	Inserts decimal point
Delete That	Mimics "delete" key on keyboard
Dissection Layout	Opens dissection equipment setup window
Dissection Layout 2	Opens dissection equipment setup window
Enter	In procedures, tabs to next field, enters time stamp and then tabs to next field. (menu command in Helix)
Feces Bloody	Moves cursor to "Feces Bloody" box in Health Check window and selects
Feces Loose/Smeared	Moves cursor to "Feces Loose/Smeared" box in Health Check window and selects
Feces Soft	Moves cursor to "Feces Soft" box in Health Check window and selects
Glovebox Power Off	Opens GB Controls window, deselects box next to "Power" and closes window
Hair Loss	Moves cursor to "Hair Loss" box in Health Check window and selects
Haircoat Soiled	Moves cursor to "Haircoat Soiled" box in Health Check window and selects
Health Check Complete	Puts cursor in final time field, inserts a time stamp and closes Health Check Window
Next Line	Places cursor on lower scroll arrow and clicks once, moving procedures down one line.
Next page	Scrolls down entire page (using a Tab command from the Helix menu)
Normal Coat	Moves cursor to "Normal Coat" box in Health Check window and selects
Normal Eyes	Moves cursor to "Normal Eyes" box in Health Check window and selects
Normal Respiration	Moves cursor to "Normal Respiration" box in Health Check window and selects
Nose Discharge	Moves cursor to "Nose Discharge" box in Health Check window and selects

Voice Command:	Explanation:
Number Eight	Number 8
Number Five	Number 5
Number Four	Number 4
Number Nine	Number 9
Number One	Number 1
Number Seven	Number 7
Number Six	Number 6
Number Three	Number 3
Number Two	Number 2
Number Zero	Number 0
One Eye Closed	Moves cursor to "One Eye Closed" box in Health Check window and selects
Pawing at Nose	Moves cursor to "Pawing at Nose"" box in Health Check window and selects
Paw/Tail Lesions	Moves cursor to "Paw/Tail Lesions" box in Health Check window and selects
Perform Health Check	Opens Health Check window in Helix and finds first record matching specimen ID
Previous Line	Places cursor on upper scroll arrow and clicks once, moving procedure up one line.
Previous Page	Scrolls back one entire page
Scratch That	Undoes the previous voice command
Select This	Mimics one click of the mouse button
Sneezing	Moves cursor to "Sneezing" box in Health Check window and selects
Time Stamp	Places time in selected field, then tabs to next field (Helix menu command)
Turn Glovebox Fan On	Opens Glovebox Control window, selects box next to "Fan Power", then closes widow.

Day 1 - Training Schedule

Training Area	Time	Training Approach
Study objectives, schedule, glovebox and equipment familiarization	**8:30** (20)	1 on 1, glovebox layout diagram
Voice input device use	**8:50** (60)	- lecture 5-10 mins on SW/HW - demonstrate use - create test subject voice/vocabulary
Break	**9:50** (15)	
Voice input device use	**10:05**(45)	finish vocabulary practice with procedure
UnMouse use, wizard's role	**10:50**(30)	- lecture 5-10 on SW/HW - demonstrate use - coach on use with procedure - demonstrate wizard interaction
Lunch	**11:20** 60)	plus 10 mins fudge factor
Dissection Demonstration	**12:30**(45)	- demonstrate rat dissection on bench-top
Break	**1:15** (15)	
1 person procedure (assist by Teri &/or Terrie)	**1:30** (90)	- wet run, 1 person procedure with UnMouse
Break	**3:00**(15)	
2 person procedure (assist by Teri &/or Terrie)	**3:15**(30)	- dry run, 2 person procedure with voice
Questionnaire	**3:45** (15)	- review questionnaires with test subjects
Training day complete	**4:00**	

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13. ABSTRACT *(Maximum 200 words)*
The present study was designed to examine the human-computer interface for data entry while performing experimental procedures within a glovebox work volume in order to make a recommendation to the Space Station Biological Research Project for a data entry system to be used within the Life Sciences Glovebox. Test subjects entered data using either a manual keypad, similar to a standard computer numerical keypad located within the glovebox work volume, or a voice input system using a speech recognition program with a microphone headset. Numerical input and commands were programmed in an identical manner between the two systems. With both electronic systems, a small trackball was available within the work volume for cursor control. Data, such as sample vial identification numbers, sample tissue weights, and health check parameters of the specimen, were entered directly into procedures that were electronically displayed on a video monitor within the glovebox. A pen and paper system with a "flip-chart" format for procedure display, similar to that currently in use on the Space Shuttle, was used as a baseline data entry condition.

Procedures were performed by a single operator; eight test subjects were used in the study. The electronic systems were tested under both a "nominal" or "anomalous" condition. The anomalous condition was introduced into the experimental procedure to increase the probability of finding limitations or problems with human interactions with the electronic systems. Each subject performed five test runs during a test day: two procedures each with voice and keypad, one with and one without anomalies, and one pen and paper procedure. The data collected were both quantitative (times, errors) and qualitative (subjective ratings of the subjects).

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