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TOUCHSCREEN USE AMONG GEOSCIENTISTS: PERCEPTIONS OF COMFORT, TASK PRODUCTIVITY, AND TASK SATISFACTION

by

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Dedication

My sincere love and thanks to my family for their support and encouragement. Without them I would not have been able to take this journey.

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ABSTRACT

TOUCHSCREEN USE AMONG GEOSCIENTISTS: PERCEPTIONS OF COMFORT, TASK PRODUCTIVITY, AND TASK SATISFACTION

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Touchscreen use among geoscientists at larger oil and gas companies has been on the rise in the past several years. The investment in this technology is high and the benefits have yet to be confirmed. It is imperative to know whether geoscientists see a reduction in their ergonomic symptoms while experiencing an increase in task productivity and task satisfaction. A group of single touchscreen plus single non-touch display users were compared against a group of dual non-touch display users to see how they relate in all three areas: perceived discomfort, task productivity, and task satisfaction. In addition, the participant's past ergonomic discomfort was taken into consideration to see if symptoms have improved, worsened, or were transferred to another body part. The aspects of their work that were evaluated and recorded including postures, equipment type, perceived task productivity levels, perceived task satisfaction, and current and previous discomfort levels. The finding supported productivity being positively affected by touchscreen use, while speed was supported at a lesser level. Discomfort was an issue due to poor historical data causing analysis issues and no real significance was found. Overall, doing

research in an uncontrolled environment caused several more confounding variables than expected that impacted the veracity of this research. In conclusion, it was found that there were enough significant differences in perceived productivity between the groups to warrant further research in this area, but any future research needs to be conducted in a controlled environment.

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CHAPTER 1: INTRODUCTION

Background

To better understand exploration geoscientists, one must come to terms with the fact that they are essentially storytellers. They tell the story of what is going on beneath the earth as it applies to the exploration for new oil and gas reservoirs. To that end, they spend a great deal of time on computers creating visual stories through applications designed for the oil and gas industry as well as commonly used presentation software (Lidal, Hauser, & Viola, et al, 2012). Some of the specialized software programs used to tell these stories are Petrel®, ArcGIS®, and Voxel Geo®, among many others. Of all of these applications, Petrel® is the most click intensive and is widely used for seismic interpretation and geologic modeling of reservoirs.

Nearly 75% of workers in the United States have deskbound, or other sedentary occupations, with about 35% of these employees reporting back and neck pain. Specifically in computer workers, neck discomfort accounts for about 33% of reports (Babski-Reeves, Stanfield, & Hughes, 2005). These numbers do not reflect exactly what types of jobs or what technologies are used, but do point out that there is high postural risk with associated Musculoskeletal Disorders (MSDs) in office work. In the Netherlands Ariëns, van Mechelen, Bongers, Bouter, & van der Wal, 2000 examined risk factors including physical, psychosocial, and individual group issues. The research concluded that the physical symptoms of concern were postural risks including neck flexion, extension, rotation, and non-neutral arm postures. Additional factors related to MSD symptoms in the neck and upper arms include exposure to repetitive activities, awkward postures, time pressures, and stressful workloads (Janwantanakul, Pensri, Jiamjarasrangsri & Sinsongsook, 2008). Over-commitment at work can cause discomfort in the neck and shoulder by a repeated activation of the low-threshold motor units of certain muscles after continual activity (Joksimovic, Starke, Knesebeck, &Siegrist, 2002). To combat some of these issues, physical variation in work tasks and reduction in the sedentary nature of computer work have been found to be essential (Jules-Kristensen, 2005). Those workers who varied tasks and spent only 75% of their day at the computer experienced a reduction in discomfort ranging from 39% in the neck and shoulders to 51% in the elbow, lower arm, and hand. Work area environment and workstation design were also noted as contributors to neck problems (Karhonen, Ketola, Toivenonen, Luukkonen, Häkkänen, & Viikari-Juntara, 2003).

Despite efforts to educate employees on the importance of taking breaks, varying tasks, and moving around, the typical geoscientist spends a great deal of time at their workstation on a single task, rarely varying postures or taking breaks. Geoscientists have very high mouse usage and lower keyboard usage (M. Parker, personal communication, August 21, 2015). Both keyboarding and mousing have been shown to be correlated to increases in MSD risks including Carpal Tunnel Syndrome and tendinitis, brought on by awkward postures including wrist pronation and extension, ulnar deviation, and contact stress when using both the keyboard and mouse (Cook, Burgess-Limerick, & Papalia, 2004).

Such risks have led to an increased interest in alternative options to mousing for geoscientists. Once this risk was acknowledged, touchscreen use began to proliferate in the user community. Touchscreens are recommended and used as a reactive tool given to injured employees, typically geoscientists, in the hope that their use would reduce the employee's discomfort and increase their productivity. On rare occasions, touchscreens have been deployed prior to discomfort, but this is a rare occurrence.   (M. Parker, personal communication, August 21, 2015).

