Risk Management
and Ergonomics, Inc.

The DXT Vertical Mouse

A Usability Study Evaluating

Qualitative, Quantitative, and Functionality of Design

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Project Overview

Two separate Usability Studies regarding the Usability of two vertical mouse designs, the DXT vertical Mouse and the Evoluent vertical mouse were used in comparison with the standard horizontal mouse design. These two separate studies were performed by VSI Risk Management & Ergonomics Inc. (VSI), a Human Factors Ergonomic Engineering firm located in Northern California.

The purpose of the study was to test for usability outcomes as they relate to

- Accuracy and Precision,
- Efficiency and Productivity,
- Wrist and finger postures outside of normal limits that could potentially lead to a RSI,
- User preference

The first and second independent studies ran for a period of four weeks and two weeks respectively and collected qualitative and quantitative data from the randomly selected subjects. These subjects (also referred to as users) worked at one of four test sites and performed computer tasks using CAD/REVIT design programs and/or Microsoft Office computer programs such as WORD, OUTLOOK, and EXCEL.

The first study focused on user preference and accuracy and precision using a computer generated Fitts Law test. The second study focused on accuracy and precision, efficiency and productivity and user preference using the Fitts law test, Microsoft EXCEL, and Microsoft WORD software programs.

Study I
Data was obtained from both studies for accuracy and precision by running a timed Fitts Law test (Studies I & II).

Study I
Goniometric Data
Goniometric measurements of the dominant mousing hand and with left hand use of the DXT were collected in Study I to determine if one of the three mouse designs was better or worse as it related to normal upper extremity posturing with use. Goniometric measurements pertaining to specific hand postures observed while using the peripherals (standard mouse, DXT, Evoluent) were measured at the onset of using each device and after using each device for one week. Hand posture measurements were of particular interest to this study as neutral hand posturing with mouse use has shown to contribute to the greatest benefits with regards to promoting correct mousing technique, discouraging awkward and static postures, and discouraging contact stress against the median and ulnar nerves with use.

Study II
Additional accuracy and precision data was collected in Study II by adding a timed Microsoft (MS) Office Excel test in addition to the timed Fitts Law test.

Efficiency and Productivity outcomes were obtained by providing a timed MS Office WORD test (Study II).

Study I & II
Qualitative data collected from Studies I & II included subject interviews for user preference, design initiatives and comfort ratings on all three mice used in addition to evaluator observations of the subjects while using the test mice.

Independent Variables
Independent variables used for this study included the DXT vertical mouse, the Evoluent vertical mouse, and the standard horizontal mouse (further referred to as standard mouse).

Criteria of the Study
As outlined in the criteria for this study, none of the subjects had ever used a Vertical mouse before. Their existing standard mouse had been the only mouse that all subjects had ever used in their working careers up until using the DXT and Evoluent vertical mouse designs. Under the criteria to be a participant for this study, subjects were also required to work a 40 hour work week spending at a minimum of 5 to 6 hours per day on the computer performing both mousing and keying tasks.

To rule out potential bias as it relates to qualitative data collection, the study was run twice first using 16 subjects and then using 17 subjects.

Executive Summary

The following data has been shown to warrant statistical significance as it relates to the usability of the DXT and Evoluent vertical mice.

Quantitative Test Results

Study I & II

Fitts Law Tests – accuracy and precision right handed use

It is statistically significant that the DXT is faster than the Evoluent with regards to accuracy and precision upon initial and final use. It is also statistically significant that the DXT is faster than the standard mouse after 5 days of use. This indicates that there is a minimal learning curve with the DXT design as opposed to the Evoluent mouse with regards to accuracy and precision and that the DXT mouse design provides greater accuracy and precision than the Evoluent and potentially standard mouse designs.

Study I

Fitts Law Tests - accuracy and precision left handed use

Although it is not statistically significant that the DXT is faster than the mouse after initial and final use with the left hand, when evaluating the mean, the data presents that the DXT is getting faster with left hand use. Therefore, this data reflects that only after a few hours of left hand use with the DXT, accuracy and precision is becoming significantly more precise and accurate and performance with left-handed use is getting faster. Further study with left hand use is suggested.

Study II

Microsoft Office Programs EXCEL

It is statistically significant that the DXT is faster than the standard mouse with EXCEL tasks upon initial and final use. It is also statistically significant that the DXT is faster than the Evoluent upon **initial** and **final** use. This indicates that there is a minimal learning curve with the DXT design as opposed to the Evoluent mouse with regards to accuracy and precision and that the DXT mouse design provides greater accuracy and precision than the Evoluent and potentially standard mouse designs.

Study II
Microsoft Office Programs WORD

It is statistically significant that the DXT is faster than the standard mouse upon initial and final use. However, there is no statistical significance supporting that the DXT is faster than the Evoluent upon initial or final use or vice versa.

Study I
Goniometric Results as they pertain to the dominant mousing hand (right)

Thumb Radial Abduction

DXT provides great benefit to maintain neutral thumb postures (less force) compared to the standard mouse. The standard mouse utilized less thumb radial abduction compared to the DXT suggesting that the standard mouse requires more squeezing with the thumb when manipulating the mouse than the DXT.

Thumb Palmar Abduction

The data collected did not provide statistical significance that any of the test mice (DXT, Evoluent, and standard mouse) demonstrated a lesser or greater degree of palmar abduction as it relates to the thumb when using any one of these three peripherals.

Pronation

The data collected provided statistical significance supporting greater pronated angles with standard mouse use than when compared to the DXT or Evoluent mouse designs. When compared against eachother, no statistical significance was found to support that the Evoluent or the DXT had greater or less pronated hand angles than eachother.

Extension

The data collected provided statistical significance supporting greater extension angles with standard mouse use than when compared to the DXT or Evoluent mouse designs. When compared against eachother, no statistical significance was found to support that the Evoluent or the DXT had greater or less wrist extension with use than eachother.

Ulnar Deviation

The data collected did not provide statistical significance that any of the test mice (DXT, Evoluent, and standard mouse) demonstrated a lesser or greater degree of ulnar deviation than eachother. However, when compared with eachother, it was found that the DXT exhibited a greater degree of ulnar deviation with use than the Evoluent.

Radial Deviation

The data collected provided statistical significance supporting greater radial deviated wrist angles with standard mouse use than when compared to the DXT. The data continued to reveal that there was no statistical significance supporting greater or lesser radial deviated wrist angles when comparing the Evoluent with the standard mouse or when comparing the Evoluent to the DXT.

Further Implications from the Author

The DXT is a revolutionary mouse where no other mouse rivals its design.
Due to the compact design of the DXT, and according to comments by users from recent use Studies I & II described within this report, the user may utilize this mouse in a number of applications such as:

- left or right handed use
- travel and laptop use
- shared workstations with left and right handed employees
- small cramped workstations such as in a laboratory where computer space is at a premium

The DXT design lends itself to easy adaption for left handed use by right hand dominant users. Therefore, employees may readily opt to learn this left handed method. Adoption of left handed use could also result in a significant cost savings for companies who would not have to procure shorter keyboard alternatives to reduce right upper extremity injuries caused by the long linear length of the standard QWERTY keyboard design. This keyboard design places the mouse too far to the right of midline promoting static and awkward postures of the dominant mousing hand, wrist, and shoulder. Facilitation of left handed mouse use could reduce the potential for overuse of the dominant right hand resulting in a "shared load" of muscle use between both hands with mousing tasks.

Positive noted behaviors observed and achieved from the DXT design were a light touch with use and/or minimal squeezing with the thumb and the index and third fingers compared to the conventional horizontal mouse versions. This is attributed to its compact but durable size that unconsciously affords the user to navigate this mouse without having to dominate it. Users commented that the lighter touch used with the DXT mouse promoted greater comfort with the digits of the dominant mousing hand with use. Most users found the fit to be comfortable and natural, and current placement of the scroll wheel affords the user to have to change up positions of the right hand to manipulate the scroll wheel decreasing the potential for static postures with mouse use.

While observing participants engaging with the DXT, it was noted that users took their hand off the DXT mouse between keying and mousing tasks and did not "ride the mouse" as they did when using the conventional horizontal mouse design. The implications of this positive behavior are significant as these findings infer that the DXT mouse promotes more neutral wrist postures and greater upper extremity movement with use. The DXT therefore eliminates and/or decreases the performance of common sustained awkward postures of the wrist and promotes good circulation/blood flow to the mousing hand normally held in sustained extension with conventional mouse use.

Overview of Use Studies I & II

A total of 33 subjects were recruited randomly via email to take part in one of two separate mouse studies that would span for over four weeks for Study I and span for slightly over two weeks for Study II. The email explained the criteria for the study and provided a brief explanation of what the evaluators would be testing for. If subjects met the criteria requirements for the study listed below, they were then encouraged to respond via email to be integrated to be part of the study.
All subjects participated with the study voluntarily and no monetary rewards or other forms of compensation were promised to the subjects as a premise to take part in the study.
However, at the end of the study, subjects were awarded a mouse of their choice (DXT or Evoluent) or a gift certificate for $15.00 at the end of the study in appreciation for their participation if they did not choose to take away the DXT or the Evoluent mice.

Both study designs utilized a Single-Factor within Subjects design and statistics were run using a one-tail Students T-test.
One-tail comparison data was comprised between

- The standard mouse and the DXT
- The standard mouse and the Evoluent
- The DXT and the Evoluent

Conclusion of ANOVA was utilized to determine statistical significance.

Dependent Variables
The dependent variables used in the study are:

- Accuracy and Precision,
- Discomfort (prior and after use)
- Efficiency and Productivity,
- Wrist and finger postures outside of normal limits that could potentially lead to a RSI,
- User preference

Independent Variables
The Independent variables used in the study are:

- Standard Mouse
- DXT mouse
- Evoluent mouse

Tools Used for the Study: Use Studies I & II

Surveys and/or data collection forms were used to collect specific data with regards to:

1. Perceived productivity (1-10 scale for productive and efficient, comments),
2. Discomfort (VAS Scale, location of discomfort, comments),
3. Product Satisfaction (1-10 scale),
4. Product Usability (1-10 scale)
    a. Posture measurements and observations (contact stress, wrist extension, and deviation finger flexion/extension,
    b. Measurement Methods:
        i. Goniometric measurements for wrist and hand angles
        ii. Visual observations for finger postures
        iii. Visual observations for idle static loading
        iv. Visual observation and estimated time exposures for contact stress.

