City Ergonomics

The use of Precision Handling in the development of an efficient pointing device

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Introduction

This white paper summarises the outcome of a usability study (Iverson, 2013) carried out on a new form of computer mouse which was designed to take advantage of a form of grip referred to as precision handling (Landsmeer,1962).

The designers of the mouse, a Physical Therapist and an Ergonomist were receiving negative comments from users of a whole handed vertical form of computer mouse concerning accuracy, precision and speed.

Observation of the users made it clear that the main difficulties arose during final target entry of the cursor during computer tasks.

A literature review of the human hand with respect to its ability to hold and manipulate objects was completed which revealed that the scientific literature has been indicating for nearly 20 years that the shape and size of computer input devices should take advantage of the fine motor control offered by the index finger and thumb for their operation (Zhai et al 1996).

The rationale for this suggestion is that the small muscle groups and joints in the fingers and hand, particularly the index finger and thumb, are densely represented in the human motor and sensory cortex and have higher information processing abilities than other body parts (Ullman et al 2003).

Long (Long et al 1970) established that there is a specific form of grip that utilises the small muscle groups in the hand and fingers thus taking advantage of the higher information processing abilities afforded to them. The form of grip is termed precision handling as described by Landsmeer (1962) which takes place between the pads of the thumb and fingers separating it from the two other forms of grip which are power and pinch.

The use of precision handling – i.e. the ability for the mouse to be manipulated by the thumb and index finger, the need to maintain neutral hand posture and for the mouse to be used in either hand became the three primary design objectives of the mouse.

The key objectives of the study (Iverson, 2013) were to explore the impact of the design objectives relating to both dominant and non dominant hand usage of the mouse.

Methods

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 (n=16) and span for slightly over two weeks for Study II (n=17). The DXT precision handling form of vertical mouse and a vertical whole handed from of mouse were used in comparison with the standard horizontal mouse design.

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.

The first and second independent studies 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.

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 whole handed vertical mouse for the duration of one week

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, whole handed vertical mouse) 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 whole handed vertical mouse, and the standard horizontal mouse (further referred to as standard mouse).

Criteria of the 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 whole handed 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.

Results

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

Quantitative Test Results

- In study 1 and study 2 the results demonstrated that at commencement of use in terms of accuracy and precision DXT was not as accurate or precise as a standard mouse but at the end of five days use the DXT was as fast and getting faster (see Appendices tables 1-4)
- In study 1 and study 2 the results demonstrated that at commencement of use in terms of accuracy and precision the whole handed vertical mouse became slower in terms of accuracy and speed than a standard mouse (see Appendices tables 5-8)
- In study 1 and study 2 the results demonstrated that the DXT mouse is faster than the whole handed vertical mouse in terms of accuracy and precision (see Appendices tables 9-10)
- In study 1 it was demonstrated that upon initial use in the non dominant hand the DXT mouse was not as fast in terms of accuracy and precision as compared to the use of a standard mouse in the dominant hand but was getting faster (see Appendices tables 11-13)

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 whole handed vertical 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:

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 whole handed vertical 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 whole handed vertical mouse.
- Wrist Ulnar Deviation - the DXT mouse did not reveal any statistical significance as promoting less ulnar deviated wrist postures with use than the whole handed vertical mouse 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 whole handed vertical mouse 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 whole handed vertical mouse are the same with regards to palmar thumb abduction.
- Pronation- the DXT and the whole handed vertical mouse equally afford a more relaxed hand posture with mousing tasks due to a less pronated wrist angle

Qualitative Test Results

Participants from both study groups related that their accuracy and precision increased with use of the DXT compared to standard mouse use – particularly the participants who worked intensively in Excel.

Positive noted behaviours 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.

Discussion

It is important to consider that both the DXT mouse and the whole handed vertical mouse 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.

The DXT mouse not only demonstrated greater accuracy and precision than a popular whole handed vertical mouse but it also demonstrated greater accuracy and precision than a standard mouse design.