The Study

The hope of this research was to be able to create a case for the more widespread use of touchscreens for geoscientists and other high risk job families as a tool to prevent illnesses and injuries while increasing task productivity and task satisfaction rather than as tool to assist in mitigating existing discomfort or pain as it is typically applied. It is important for companies to understand that it is to their advantage, both monetarily and from a human perspective, to provide the tools and education required to reduce or prevent musculoskeletal disorders, injuries, and illnesses of their workforce rather than to attempt to heal a person once they have been injured (Goldberg, 2015). If a person is hired with an ergonomic issue or develops one after employment, it is incumbent upon a company to have every tool and resource at their convenience to quickly and effectively mitigate any further injury to that individual. Touchscreens could be a powerful tool in a company's arsenal.

CHAPTER II: REVIEW OF LITERATURE

Peripherals and MSD Risks

Mousing is the most common input activity of geoscientists and seems to be the activity that most commonly exacerbates existing or triggers new discomfort (M. Parker, personal communication, August 21, 2015). Mousing activities corresponded with increased muscle activity in the upper extremities along with an increase in exertion and force (Visser, de Looze, De Graff, & van Dienn, 2004). The demand for precision in highly detailed work and the associated mental stress in completing these tasks is factor for continued mouse use. Overall, workers who use a mouse for long periods of time may be at a much greater exposure level for getting an MSD than those that do not use the mouse as long (Keir, Bach, & Rempel, 1999). An example of the mouse being preferred over newer input device is the 3D SpaceNavigator®. This input device was provided to geoscientists, as a tool to reduce mouse clicking for geologic modelers who work with 3D models. This device was designed specifically to deal with manipulating models in 3D space and was ideally suited for the given tasks. Geoscientists were unable to adapt to device and went back to using mice (M. Parker, personal communication, May 2015). While specific devices have been created to manipulate 3D computer environments, such as the 3D SpaceNavigator® and other similar devices, mice continue to be the tool of choice for those that manipulate 3D renderings (Bérard, Ip, Benovov, El-Shimy, Blum & Cooperstock, 2009).

While keyboard use may be less of a MSD risk for geoscientists, it may be a contributing factor. Supporting the forearms takes the pressure off of the shoulders appears to increase comfort as well as reduce muscle load on the shoulders and neck while reducing extreme wrist deviation (Cook, et al, 2004). Another MSD related concern of the keyboard is the force users apply to the keys. Factors to be considered are prolonged exertion, forceful exertion, non-neutral postures, and mechanical stress. It has been noted that many who are not touch typists tend to compensate for it by hitting the keys with more force than is needed, increasing their ergonomic risk. Many of the mechanical stresses that cause upper arm problems have been mitigated by the extremely adjustable workstations upon which the keyboard and mouse lie (Armstrong, Foulke, Martin, Gerson, & Rempel, 1994).

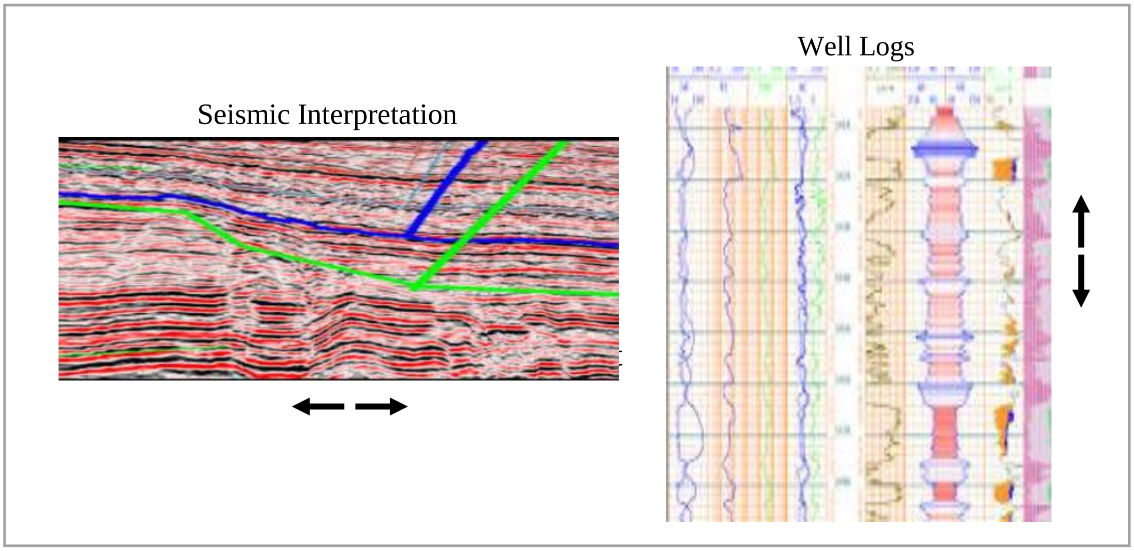
Dual Displays

Multiple display workstation configurations are becoming more common. (Hutchings, Czerwinski, Meyers, & Stasko, 2015). Dual displays have been shown to increase productivity by reducing or combining task steps, such as window minimizing and reduced clicking (Russell & Wong, 2005). Users of dual displays tend not to stretch a single screen across both displays, but rather have two different applications open at the same time on different displays. Many users are inclined to use one display as a primary display, for example, keeping e-mail open (Hutchings, et al, 2004). For geoscientists the advantage is the ability to display multiple sources of information simultaneously for mapping or seismic interpretation. Another advantage noted is that one display can be rotated to a portrait position so that well logs can be read more easily while the other display remains in the standard landscape position as the working display (Figure 2.1).