Criteria Use Study: Use Studies I & II

Participant Population:

- Currently using a standard mouse
- Subject has never used a Vertical mouse design in their working career
- Currently using a standard QWERTY keyboard with inclusive number pad
- Right hand dominant
- Working at proper keyboard/mouse height
- Working a standard 40 hour week
- Performing computer tasks for a minimum 60% of their shift
- Subjects have agreed to continually use the DXT mouse right handed for the duration of one week
- Subjects have agreed ***to try*** and continually use the DXT mouse with their non-dominant hand (left) for the duration of one week
- Subjects have agreed to continually use the Evoluent mouse for the duration of one week

Quantitative Research: Use Studies I & II

- Collect goniometric measurement data reflecting comfort of use for ulnar and radial wrist deviation, wrist extension, radial thumb abduction, and palmar abduction.
- Collect quantitative data by running Fitts Law tests with right handed **standard mouse** use, right handed DXT use, left handed DXT use, and right handed Evoluent use to test for adaptation for precision and accuracy with mousing tasks,
- Collect quantitative data by running MS Office EXCEL tests with right handed standard mouse, DXT, and Evoluent use to test for adaptation for precision and accuracy with mousing tasks,
- Collect quantitative data by running MS Office WORD EXCEL tests with right handed standard mouse, DXT, and Evoluent use to test for adaptation for efficiency and productivity with mousing tasks,

Qualitative Research Questions: Use Study I & II

- Is the DXT more comfortable and more versatile to use as compared to the standard mouse?

"Yes"; Subject interviews related that they enjoyed the light weight feel of the DXT compared to the standard mouse. They also related that they felt that they were more in control of their documents due to the precision feel/grip of the DXT mouse.

- Is the DXT more comfortable and more versatile to use as compared to the Evoluent mouse?

"Yes"; Subject interviews related that the Evoluent felt like they had a rock in their hand heavy compared to the lightweight feel of the DXT. Subjects continued to comment that the Evoluent was heavy and cumbersome to move on the worksurface as compared to the DXT that moved where they wanted it to with minimal effort. Additional comments were that they would not take the Evoluent with their laptops for travel but would gladly take the DXT with their laptops for travel.

Qualitative Research Collection

- Collect qualitative data reflecting comfort of use by posturing markers for wrist deviation and extension, shoulder movement, "getting off the mouse" or the ability for bilateral use of the DXT mouse,
- Collect qualitative data of ease of left handedness use of the DXT mouse (or non dominant hand use),

Protocol: Use Study I

Once subjects were recruited to be part of the study, VSI then began collecting qualitative data as it related to the use of the existing standard mouse, their initial responses to right handed and left handed use of the DXT mouse, and with right-handed use of the Evoluent mouse.

DXT Mouse
Initial Start Date Tuesday

1. Observe them using their standard mouse
2. Collect Qualitative information regarding what they like and dislike about their standard mouse:
3. Other qualitative and quantitative data collected
    a. Height:
    b. Gender:
    c. Job Title:
    d. Keyboard type (include width):
    e. How many hours each day do you spend on the computer?
    f. Have you ever had any ergonomic training or an ergonomic evaluation?
    g. What types of applications do you perform?
    h. Do you feel comfortable using your current mouse?
    i. Do you currently experience any discomfort with your current mouse?
    j. Have you ever performed mousing tasks with your non-dominant (left) hand?
    k. Have you ever used a non-standard mouse or "ergonomic" mouse?
    l. Additional Comments:

4. Observe and document ergonomic risk factors as they relate to hand/wrist postures
5. Take **photographs of standard mouse posturing**
6. Introduce the DXT mouse
1. Record initial reactions to the DXT mouse
2. Observe them use the **DXT mouse** and collect **qualitative comments** regarding design, hand fit, etc.
3. Take **photographs of DXT posturing**
4. Obtain goniometric measurements as they pertain to deviated and other incorrect hand/wrist postures while using DXT mouse
5. Instruct to use DXT in right hand for the next week.

End of Week One Tuesday (one week lapse time)

1. Observe them using the DXT mouse and record posturing
2. Collect qualitative data with regards to likes/dislikes about DXT mouse
3. Obtain goniometric measurements as they pertain to deviated and other incorrect hand/wrist postures while using DXT mouse
4. Run Fitts Law Test for gauging of precision with DXT mouse
5. Record Fitts Law results
6. Instruct to use DXT in left hand for the next week – see questions below

Initial Start of Week Two (left handed use of DXT mouse)

7. **Time** them to see how long it takes them to **innately** figure out how to use it with the left hand (posture)
8. Observe them using the DXT mouse left handed and record qualitative comments - Collect qualitative data with regards to likes/dislikes about DXT mouse use with the left hand. ****Did they understand how to switch from right to left handed use without additional instruction?**
9. Obtain goniometric measurements as they pertain to deviated and other incorrect hand/wrist postures while using DXT mouse left handed
10. Take **photographs of DXT posturing with left handed use.**
11. Run Fitts Law Test for gauging of precision with DXT mouse left handed use
12. Record Fitts Law results
13. Check in at end of day before leaving the site to see if initial reactions have changed

End of Week Two (left handed use of DXT mouse)

1. Collect qualitative data with regards to likes/dislikes about DXT mouse with left-handed use
    a. Did you like the DXT mouse?
    b. Did you like the shape/design?
    c. Do you have any comments on the way it looks?
    d. Do you have any comments on the way that it feels in your hand?
    e. Did its design encourage you to use better "mousing" postures as compared to your standard mouse?
    f. If you had discomfort using your standard mouse, did you perceive a decrease in discomfort with the use of the DXT mouse?
    g. Did you prefer the DXT mouse over your standard mouse? Why or why not?
    h. Did you find that your accuracy increased with use of the DXT mouse?
    i. Did you find that it was comfortable to use with both hands?
    j. Did you find it more comfortable to use with your left (non dominant) or right (dominant) hand?
    k. Will you continue to use the DXT mouse over your standard mouse and why?
    l. Additional Comments:
2. Observe them with left-handed use of the DXT mouse and record posturing
3. Obtain goniometric measurements as they pertain to deviated and other incorrect hand/wrist postures while using DXT mouse left handed
4. Run Fitts Law Test for gauging of precision with DXT mouse
5. Record Fitts Law results with left-handed use after one week of use

Procedures: Use Study I

Baseline/Beginning of Week 1:
Initial Data Collection with standard mouse use

- Initial qualitative comments are collected from each subject as they pertain to the use of the subjects' standard mouse
- Goniometric measurements of the various hand postures assumed while using the standard mouse are collected from each subject by a Certified Hand Therapist
- Initial discomfort rating are collected from each subject as they pertain to the use of the subjects' standard mouse
- Initial productivity surveys are collected from each subject as they pertain to the use of the subjects' standard mouse use
- Fitts Law test is run three times with use of the subjects' standard mouse to obtain the true statistical mean for each subject

Baseline/Beginning of Week 1:
Initial Data Collection with the DXT mouse

- Initial qualitative comments are collected from each subject as they pertain to the look of the DXT mouse
- Initial qualitative comments are collected from each subject as they pertain to the use of the DXT mouse
- Initial observation of using the DXT mouse are collected
- Paper instruction (included with the packaging) on proper posture use of the DXT is provided for subjects that did not respond to the innateness of the design
- Goniometric measurements of the various hand postures assumed while using the DXT mouse are collected from each subject by a Certified Hand Therapist
- Fitts Law test is run three times with use of the subjects' DXT mouse to obtain the true statistical mean for each subject

End of Week 1:

- Researchers perform a personal check in with regards to comfort and productivity surveys
- Researchers perform a personal check in for observations of how the subjects are using the DXT mouse,
- Researchers perform a personal check in with regards to reactions and/or comments as they pertain to use of the DXT mouse,
- Fitts Law test is run three times with use of the subjects' DXT mouse to obtain the true statistical mean for each subject after one week of use

Beginning of Week 2:

- Subjects are asked to use the DXT mouse with their left hand
- Initial reactions for left hand use are recorded

- Goniometric measurements of the various hand postures assumed while using the DXT mouse left handed are collected from each subject by a Certified Hand Therapist
- Fitts Law test is run three times with use of the subjects' DXT mouse using their left hand to obtain the true statistical mean for each subject

End of Week 2:

- Researchers perform a personal check in with regards to comfort and productivity surveys
- Researchers perform a personal check in for observations of how the subjects are using the DXT mouse with their left hand,
- Researchers perform a personal check in with regards to reactions and/or comments as they pertain to left handed use of the DXT mouse,
- Fitts Law test is run three times with left-handed use of the subjects' DXT mouse to obtain the true statistical mean for each subject after one week of use

Week 3 - Reset Period - no data collection is performed

Beginning of Week 4:

- Collect discomfort/productivity surveys for standard mouse AND qualitative data on reactions/comments of return to standard mouse.
- Provide Evoluent mice to subjects
- Record Initial Qualitative data on initial reactions/comments of the Evoluent design
- Perform observation of how the subjects are using the Evoluent mouse
- Provide appropriate instruction on how to use Evoluent mouse if needed
- Perform initial goniometric measurements of the selected hand postures for Evoluent use
- Fitts Law test is run three times with right handed use of the subjects' Evoluent mouse to obtain the true statistical mean for each subject after initial use

End of Week 4:

- Researchers perform a personal check in with regards to comfort and productivity surveys
- Researchers perform a personal check in for observations of how the subjects are using the Evoluent mouse with their right hand,
- Researchers perform a personal check in with regards to reactions and/or comments as they pertain to use of the Evoluent mouse,
- Fitts Law test is run three times with right handed use of the subjects' Evoluent mouse to obtain the true statistical mean for each subject after one week of use

End of Week 5:

- Final discomfort/productivity surveys are collected
- Final Qualitative data on initial reactions/comments

Use Study II

17 participants were recruited for the second study and were asked to perform a series of three timed tests with their right, dominant mousing hand; a WORD test, an EXCEL test, and then a Fitts Law test.

Participants were first asked to perform these three timed tests using their standard mouse and data was collected. To eliminate bias, two separate WORD and two separate EXCEL tests with the same number of character layouts were provided so that the participant would not gain familiarity with the verbiage and mousing commands.

Participants were then asked to repeat these three timed tests using the second WORD and EXCEL test layouts using their first test mouse. They were then asked to use the first test mouse for a period of 5 days.

After a period of 5 days, the timed test series was rerun and data was collected.

After the data was collected from use with the first test mouse, the second test mouse was introduced. The alternate series of timed tests were run and the data was collected. Users were asked to use the second test mouse for a period of 5 days. At the end of the second trial period of 5 days, the three timed tests were re-administered and the data was collected.