This is an interesting outcome as MacKenzie et al (2001)who developed accuracy measures for discriminating between computer pointing devices demonstrated that a standard mouse outperformed track balls, touch pads and an upright form of whole handed mouse (joystick) in terms of accuracy and throughput.

A possible explanation for the DXT mouse outperforming a whole handed vertical mouse is that while the DXT mouse and a standard mouse share the ability to utilise precision handling the DXT avoids excessive pronated postures of the wrist and forearm seen in the standard mouse.

The neutral posture of the forearm and wrist utilised by the DXT mouse may well enhance precision handling reinforcing the major aim of pointing device research which is to develop devices that are as efficient as possible (MacKenzie et al 2001).

The outcome from this study indicates that there is a minimal learning curve with the DXT Mouse design as opposed to the whole handed vertical mouse with regards to accuracy and precision and that the DXT mouse design provides greater accuracy and precision than the whole handed vertical mouse.

In addition the DXT mouse also demonstrated that only after a few hours of non dominant hand use accuracy and precision were improving and getting faster which offers opportunities for the prevention and rehabilitation of work related upper limb disorders in display screen users.

Conclusions

One of the goals of the independent study was to determine whether precision handling would enhance the performance of a computer pointing device.

The results related to performance illustrated that a positive effect was seen on performance while maintaining neutral postures.

This improvement posed an interesting question regarding the influencers of mouse performance. The postural data showed that DXT mouse and whole handed vertical mouse users were working with less pronated wrist and forearm postures than when using a standard mouse. The difference between DXT mouse and whole handed vertical mouse users is that DXT users can carry out unrestricted manipulation as the mouse DXT mouse does not occupy the palm.

The primary focus for ergonomic mice has been around whole handed forms of grip but it appears that the overall effect of this approach has been to reduce performance.

A constant concern with the introduction of alternative mice from a company and employee perspective is the level of acceptance of the users and any potential impact on performance.

The performance data illustrated that the performance of the users could be maintained and, indeed improved upon as they transitioned to the new form of mouse.

The effect of such impact on productivity cannot be ignored when selecting alternatives to the standard mouse.

Due to the compact design of the DXT, and according to comments by users from Studies I & II, described within the main report (Iverson, 2013) the user may utilise 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. Employees may, therefore, 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.

The easy adaption to left handed use carries significant implications for the prevention and rehabilitation of upper limb disorders whereby the mouse is used in the opposite hand before symptom aggravation occurs in within the affected limb

The results of this study provide positive information on the value and use of precision handling of pointing devices as an ergonomic solution in the office environment.

References

- Iverson, J ; (2013) The DXT Vertical Mouse A Usability Study Evaluating Qualitative, Quantitative, and Functionality of Design VSI Risk Management & Ergonomics Inc. Placerville, California 95667

- Landsmeer, J. M. F (1962) Power Grip and Precision Handling. Ann.Rheumhatism. Dis., 21: 164-170.

- Ullman, J et al (2003) A new Approach to the Mouse Arm Syndrome. International Journal of Occupational Safety and Ergonomics; 9, 4 : 463-477

- MacKenzie, I. S., Kauppinen, T., & Silfverberg, M. (2001). Accuracy measures for evaluating computer pointing devices. Proceedings of the ACM Conference on Human Factors in Computing Systems – CHI 2001, pp. 9-16. New York: ACM.

- Zhai S, Milgram P, Buxton W. (1996) The Influence of Muscle Groups on Performance of Multiple Degree-of-Freedom Input - CHI http://www.sigchi.org/chi96/proceedings/papers/Zhai/sz_txt.htm

- Long C; Conrad P. W; Hall E. A.; Furler S. L. (1970) Intrinsic-Extrinsic Muscle Control of the Hand in Power Grip and Precision Handling AN ELECTROMYOGRAPHIC STUDY, J Bone Joint Surg Am, Jul 01;52(5):853-867

Appendices

Table 1 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

Table 2 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

Table 3 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.

Table 4 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.

Table 5 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.

Table 6 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.

Table 7 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.

Table 8 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.

Table 9 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.

Table 10 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.

Table 11 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.

Table 12 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

Table 13 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.