Quantitative Results using Fitts Law and Microsoft Office EXCEL to Measure Accuracy and Precision

Use of Microsoft Office WORD to measure Efficiency and Productivity

Standard Mouse, DXT and Evoluent Mice Designs

Fitts Law Quantitative Results

Fitts' law is a model of human movement primarily used in human–computer interaction and ergonomics that predicts the time required to rapidly move to a target area. This application is used both with point-and-click and drag-and-drop actions and is often used with usability studies to model the act of *pointing*, either by physically touching an object with a hand or finger as with a touch pad or screen or by pointing to an object on a computer monitor using a pointing device such as a mouse. Since the advent of graphical user interfaces, Fitts' law has been applied to tasks where the user must position a mouse cursor over an on-screen target, such as a button or other widget.

Fitts Law in its original and strictest form;

- Describes untrained movements, (not movements that are executed after months or years of practice),
- Applies only to movement in a single dimension and not to movement in two dimensions (though it is successfully extended to two dimensions in the Accot-Zhai steering law);

This study utilized Fitt's Law to collect data on accuracy and precision when using the standard mouse, the DXT mouse, and the Evoluent mouse. This data was then organized for statistical comparison using a single tail T-test paired two samples for Means between independent variables to determine if one device was in fact more accurate or precise than the other.

For Study I, the Fitts Law Test was run three timers per entry to eliminate psychosocial factors and to obtain a true mean. The test was performed in each subject's cubicle and/or hard wall office in a relaxed and comfortable manner.

Please Note: It is important to consider that both the DXT and the Evoluent mice were only used for the duration of four to five days compared to the subject's standard mouse design that they had been using for several years if not decades.

Use Study I

Analysis of the Data Using Fitts Law

Fitts Law: Standard Mouse vs. Initial Right handed use with DXT mouse

T-Test Paired two sample for Means

	Variable 1	*Variable 2*
Mean	834.8461538	876.2307692
Variance	10554.30769	13473.52564
Observations	13	13
Pearson Correlation	0.724131027	
Hypothesized Mean Difference	0	
df	12	
t Stat	-1.815181448	
P(T<=t) one-tail	0.047276396	
t Critical one-tail	1.782287548	
P(T<=t) two-tail	0.094552791	
t Critical two-tail	2.178812827	

In the above statistical result, you will denote that the "T-Stat" is greater than the "T Critical" for a one-tail result. This data reflects that the numbers are truly different and did not occur by chance. The mean reflecting the mouse speed is also smaller.

This data above reflects that at the initial onset of use with no prior training or practice using the DXT mouse, the DXT mouse was "not as accurate or precise" as the standard mouse with regards to accuracy and precision for Study I.

Based on a p value of .05, this data reflects that there is statistical significance and that the results did not occur by chance.

Statistically significant that the mouse is faster than the DXT initially with accuracy and precision

Use Study II

Analysis of the Data Using Fitts Law

Fitts Law: Standard Mouse vs. Initial Right handed use with DXT mouse

T-Test: Paired Two Sample for Means

	Variable 1	*Variable 2*
Mean	833.7333333	931.4
Variance	10400.92381	13657.25714
Observations	15	15
Pearson Correlation	0.333060243	
Hypothesized Mean Difference	0	
df	14	
t Stat	-2.979350957	
P(T<=t) one-tail	0.004975219	
t Critical one-tail	1.761310115	
P(T<=t) two-tail	0.009950437	
t Critical two-tail	2.144786681	

In the above statistical result, you will denote that the "T-Stat" is greater than the "T Critical" for a one-tail result. This data reflects that the numbers are truly different and did not occur by chance. The mean reflecting the mouse speed is also smaller.

It also reflects that in Study II, at the initial onset of use with no prior training or practice using the DXT mouse, the DXT mouse was "not as accurate or precise" as the standard mouse with regards to accuracy and precision.

Based on a p value of .05, this data reflects that there is statistical significance and that the results did not occur by chance. This same result was obtained from Study II.

Statistically significant that the mouse is faster than the DXT initially with accuracy and precision

Use Study I

Analysis of the Data Using Fitts Law

Fitts Law: Standard Mouse vs. DXT mouse post five days of use with DXT

T-Test Paired two sample for Means

	Variable 1	*Variable 2*
Mean	834.84615	849.7692
Variance	10554.308	14925.03
Observations	13	13
Pearson Correlation	0.6796532	
Hypothesized Mean Difference	0	
df	12	
t Stat	-0.586411	
P(T<=t) one-tail	0.2842333	
t Critical one-tail	1.7822875	
P(T<=t) two-tail	0.5684665	
t Critical two-tail	2.1788128	

In the above statistical result, you will denote that the "T-Stat" is less than the "T Critical" for a one-tail result. This data reflects no statistical significance that the mouse is faster than the DXT or vice versa. You will also denote the mean is getting smaller for the DXT (849.7692) compared to the mean from initial use compared to the mouse.

Based on a p value of .05, this data reflects that this result is not statistically significant and that the results could have occurred by chance.

No statistical significance that the mouse is faster than the DXT initially with accuracy and precision. However, the mean reveals that the DXT is getting faster with use.

Use Study II

Fitts Law: Standard Mouse vs. DXT mouse post five days of use with DXT

T-Test Paired two sample for Means

	Variable 1	*Variable 2*
Mean	833.7333333	819.8
Variance	10400.92381	12781.6
Observations	15	15
Pearson Correlation	0.636441424	
Hypothesized Mean Difference	0	
df	14	
t Stat	0.585103396	
P(T<=t) one-tail	0.283894803	
t Critical one-tail	1.761310115	
P(T<=t) two-tail	0.567789606	
t Critical two-tail	2.144786681	

In the above statistical result, you will denote that the "T-Stat" is less than the "T Critical" for a one-tail result. This data reflects no statistical significance that the mouse is faster than the DXT or vice versa. You will also denote the mean is getting smaller for the DXT (819.8) compared to the mean from initial use compared to the mouse.

Based on a p value of .05, this data reflects that this result is not statistically significant and that the results could have occurred by chance.

No statistical significance that the mouse is faster than the DXT initially with accuracy and precision. However, the mean reveals that the DXT is getting faster with use.

Use Study I

Analysis of the Data Using Fitts Law

Fitts Law: Standard Mouse vs. Initial Evoluent mouse use

T-Test Paired two sample for Means

	Variable 1	*Variable 2*
Mean	820.3333	880.4444
Variance	11312.25	13789.53
Observations	9	9
Pearson Correlation	0.405553	
Hypothesized Mean Difference	0	
df	8	
t Stat	-1.47382	
P(T<=t) one-tail	0.089378	
t Critical one-tail	1.859548	
P(T<=t) two-tail	0.178756	
t Critical two-tail	2.306004	

In the above statistical result, you will denote that the "T-Stat" is less than the "T Critical" for a one-tail result. This data reflects that the numbers are not truly different and the result could have occurred by chance therefore having no statistical significance.

Based on a p value of .05, this data reflects that there is **no** statistical significance and that the results could have occurred by chance.

No statistical significance that the mouse is faster than the Evoluent initially with accuracy and precision.

Use Study II

Analysis of the Data Using Fitts Law

Fitts Law: Standard Mouse vs. Initial Evoluent mouse use

T-Test Paired two sample for Means

	Variable 1	*Variable 2*
Mean	833.73	1004.6
Variance	10400.92	20660.82857
Observations	15.00	15
Pearson Correlation	0.43	
Hypothesized Mean Difference	0.00	
df	14.00	
t Stat	-4.87	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.76	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.14	

In the above statistical result, you will denote that the "T-Stat" is greater than the "T Critical" for a one-tail result. Based on a p value of .05, this data reflects that the numbers are truly different and did not occur by chance.

Statistically significant that the mouse is faster than the Evoluent initially with accuracy and precision.

Use Study I

Analysis of the Data Using Fitts Law

Fitts Law: Standard Mouse vs. Final Evoluent mouse use

T-Test Paired two sample for Means

	Variable 1	*Variable 2*
Mean	839.0833	906.25
Variance	10555.17	16245.84
Observations	12	12
Pearson Correlation	0.731543	
Hypothesized Mean Difference	0	
df	11	
t Stat	-2.66159	
P(T<=t) one-tail	0.011062	
t Critical one-tail	1.795885	
P(T<=t) two-tail	0.022124	
t Critical two-tail	2.200985	

In the above statistical result, you will denote that the "T-Stat" is greater than the "T Critical" for a one-tail result. This data reflects that after three to five days of use with the Evoluent mouse, the Evoluent mouse became "slower" than use with the Standard mouse with regards to accuracy and precision.

This is a negative result for the Evoluent.

Based on a p value of .05, this data reflects that this result is statistically significant and that the results did not occur by chance.

Use Study II

Analysis of the Data Using Fitts Law

Fitts Law: Standard Mouse vs. Final Evoluent mouse use

T-Test Paired two sample for Means

	Variable 1	*Variable 2*
Mean	833.7333333	939.8666667
Variance	10400.92381	13882.12381
Observations	15	15
Pearson Correlation	0.430359525	
Hypothesized Mean Difference	0	
df	14	
t Stat	-3.481428198	
P(T<=t) one-tail	0.001834069	
t Critical one-tail	1.761310115	
P(T<=t) two-tail	0.003668139	
t Critical two-tail	2.144786681	

In the above statistical result, you will denote that the "T-Stat" is greater than the "T Critical" for a one-tail result. This data reflects that after three to five days of use with the Evoluent mouse, the Evoluent mouse became "slower" than use with the Standard mouse with regards to accuracy and precision.

This is a negative result for the Evoluent.

Based on a p value of .05, this data reflects that this result is statistically significant and that the results did not occur by chance.

Use Study I

Analysis of the Data Using Fitts Law

Fitts Law: Final DXT Mouse vs. Evoluent mouse:

T-Test Paired two sample for Means

	Variable 1	*Variable 2*
Mean	808.4444	886.6667
Variance	10462.53	14069.25
Observations	9	9
Pearson Correlation	0.410282	
Hypothesized Mean Difference	0	
df	8	
t Stat	-1.9437	
P(T<=t) one-tail	0.043921	
t Critical one-tail	1.859548	
P(T<=t) two-tail	0.087843	
t Critical two-tail	2.306004	

In the above statistical result, you will denote that the "T-Stat" is greater than the "T Critical" for a one-tail result. This data reflects that after five days of use with the DXT and the Evoluent mouse, **the DXT mouse was "more precise and accurate" than the Evoluent mouse**.

This is a positive result for the DXT.

Based on a p value of .05, this data reflects that this result is statistically significant and that the results did not occur by chance.

Use Study II

Analysis of the Data Using Fitts Law

Fitts Law: Final DXT Mouse vs. Evoluent mouse:

T-Test Paired two sample for Means

	Variable 1	*Variable 2*
Mean	939.8666667	819.8
Variance	13882.12381	12781.6
Observations	15	15
Pearson Correlation	0.405184237	
Hypothesized Mean Difference	0	
df	14	
t Stat	3.691394291	
P(T<=t) one-tail	0.001209089	
t Critical one-tail	1.761310115	
P(T<=t) two-tail	0.002418178	
t Critical two-tail	2.144786681	

In the above statistical result, you will denote that the "T-Stat" is greater than the "T Critical" for a one-tail result. This data reflects that after five days of use with the DXT and the Evoluent mouse, **the DXT mouse was "more precise and accurate" than the Evoluent mouse**.

This is a positive result for the DXT.

Based on a p value of .05, this data reflects that this result is statistically significant and that the results did not occur by chance.

Use Study I

Analysis of the Data Using Fitts Law

Fitts Law: Standard Mouse vs. DXT Mouse with Left Handed Use

T-Test Paired two sample for Means

	Variable 1	*Variable 2*
Mean	812.5	1216.4
Variance	7682.277778	33169.37778
Observations	10	10
Pearson Correlation	0.69268652	
Hypothesized Mean Difference	0	
df	9	
	-	
t Stat	9.330908991	
P(T<=t) one-tail	3.17421E-06	
t Critical one-tail	1.833112923	
P(T<=t) two-tail	6.34841E-06	
t Critical two-tail	2.262157158	

In the above statistical result, you will denote that the "T-Stat" is greater than the "T Critical" for a one-tail result. This data reflects statistical significance that at the initial onset of DXT left handed use compared to right handed standard mouse use, the DXT is "not as accurate or precise" as the standard mouse.

Based on a p value of .05, this data reflects that this result is statistically significant and that the results did not occur by chance.

Use Study I

Analysis of the Data Using Fitts Law

Fitts Law: Initial DXT left handed mouse use compared to Final DXT Left Handed Use

T-Test Paired two sample for Means

	Variable 1	*Variable 2*
Mean	1216.4	1128.5
Variance	33169.37778	36245.61111
Observations	10	10
Pearson Correlation	0.754603527	
Hypothesized Mean Difference	0	
df	9	
t Stat	2.12653753	
P(T<=t) one-tail	0.031185749	
t Critical one-tail	1.833112923	
P(T<=t) two-tail	0.062371498	
t Critical two-tail	2.262157158	

In the above statistical result, you will denote that the "T-Stat" is still greater than the "T Critical" for a one-tail result. However by evaluating the mean from the initial to the final left handed use trials, this data reflects that only after a few hours of left handed use, accuracy and precision with left-handed DXT use is becoming significantly more precise and accurate and performance with left-handed use is getting faster.

It may be inferred from this result that with more practice, left-handed use with the DXT would be "as accurate and precise" as use with the right hand and/or with use of the standard Mouse.

Although statistically significant for greater accuracy and precision with Standard mouse use, this is a positive result for DXT as the Mean shown above is becoming more equal

**To accurately reflect this statistic, a study of left handed standard mouse use should be compared to left handed DXT use.

It is important to note that this is:

- Not an equal comparison for left-handed use with regards to the DXT as this data was compared to right-handed standard mouse use,
- Most subjects within this test group only used the DXT left handed for a few minutes to a few hours with the exception of three users.

TEST VIII T-Test Paired two sample for Means

Fitts Law: Initial Standard Mouse vs. DXT Mouse with Left Handed Use

	Variable 1	*Variable 2*
Mean	812.5	1216.4
Variance	7682.277778	33169.37778
Observations	10	10
Pearson Correlation	0.69268652	
Hypothesized Mean Difference	0	
df	9	
	-	
t Stat	9.330908991	
P(T<=t) one-tail	3.17421E-06	
t Critical one-tail	1.833112923	
P(T<=t) two-tail	6.34841E-06	
t Critical two-tail	2.262157158	

Final Standard Mouse vs. DXT Mouse with Left Handed Use

	Variable 1	*Variable 2*
Mean	812.5	1128.5
Variance	7682.277778	36245.61111
Observations	10	10
Pearson Correlation	0.812888676	
Hypothesized Mean Difference	0	
df	9	
t Stat	-7.709865536	
P(T<=t) one-tail	1.48486E-05	
t Critical one-tail	1.833112923	
P(T<=t) two-tail	2.96972E-05	
t Critical two-tail	2.262157158	

The above statistical tables reflect that only after a few minutes to hours of left handed use, the DXT mouse has shown to increase rapidly with regards to "accuracy and precision" compared to right-handed use of the standard mouse. The above tables also reflect that the learning curve towards adoption of left handed use with the DXT also appears to be rapid. This inference is illustrated with the T Stat and T Critical one-tail values where the initial results for DXT were 9.3309 and the final result has decreased to 7.7098. **Further testing to prove this data point is recommended to provide an accurate result based on true time when using the DXT mouse left-handed. This is a positive result for DXT.

Study II Summary of Quantitative Results – Fitts Law Accuracy and Precision

Summary of Statistical Values	Statistical Values
Standard Mouse vs. Evoluent Initial Statistically significant that the mouse is faster than the Evoluent initially with regards to accuracy and precision.	t Stat Value = -4.87 (absolute value) t Critical Value = 1.76 **Mean** Mouse Evoluent 833.73 1004.6
Standard Mouse vs. Evoluent Final Statistically significant that the mouse is faster than the Evoluent after one weeks use of the Evoluent with regards to accuracy and precision.	t Stat Value = -3.481428198 (absolute value) t Critical Value = 1.761310115 **Mean** Mouse Evoluent 833.73 939.8666667
Standard Mouse vs. DXT Initial Statistically significant that the mouse is faster than the DXT initially with regards to accuracy and precision.	t Stat Value = -2.979350957 (absolute value) t Critical Value = 1.761310115 **Mean** Mouse DXT 833.73 931.4
Standard Mouse vs. DXT Final No statistical significance that the mouse is faster than the DXT with regards to accuracy and precision.	t Stat Value = 0.585103396 (absolute value) t Critical Value = 1.761310115 **Mean** Mouse DXT 833.73 819.8
Evoluent Initial vs. DXT Initial Statistically significant that the DXT is faster than the Evoluent initially with regards to accuracy and precision.	t Stat Value = 2.59719142 (absolute value) t Critical Value = 1.761310115 **Mean** Evoluent DXT 1004.6 931.4
Evoluent Final vs. DXT Final Statistically significant that the DXT is faster than the Evoluent after one weeks use with regards to accuracy and precision	t Stat Value = 3.691394291 (absolute value) t Critical Value = 1.761310115 **Mean** Evoluent DXT 939.8666667 819.8

Study II Quantitative Results Microsoft Office Programs WORD

Summary of Statistical Values	Statistical Values
Standard Mouse vs. Evoluent Initial Statistically significant that the Evoluent is as fast as fast as the mouse initially with regards to MS Office WORD programs.	t Stat Value = 3.109686013 (absolute value) t Critical Value = 1.761310115 **Mean** Mouse Evoluent 2.687333333 2.190666667
Standard Mouse vs. Evoluent Final Statistically significant that the Evoluent is as fast as the standard mouse after one weeks use with regards to MS Office WORD programs.	t Stat Value = -3.481428198 (absolute value) t Critical Value = 1.761310115 **Mean** Mouse Evoluent 2.687333333 2.021333333
Standard Mouse vs. DXT Initial Statistically significant that the DXT is as faster or faster than the mouse with initial use with regards to MS Office WORD programs.	t Stat Value = 2.817140338 (absolute value) t Critical Value = 1.761310115 **Mean** Mouse DXT 2.687333333 2.107333333
Standard Mouse vs. DXT Final Statistically significant that the DXT is is fast or faster than the mouse after one weeks use with regards to MS Office WORD programs.	t Stat Value = 4.196728795 (absolute value) t Critical Value = 1.761310115 **Mean** Mouse DXT 2.687333333 1.908666667
Evoluent Initial vs. DXT Initial Not statistically significant that the DXT is faster than the Evoluent initially with regards to MS Office WORD programs.	t Stat Value = 0.494271405 (absolute value) t Critical Value = 1.761310115 **Mean** Evoluent DXT 2.190666667 2.107333333
Evoluent Final vs. DXT Final Not statistically significant that the DXT is faster than the Evoluent after one weeks use with regards to MS Office WORD programs, However, the Mean reveals that the DXT is getting faster than the Evoluent with use.	t Stat Value = 0.717913163 (absolute value) t Critical Value = 1.761310115 **Mean** Evoluent DXT 2.021333333 1.908666667

Study II Quantitative Results Microsoft Office Programs EXCEL

Summary of Statistical Values	Statistical Values
Standard Mouse vs. Evoluent Initial Not statistically significant that the mouse is faster than the Evoluent initially with regards to MS Office EXCEL programs. They are relatively the "same" speed.	t Stat Value = 0.432577962 (absolute value) t Critical Value = 1.761310115 **Mean** Mouse Evoluent 2.551333333 2.4
Standard Mouse vs. Evoluent Final Statistically significant that the Evoluent is as fast or faster than the standard mouse after one weeks use with regards to MS Office EXCEL programs.	t Stat Value = 3.272771601 (absolute value) t Critical Value = 1.761310115 **Mean** Mouse Evoluent 2.551333333 1.823333333
Standard Mouse vs. DXT Initial Statistically significant that the DXT is initially faster than the standard mouse with regards to MS Office EXCEL programs.	t Stat Value = 4.697868319 (absolute value) t Critical Value = 1.761310115 **Mean** Mouse DXT 2.551333333 1.609333333
Standard Mouse vs. DXT Final Statistically significant that the DXT is still faster than the mouse after one weeks use with regards to MS Office EXCEL programs.	t Stat Value = 5.092790929 (absolute value) t Critical Value = 1.761310115 **Mean** Mouse DXT 2.551333333 1.464666667
Evoluent Initial vs. DXT Initial Statistically significant that the DXT is faster than the Evoluent initially with regards to MS Office EXCEL programs.	t Stat Value = 1.99657439 (absolute value) t Critical Value = 1.761310115 **Mean** Evoluent DXT 2.4 1.609333333
Evoluent Final vs. DXT Final Statistically significant that the DXT is still faster than the Evoluent after one weeks use with regards to MS Office EXCEL programs	t Stat Value = 2.206371772 (absolute value) t Critical Value = 1.761310115 **Mean** Evoluent DXT 1.823333333 1.464666667

Quantitative Goniometric Measurement Results

Reflecting user comfort and the potential for reduction of ergonomic risk factors as they relate to neutral hand postures due to optimal design with regards to the Standard mouse, the DXT and the Evoluent Mice

Goniometric Measurement Values

Goniometric Measurements were performed initially with the subjects using their Standard mouse, and then with the introduction of the DXT mouse, and then with the later introduction of the Evoluent mouse.

The following wrist and thumb angles were measured while using these peripherals to establish comfort and a decrease of awkward and static postures in addition to contact stress exposure due to optimal mouse design.

The following kinesthetic motions were measured with a manual goniometer with use on all three mice and are included with this study:

- Wrist Extension
- Wrist Ulnar Deviation
- Wrist Radial Deviation
- Radial Thumb Abduction
- Palmar Thumb Abduction
- Pronation

Summary of Findings

- *Study I Wrist Extension* – results do not show any statistical significance (no difference) of wrist extension angles between the DXT and the Evoluent mouse however both promote less wrist extension than the standard mouse.
- *Study II Wrist Extension* – results show statistical significance that the DXT has less wrist extension angles than the Evoluent mouse.
- *Wrist Ulnar Deviation* - the DXT mouse did not reveal any statistical significance as promoting less ulnar deviated wrist postures with use than the Evoluent however it did prove to show less ulnar deviated wrist angles than the standard mouse.
- *Wrist Radial Deviation*- the Standard mouse revealed statistical significance as promoting greater radial deviated wrist postures with use than the DXT. When compared to the standard mouse, the Evoluent revealed the same degree of radial deviated wrist postures.
- *Radial Thumb Abduction* – most optimal result for the DXT (less squeezing)
- *Palmar Thumb Abduction* - the DXT mouse and the Evoluent mouse are the same with regards to palmar thumb abduction.
- *Pronation*- the DXT and the Evoluent mice equally afford a more relaxed hand posture with mousing tasks due to a less pronated wrist angle

Radial Thumb Abduction - Standard Mouse vs. the DXT

	Variable 1	*Variable 2*
Mean	32.1875	5
Variance	286.5625	190
Observations	16	16
Pearson Correlation	0.178567443	
Hypothesized Mean Difference	0	
df	15	
t Stat	5.484113118	
P(T<=t) one-tail	3.14499E-05	
t Critical one-tail	1.753050325	
P(T<=t) two-tail	6.28999E-05	
t Critical two-tail	2.131449536	

In the above statistical result, you will denote that the "T-Stat" is greater than the "T Critical" for a one-tail result. The above data reflects statistical significance where as radial thumb abduction is less with the standard mouse (more squeezing) than with the DXT mouse. When trying to achieve a neutral wrist/hand posture, less of an abducted thumb angle is preferred.

This data is supported statistically that sustained "squeezing" postures/lesser angle of abduction (radial thumb abduction) are less with standard mouse use than with the DXT. This further supports the premise that the DXT mouse affords a more relaxed hand posture with mousing tasks therefore reducing the muscle forces applied at the involved joints of the thumb, finger, and the forearm.

This is a positive result for the DXT.

The above results are based on a p value of .05 and reflect that this result is statistically significant and that the results did not occur by chance.

Radial Thumb Abduction - Standard Mouse vs. the Evoluent

	Variable 1	*Variable 2*
Mean	32.1875	3.125
Variance	286.5625	32.91666667
Observations	16	16
Pearson Correlation	-0.418288352	
Hypothesized Mean Difference	0	
df	15	
t Stat	5.807209381	
P(T<=t) one-tail	1.72741E-05	
t Critical one-tail	1.753050325	
P(T<=t) two-tail	3.45482E-05	
t Critical two-tail	2.131449536	

In the above statistical result, you will denote that the "T-Stat" is greater than the "T Critical" for a one-tail result. The above data reflects statistically significant results where as radial thumb abduction is less with the standard mouse (more squeezing) than with the Evoluent mouse. When trying to achieve a neutral wrist/hand posture, less of an abducted thumb angle is preferred.

This data is supported statistically that sustained "squeezing" postures/lesser angle of abduction (radial thumb abduction) are less with standard mouse use than with the Evoluent. This further supports the premise that the Evoluent mouse could afford a more relaxed hand posture with mousing tasks therefore reducing the muscle forces applied at the involved joints of the thumb, fingers, and the forearm.

This is a positive result for the Evoluent.

The above results are based on a p value of .05 and reflect that this result is statistically significant and that the results did not occur by chance.

Radial Thumb Abduction - DXT vs. the Evoluent

	Variable 1	*Variable 2*
Mean	0	4.5
Variance	0	46.94444444
Observations	10	10
Pearson Correlation	#DIV/0!	
Hypothesized Mean Difference	0	
df	9	
t Stat	-2.076923077	
P(T<=t) one-tail	0.033800731	
t Critical one-tail	1.833112923	
P(T<=t) two-tail	0.067601463	
t Critical two-tail	2.262157158	

In the above statistical result, you will denote that the "T-Stat" is greater than the "T Critical" for a one-tail result. The above data reflects statistical significance where as radial thumb abduction is less with the DXT mouse than with the Evoluent mouse.

This data is also supported statistically that sustained "squeezing" postures (radial thumb abduction) are greater with Evoluent mouse use than with the DXT. This further supports the premise that the DXT mouse could afford a more relaxed hand posture with mousing tasks than the Evoluent therefore reducing the muscle forces applied at the involved joints of the thumb, fingers, and the forearm.

This is a positive result for the DXT.

The above results are based on a p value of .05 and reflect that this result is statistically significant and that the results did not occur by chance.

Palmar Thumb Abduction - Standard Mouse vs. DXT

	Variable 1	*Variable 2*
Mean	41.15384615	43.84615385
Variance	258.974359	71.47435897
Observations	13	13
Pearson Correlation	0.684365369	
Hypothesized Mean Difference	0	
df	12	
t Stat	-0.808290377	
P(T<=t) one-tail	0.217327668	
t Critical one-tail	1.782287548	
P(T<=t) two-tail	0.434655336	
t Critical two-tail	2.178812827	

In the above statistical result, you will denote that the "T-Stat" is less than the "T Critical" for a one-tail result. The above data reflects no statistical significance with regards to the mouse having greater or less palmar thumb abduction than the DXT mouse.

When compared to one another, this data supports the premise that the standard mouse and the DXT mouse do not afford significant palmar thumb abduction.

In effect, this is a positive result for the DXT.

The above results are based on a p value of .05 and reflect that this result is not statistically significant and that the results could have occurred by chance.

Palmar Thumb Abduction - Standard Mouse vs. Evoluent

	Variable 1	*Variable 2*
Mean	43.33333333	43.33333333
Variance	106.0606061	19.6969697
Observations	12	12
Pearson Correlation	0.281772256	
Hypothesized Mean Difference	0	
df	11	
t Stat	0	
P(T<=t) one-tail	0.5	
t Critical one-tail	1.795884814	
P(T<=t) two-tail	1	
t Critical two-tail	2.200985159	

In the above statistical result, you will denote that the "T-Stat" is less than the "T Critical" for a one-tail result. The above data reflects no statistical significance with regards to the mouse having greater or less palmar thumb abduction than the Evoluent mouse.

When compared to one another, this data supports the premise that the standard mouse and the Evoluent mouse do not afford significant palmar thumb abduction.

This is a positive result for the Evoluent.

The above results are based on a p value of .05 and reflect that this result is not statistically significant and that the results could have occurred by chance.

Palmar Thumb Abduction - DXT vs. Evoluent

	Variable 1	*Variable 2*
Mean	44.44444444	42.77777778
Variance	77.77777778	19.44444444
Observations	9	9
Pearson Correlation	0.446428571	
Hypothesized Mean Difference	0	
df	8	
t Stat	0.632455532	
P(T<=t) one-tail	0.27236865	
t Critical one-tail	1.859548033	
P(T<=t) two-tail	0.544737301	
t Critical two-tail	2.306004133	

In the above statistical result, you will denote that the "T-Stat" is less than the "T Critical" for a one-tail result. The above data reflects no statistical significance with regards to the DXT having greater or less palmar thumb abduction than the Evoluent mouse.

When compared to one another, this data supports the premise that the DXT mouse and the Evoluent mouse are the same with regards to palmar thumb abduction or that they both have minimal exposure to palmar abduction.

The above results are based on a p value of .05 and reflect that this result is not statistically significant and that the results could have occurred by chance.

This is a positive result for both DXT and Evoluent.

Pronation - Standard Mouse vs. DXT

	Variable 1	*Variable 2*
Mean	58.75	44.0625
Variance	258.3333333	114.0625
Observations	16	16
Pearson Correlation	0.216031508	
Hypothesized Mean Difference	0	
df	15	
t Stat	3.401988283	
P(T<=t) one-tail	0.001970834	
t Critical one-tail	1.753050325	
P(T<=t) two-tail	0.003941669	
t Critical two-tail	2.131449536	

In the above statistical result, you will denote that the "T-Stat" is greater than the "T Critical" for a one-tail result. The above data reflects statistical significance where pronation is greater with the standard mouse (less neutral hand posturing) than with the DXT mouse. When trying to achieve a neutral wrist/hand posture, less of a pronation angle is preferred.

This data is also supported statistically that the DXT mouse affords a more relaxed hand posture with mousing tasks therefore reducing the muscle forces applied at the involved joints of the thumb, fingers, and the forearm.

This is a positive result for the DXT.

The above results are based on a p value of .05 and reflect that this result is statistically significant and that the results did not occur by chance.

Pronation - Standard Mouse vs. Evoluent

	Variable 1	*Variable 2*
Mean	53.75	41.25
Variance	473.2954545	68.75
Observations	12	12
Pearson Correlation	0.286633011	
Hypothesized Mean Difference	0	
df	11	
t Stat	2.067513337	
P(T<=t) one-tail	0.031521472	
t Critical one-tail	1.795884814	
P(T<=t) two-tail	0.063042944	
t Critical two-tail	2.200985159	

In the above statistical result, you will denote that the "T-Stat" is greater than the "T Critical" for a one-tail result. The above data reflects statistically significant results where as pronation is greater with the standard mouse (less neutral hand posturing) than with the Evoluent mouse. When trying to achieve a neutral wrist/hand posture, less of a pronation angle is preferred.

This data is also supported statistically that the Evoluent mouse affords a more relaxed hand posture with mousing tasks therefore reducing the muscle forces applied at the involved joints of the thumb, fingers, and the forearm.

This is a positive result for the Evoluent.

The above results are based on a p value of .05 and reflect that this result is statistically significant and that the results did not occur by chance.

Pronation – DXT vs. Evoluent

	Variable 1	*Variable 2*
Mean	45.5	41
Variance	119.1666667	82.22222222
Observations	10	10
Pearson Correlation	0.3030744	
Hypothesized Mean Difference	0	
df	9	
t Stat	1.196753959	
P(T<=t) one-tail	0.130987419	
t Critical one-tail	1.833112923	
P(T<=t) two-tail	0.261974838	
t Critical two-tail	2.262157158	

In the above statistical result, you will denote that the "T-Stat" is less than the "T Critical" for a one-tail result. The above data reflects no statistical significance that the DXT affords less pronation than the Evoluent and vice-versa.

This data also infers that both the DXT and the Evoluent mice equally afford a more relaxed hand posture with mousing tasks due to a less pronated wrist angle therefore reducing the muscle forces applied at the involved joints of the thumb, fingers, and the forearm.

This is a positive result for the DXT and the Evoluent.

The above results are based on a p value of .05 and reflect that this result is not statistically significant and that the results could have occurred by chance.

Wrist Extension - Standard mouse vs. DXT

	Variable 1	*Variable 2*
Mean	19.61538462	32.69230769
Variance	151.9230769	223.3974359
Observations	13	13
Pearson Correlation	0.379272133	
Hypothesized Mean Difference	0	
df	12	
t Stat	-3.07192687	
P(T<=t) one-tail	0.004841035	
t Critical one-tail	1.782287548	
P(T<=t) two-tail	0.009682069	
t Critical two-tail	2.178812827	

In the above statistical result, you will denote that the "T-Stat" is greater than the "T Critical" for a one-tail result. The above data reflects statistical significance where as wrist extension is greater with the standard mouse (less neutral hand posturing) than with the DXT mouse.

Based on clinical support documentation, it has been shown that sustained and repetitive wrist extension will promote the development of lateral epicondylitis, wrist tendonitis and potentially the development of carpal tunnel if contact stress forces are also applied at the anterior wrist region with mousing tasks.

This data is also supported statistically that the DXT mouse affords a more relaxed hand posture with mousing tasks reducing the static muscle forces applied at the extensor muscles of the hands and forearms therefore reducing the likelihood of developing tendonitis at the wrist and/or elbow regions.

This is a positive result for the DXT.

The above results are based on a p value of .05 and reflect that this result is statistically significant and that the results did not occur by chance.

Wrist Extension - Standard mouse vs. Evoluent

	Variable 1	*Variable 2*
Mean	20.83333333	36.66666667
Variance	158.3333333	146.969697
Observations	12	12
Pearson Correlation	0.198648817	
Hypothesized Mean Difference	0	
df	11	
t Stat	-3.506296857	
P(T<=t) one-tail	0.002457759	
t Critical one-tail	1.795884814	
P(T<=t) two-tail	0.004915519	
t Critical two-tail	2.200985159	

In the above statistical result, you will denote that the "T-Stat" is greater than the "T Critical" for a one-tail result. The above data reflects statistically significant results where as wrist extension is greater with the standard mouse than with the Evoluent mouse.

Based on clinical support documentation, it has been shown that sustained and repetitive wrist extension will promote the development of lateral epicondylitis, wrist tendonitis and potentially the development of carpal tunnel if contact stress forces are also applied at the anterior wrist region with mousing tasks.

This data is also supported statistically that the Evoluent mouse affords a more relaxed hand posture with mousing tasks reducing the static muscle forces applied at the extensor muscles of the hands and forearms therefore reducing the likelihood of developing tendonitis at the wrist and/or elbow regions.

This is a positive result for the Evoluent however, **Please Note,** Visual observations of the subjects using the Evoluent mouse showed sustained contact stress or static resting on the ulnar border with mousing tasks. The DXT mouse encouraged the subjects to float the wrist above the worksurface with use and also to remove their hand from the DXT mouse when not in use therefore not showing the same contact stress against the ulnar border with use as with the Evoluent mouse.

The above results are based on a p value of .05 and reflect that this result is statistically significant and that the results did not occur by chance.

Wrist Extension – DXT vs. Evoluent

	Variable 1	*Variable 2*
Mean	37.22222222	40
Variance	231.9444444	143.75
Observations	9	9
Pearson Correlation	0.547651253	
Hypothesized Mean Difference	0	
df	8	
t Stat	-0.628694613	
P(T<=t) one-tail	0.273537794	
t Critical one-tail	1.859548033	
P(T<=t) two-tail	0.547075587	
t Critical two-tail	2.306004133	

Although the DXT mouse showed slightly less performance of wrist extension with use than the Evoluent, it did not reveal statistical significance when compared to the Evoluent when run statistically.

Therefore, the results illustrated above do not show any statistical significance (no difference) of wrist extension angles between the DXT and the Evoluent mouse and illustrate that they are significantly the same but both less than the Standard mouse.

The above results are based on a p value of .05 and reflect that this result is not statistically significant and that the results could have occurred by chance.

Ulnar Deviation – Standard mouse vs. DXT

	Variable 1	*Variable 2*
Mean	7.5	7.857142857
Variance	45.19230769	91.20879121
Observations	14	14
Pearson Correlation	0.509207707	
Hypothesized Mean Difference	0	
df	13	
t Stat	-0.158571964	
P(T<=t) one-tail	0.43822149	
t Critical one-tail	1.770933383	
P(T<=t) two-tail	0.876442979	
t Critical two-tail	2.160368652	

When compared statistically, the Standard mouse did not reveal any statistical significance as promoting less ulnar deviated wrist postures with use than the DXT. This result also refers that ulnar deviated wrist postures were not observed to be significant in either mouse; the Standard mouse or the DXT mouse.

This is a positive result for the DXT.

The above results are based on a p value of .05 and reflect that this result is not statistically significant and that the results could have occurred by chance.

Ulnar Deviation – Standard mouse vs. Evoluent

	Variable 1	*Variable 2*
Mean	5.833333333	3.333333333
Variance	53.78787879	33.33333333
Observations	12	12
Pearson Correlation	-0.339936727	
Hypothesized Mean Difference	0	
df	11	
t Stat	0.804399667	
P(T<=t) one-tail	0.21910295	
t Critical one-tail	1.795884814	
P(T<=t) two-tail	0.438205899	
t Critical two-tail	2.200985159	

When compared statistically, the Standard mouse did not reveal any statistical significance as promoting less ulnar deviated wrist postures with use than the Evoluent. This result also refers that ulnar deviated wrist postures were not observed to be significant in either mouse; the Standard mouse or the DXT mouse.

This is a positive result for the DXT.

The above results are based on a p value of .05 and reflect that this result is not statistically significant and that the results could have occurred by chance.

Ulnar Deviation – DXT vs. Evoluent

	Variable 1	*Variable 2*
Mean	4.6875	8.4375
Variance	8.229166667	22.39583333
Observations	16	16
Pearson Correlation	0.207171967	
Hypothesized Mean Difference	0	
df	15	
t Stat	-3	
P(T<=t) one-tail	0.004486369	
t Critical one-tail	1.753050325	
P(T<=t) two-tail	0.008972737	
t Critical two-tail	2.131449536	

When compared statistically, the DXT mouse did not reveal any statistical significance as promoting less ulnar deviated wrist postures with use than the Evoluent. This result also refers that ulnar deviated wrist postures were not observed to be significant in either mouse; the DXT or the Evoluent mouse.

This is a positive result for the DXT and the Evoluent.

The above results are based on a p value of .05 and reflect that this result is not statistically significant and that the results could have occurred by chance.

Radial Deviation Mouse vs. the DXT

	Variable 1	*Variable 2*
Mean	6.428571429	2.5
Variance	36.26373626	25.96153846
Observations	14	14
Pearson Correlation	0.313375597	
Hypothesized Mean Difference	0	
df	13	
t Stat	2.241775882	
P(T<=t) one-tail	0.021528003	
t Critical one-tail	1.770933383	
P(T<=t) two-tail	0.043056006	
t Critical two-tail	2.160368652	

When compared statistically, the Standard mouse revealed statistical significance as promoting greater radial deviated wrist postures with use than the DXT.

This is a positive result for the DXT.

The above results are based on a p value of .05 and reflect that this result is statistically significant and that the results did not occur by chance.

Radial Deviation Mouse vs. Evoluent

	Variable 1	*Variable 2*
Mean	7.083333333	3.75
Variance	65.71969697	14.20454545
Observations	12	12
Pearson Correlation	0.092981359	
Hypothesized Mean Difference	0	
df	11	
t Stat	1.340118789	
P(T<=t) one-tail	0.103615587	
t Critical one-tail	1.795884814	
P(T<=t) two-tail	0.207231175	
t Critical two-tail	2.200985159	

When compared statistically, the Standard mouse did not reveal any statistical significance as promoting less radial deviated wrist postures with use than the Evoluent. This result also refers that radial deviated wrist postures were equally present in both mice; the Standard and the Evoluent mouse.

This is a negative result for the Evoluent.

The above results are based on a p value of .05 and reflect that this result is not statistically significant and that the results could have occurred by chance.

Radial Deviation DXT vs. Evoluent

	Variable 1	*Variable 2*
Mean	2.5	4
Variance	29.16666667	15.55555556
Observations	10	10
Pearson Correlation	0.521640531	
Hypothesized Mean Difference	0	
df	9	
t Stat	-1	
P(T<=t) one-tail	0.171718198	
t Critical one-tail	1.833112923	
P(T<=t) two-tail	0.343436396	
t Critical two-tail	2.262157158	

When compared statistically, the DXT mouse did not reveal any statistical significance as promoting less radial deviated wrist postures with use than the Evoluent. This result also refers that radial deviated wrist postures were equally present at the same degree in both mice; the DXT and the Evoluent mouse.

Although the Mean above shows less of an effect than the Evoluent (2.5 – 4) when compared statistically, the result was not significant to show that one mouse had greater or less radial deviation with regards to wrist postures.

The above results are based on a p value of .05 and reflect that this result is not statistically significant and that the results could have occurred by chance.

Study I Qualitative Data Analysis

DXT Mouse- Interview Questions

Initial/ Standard Mouse Questionnaire (First Visit)

During the first visit with each participant the ergonomists performed a verbal interview and recorded the results by hand. Employees were encouraged to discuss each topic in question, and prompted for more detail when necessary. The questions addressed in this interview included:

Initial Interview Questionnaire
1. Height: 2. Gender: 3. Job Title: 4. Keyboard type: 5. How many hours each day do you spend on the computer? 6. Have you ever had any ergonomic training or an ergonomic evaluation? 7. What types of applications do you perform? 8. Do you feel comfortable using your current mouse? 9. Do you currently experience any discomfort with your current mouse? 10. Have you ever performed mousing tasks with your non-dominant hand? 11. Have you ever used a non-standard mouse or "ergonomic" mouse? 12. Additional Comments:

A summary of the information collected from the participants is included in the following paragraphs:

Qualitative Responses Use Study I

This study included a total of 16 participants; 12 women and 4 men. Their heights ranged from 5'0" to 6'4", the average height being 5'5", and the median height being 5'4". Each participant reported their height verbally, and no actual height measurements took place during this study.

Participants were randomly selected from the sponsor company site. Some examples of participants' job titles are: Accounts Payable Coordinator, Senior Human Resources Manager, IT Manager, Administrative Assistant, Sr. Stock and Payroll Administrator, International Marketing Specialist, Technical Support Associate, Clinical Research Associate, Director of Clinical Operations, and Executive Directly or Engineering and Clinical Packaging.

Prior to this usability study, all users were performing mousing tasks with a standard horizontal mouse. With regards to keyboard design, four users were using Goldtouch adjustable ergonomic keyboards (without a numeric 10-key pad), three were using other ergonomic keyboards with inclusive number pads (Microsoft Natural or Microsoft Fixed- split), and the remainder of the participants were typing on standard linear QWERTY keyboard with inclusive number pads.

They reported spending an average of 6.75 hours per day performing computer related tasks at their workstation. Eleven participants related receiving some sort of ergonomic training in the past (either in the form of a one-on-one evaluation or a training class). However, most employees who had received training related that their ergonomic training took place at a previous company or workstation over two years ago.

Due to the variety of job titles of the participants, each employee used a variety of applications. However, most users in the Finance department (four employees) performed numeric intensive tasks mostly in Microsoft Excel. Most other users related that they utilized a combination of Microsoft Excel, Word and PowerPoint and email programs.

With regards to comfort with their current mouse, five users reported experiencing physical discomfort when performing computer related tasks before the usability study began. We asked employees to provide additional details regarding their "likes and dislikes" of their current mouse. Some responses included:

- "It does what I need it to do"
- "It's fine, I'm just used to it"
- I'm just using what was given to me [when I started]
- I never really thought about it
- It's comfortable and does everything it needs to do
- Smoother and accurate
- It's wireless and easy to use
- It's a good weight (wireless mouse)
- Not really fond of it. The cord gets in the way.
- Not particularly comfortable, but I am not having any pain

Of the sixteen participants, one was left hand dominant, and fifteen were right hand dominant. Only one employee related that she intermittently used her non-dominant hand for mousing, the rest of the subjects performed mousing tasks with only their dominant (in most cases right) hand. One additional employee related that she had attempted to utilize her non-dominant hand for mousing, but was unsuccessful and returned to solely dominant hand use.

None of the participants had ever used either of the mice (DXT or Evoluent) used in this study. When asked if they had used any alternate mouse designs, three participants reported using a trackball in the past, one reported using a touchpad, and one reported using a "Logitech Ergonomic Mouse" (but could not recollect the specific model).

DXT Questionnaire after Use

After using the DXT with the right hand for one week and then using the DXT with the left hand for one week the ergonomists provided each employee with the following Questionnaire.
The questions included:

DXT Exit Interview Questionnaire
1. Did you like the DXT mouse? 2. Did you like the shape/design? 3. Do you have any comments on the way it looks? 4. How useful was the DXT in enabling you to use better "mousing" postures as compared to your standard mouse? 5. If you had discomfort using your standard mouse to what extent did you perceive a decrease in discomfort with the use of the DXT mouse? 6. Did you prefer the DXT mouse over your standard mouse? 7. Please explain the reason for your preference. 8. Did you find that your accuracy increased with use of the DXT mouse? 9. Was the DXT comfortable to use with both hands? 10. Was the DXT easy to use with your non-dominant hand? 11. Do you have any comments on the way it feels in your hand? 12. How likely are you to continue to use the DXT over your standard mouse? 13. Additional Comments

Some comments included:

- It looks fine, but it needs to be larger
- It's "cute"
- This would make a great travel mouse
- I would like it better if it was cordless
- It was comfortable in my hand, but a little too light
- The design looks very "techy"
- It looks futuristic, like Star trek

While the majority of participants did not report experienced discomfort when using their standard mouse at the start of this study, employees related on average that their discomfort

using the DXT mouse was "slightly worse" than with their standard mouse. Additionally, the DXT mouse received an average rating of "slightly worse preference" in relation to participant's standard mouse. However, when asked to elaborate on their preference, responses included:

- "I love it!"
- "It's little, just like my wrist"
- The vertical position eases the twisting feeling in my wrist
- Lighter weight, and less stress on my hand when I use it a lot
- DXT is too small for my hand, but I like the upright [vertical] design
- I felt that I was less productive with the DXT
- The scroll wheel placement was not comfortable for my hand
- I repeatedly knocked the [DXT] mouse off of my keyboard tray- It's too high

**Employees who worked intensively in Excel related that the accuracy increased with DXT use.

Since each participant used the DXT in his or her non-dominant hand during the second week of testing, we inquired if the DXT was comfortable to use in both hand. The average rating was 2.2, or "slightly comfortable". However, the average rating for "Was the DXT easy to use with your dominant hand" was slightly higher- ranking 2.4 out of 5. This translates to between "slightly easy" and "moderately easy".

Participants listed comments on how the DXT mouse felt in their hand during use. Some comments are below:

- The mouse was fairly comfortable in my hand with regards to the natural positioning of my wrist
- It was too small so it was not a comfortable grip in my hand
- Way too small
- It felt too small
- The DXT is a little small
- It felt strange
- I felt tension in the "web" between my thumb and pointer finger
- Would be better if the buttons and scroll wheel were in the correct place for my hand

Each participant was asked how likely they were to use the DXT mouse over their standard mouse after this study.

Additional comments collected (both verbally and on the hardcopy questionnaire) included:

- I think this mouse would be great if the person is ambidextrous, but the location of the wire seems to pose problems.
- **Post Note:** I have now gone back to my old mouse and I have to say this mouse [DXT] is more comfortable in my hand than I realized
- I prefer a more substantial mouse- this one is just too light
- The cursor jumped around a lot but it could be the way I was holding it?
- I would definitely use this if it was wireless, probably for travel or laptop use

Study II Qualitative Data Analysis

STUDY II Qualitative Research Question Results:

The second study comprised of 17 total subjects interviewed the subjects using the same questions used in the Study I.

STUDY II subjects (n = 17) consistently used precision based programs such as EXCEL, OUTLOOK, CAD, REVIT and WORD.

Study II Qualitative Results Group 1 (11 participants):

The 11 participants in Study II Group One were located at one test site and predominantly used MS Office tools such as EXCEL, OUTLOOK, CAD and REVIT design programs. Although used, WORD programs were used approximately 10% of the time in their work.

All participants were right handed.

- 9 of the 11 participants chose the DXT mouse as their favorite mouse over their standard and the Evoluent mice.
- 1 participant did not like either mouse and chose to stay with his Microsoft mouse
- 1 participant chose to go with the Evoluent mouse
- All users related that they wished that it was cordless
- All 9 of the 11 participants chose to keep and use the DXT mouse after the study was completed.
- Please note: these participants used CAD/REVIT/EXCEL programs almost exclusively and enjoyed the precision afforded by the DXT mouse.

Study II Qualitative Results Group 2- Random Sample (6 participants):

The other 6 participants in Study II were located at four different test sites and predominantly used MS Office tools such as WORD, EXCEL and OUTLOOK Email programs. All participants were right handed.

- 5 of the 6 participants chose the DXT for overall comfort, accuracy and precision in addition to enjoying the small compact design over the Evoluent and their standard mouse.
- 3 of the 6 did not like the placement of the cord and preferred it to be cordless

- 2 of the 6 participants chose the Evoluent over the DXT. The reasoning behind this was that he preferred the placement of the scroll wheel on the Evoluent as opposed to the DXT mouse. It is important to note that both of these participants were large sized men with large muscular hands. They both rely heavily on the scroll wheel function for their work tasks.

Study II Qualitative Comments:

Q1 & Q6 & Q12
12 of the 17 subjects or 70% of the subjects who participated in the second study chose to continue using the DXT mouse over their standard mouse designs.
One participant chose to use the Evoluent and two others declined to use either the DXT or the Evoluent vertical mouse designs and chose to stay with their standard mouse.

Q2
Of the 13 participants who chose to keep the DXT mouse after the conclusion of the study, all of them liked the shape and design with the exception of three. Negative comments regarding the position of the scroll wheel and the wire are described on the following page.

Q3
Of the 17 subjects who used the DXT mouse, 14 of the 17 related that they felt more comfortable using the DXT over the standard mouse. Two users who had significant discomfort levels experienced at their mousing hand/wrist (right) at the onset of the study, experienced a decrease in discomfort at their affected regions after use of the DXT in less than one week.

Q8
14 of the 17 participants related that their accuracy and precision increased with use of the DXT compared to standard mouse use.

Study II Positive Qualitative Comments

“I love how small and compact it is making it so easy to use”

“I liked how there was no software to download like the Evoluent mouse that made me set up the buttons. I don’t want to hassle with this I just want to plug my mouse in and use it.”

“It seems as accurate as my other mouse. “

“My hand doesn’t hurt when I use the DXT mouse”

“It is so cute”

“I like how it does not require much surface area to operate”

"It is lightweight and fits easily into my laptop bag for travel"

"I love how it can be easily made for left and right hand use"

"I like how quickly it responds with my work (EXCEL & CAD) tasks"

"It feels very precise"

"Fine motor movements feel easy"

Study II Negative Qualitative Comments:

"Needs to be wireless"

"I scotch taped the cord to the back so it would not interfere with what I was working on"

"Maybe a convex design would be better than a concave design?"

"A thumb button would be nice"

"The scroll wheel is too far down; it should be placed further up"

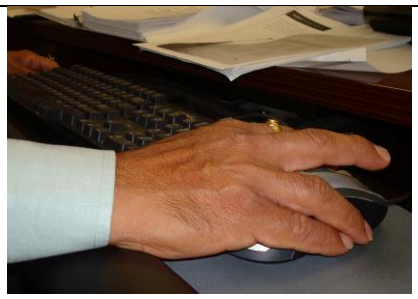
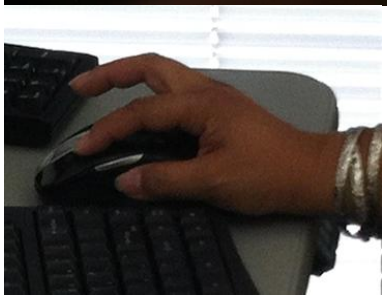
"I knocked it over a few times on the desk before I got used to how lightweight it is"

Photograph Documentation

Standard Mouse Use


Standard Mouse- Wrist Extension and Contact Stress
 

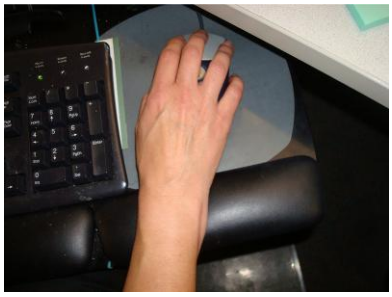
Standard Mouse- Hovering fingers over buttons

Standard Mouse- Ulnar Deviation



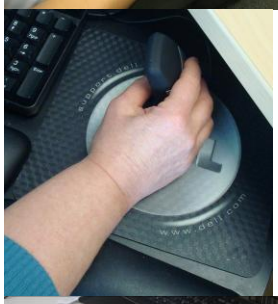
Standard Mouse- Contact Stress

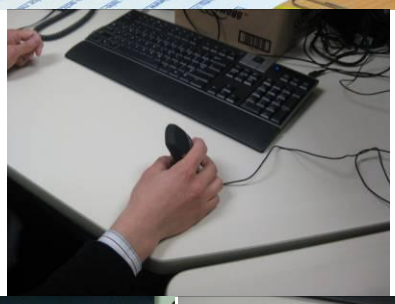
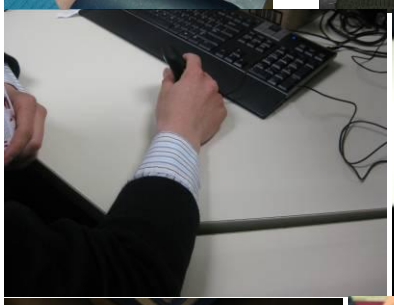


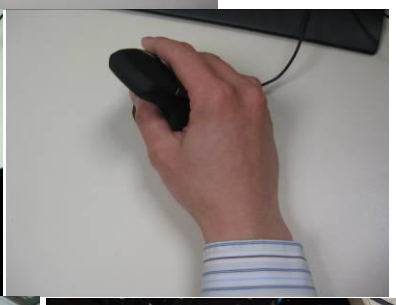
DXT Mouse Use- Dominant Hand (Right)

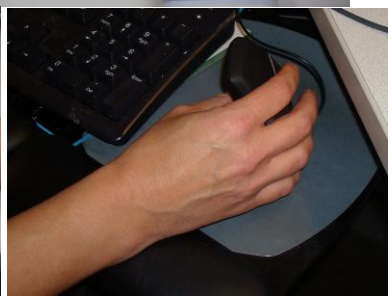
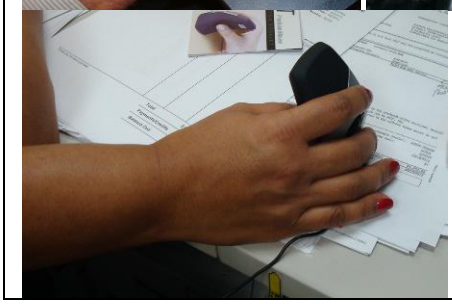
Using Precision Grip- good posture

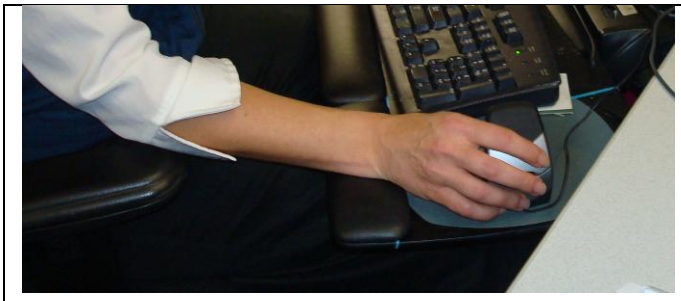




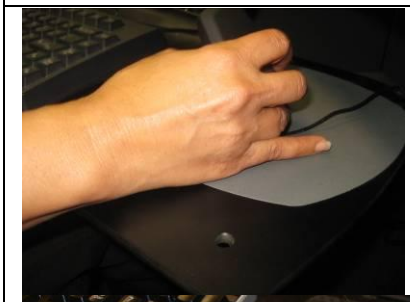



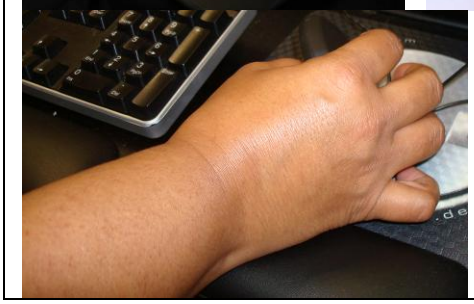


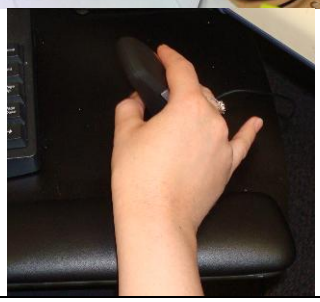




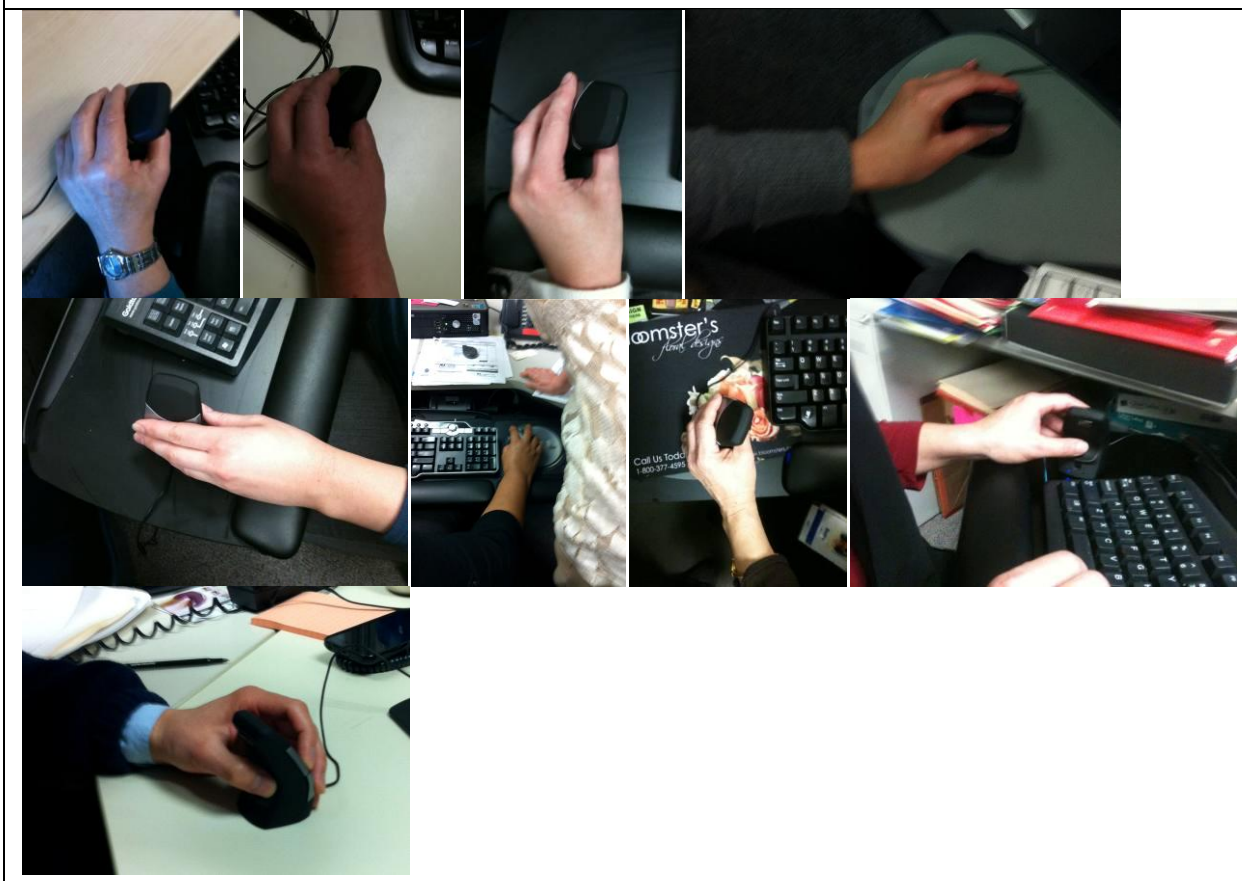


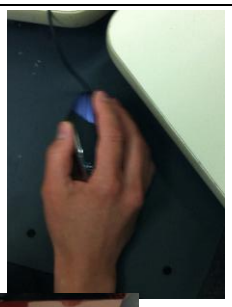
DXT Mouse- “Anchoring”

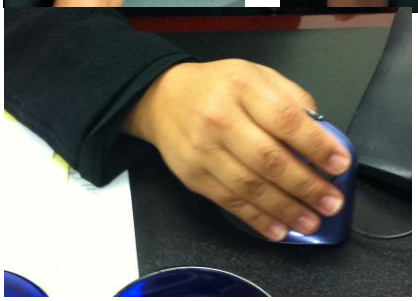






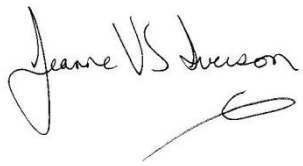
DXT Mouse Use- Non-Dominant Hand (Left)

DXT Mouse - Wrist Extension on keyboard tray
n 
Evoluent Mouse - “Manhandle” & Wrist Extension





Signatures of Professional Consultants

This Use Study for City Ergonomics Ltd. was developed by:



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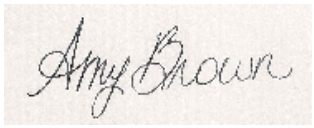

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