As geoscientist commonly utilize these input modalities risk levels rise due to prolonged exertion based on hours of continual computer work without sufficient breaks.

Figure 2.1

Screen Needs Horizontal vs. Vertical



Touchscreens

Touchscreen present a unique option whose advantage is that it acts as both the display and input device. This ability reduces the need for extra devices and associated space needs. They are very intuitive to use (Albinsson & Zhai, 2003), reduce discomfort and improve task productivity (Bartha, Meigast, Purvis, Kokot, & Allie, 2013). Newer touchscreens are highly adjustable and allow for a wide range of positions to best accommodate a neutral posture (Bartha, et al, 2013).

However, the screen can be obstructed by the user's body, specifically the upper extremities. While the human finger is not the best for pointing at targets with great precision (Albinsson & Zhai, 2003; Holzinger, 2003), a stylus can ameliorate this limitation. Another limitation is that positioning the touchscreen can be difficult. Improper position and adjustment can cause muscle fatigue as well as increasing exposure to MSDs and degraded interaction with the device itself (Barbé, Mollard, & Wolff, 2014).

Touchscreen use among geoscientists has been increasing over the last several years. Increases in touchscreen investments have been made at one company in an attempt to reduce MSDs related to increased rates of mild to severe symptoms, including tingling and numbness of the arms and hands (M. Parker, Personal Communication, August 21, 2015). In the oil and gas industry, 40% of lost time incidents can be attributed to MSDs (Peres, Kortum, Muddimer, Akladios, & Napit, 2011). Geoscientists typically spend long hours at the computer with tight deadlines. Peres, et al demonstrated (2011) that cycles of "binge computing", defined as working longer than normal hours with great intensity while taking few breaks, contribute to increased risk among geoscientists and is commonly done in advance of deadlines, bid cycles, and management reviews.

Geoscientists typically have accessibility to a wide variety of mice and keyboards ranging from typical designs to those more unusual in design. Speech recognition software is also used in conjunction with mice and keyboards. All of this variety is a method to find the technology or combination of technologies that provide the best options for users (M. Parker, personal communication, August 21, 2015). Duey, (2010) contends that touchscreens are ideal for seismic interpretation allowing a user to pick up a stylus or use their fingers to interpret directly on screen with a single smooth movement rather than with a multitude of individual mouse clicks.

Beevis (2003) noted that the investment in technology without any substantial analysis of its purported benefits is typical for most companies. As long as organizations see an improvement in the health of their workforce, they assume all the parts involved in this improvement are working. While ergonomic benefits can be documented, but it may be hard to tie these benefits to specific interventions such as workstation adjustments and new equipment. (Demure, et al. 2000)

If the proper positioning of, training in, and increasing use of touchscreens can provide neutral upper body and arm postures while reducing repetitive activities, a reduction in new and pre-existing musculoskeletal issues should be evident for geoscientists. The use of touchscreens as a mitigation tool before symptoms begin will reduce their use as a reactive tool.

To validate this assumption, it is necessary to understand how geoscientists use touchscreens, what postures they adopt naturally, what additional training may be required, and what, if any, discomfort they are experiencing. Additionally, it is necessary to determine if the touchscreen equipped geoscientists feel more productive and have a higher level of task satisfaction than non-touchscreen equipped geoscientists. Conversely, if touchscreens do not reduce ergonomic risks while increasing task productivity and task satisfaction, it might prompt further exploration toward a more beneficial solution.

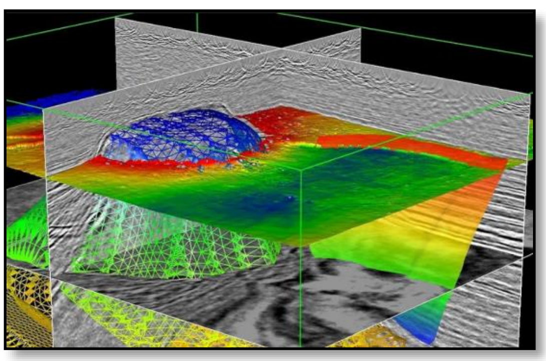
Common Geological Tasks

A brief explanation of a few the geological tasks the researchers are interested in are warranted to provide a basic understanding of what geoscientist do on a regular basis.

Seismic interpretation is the "understanding of the subsurface geological formations from seismic data which is collected during the extraction process. The drilling team can also use the seismic data to interpret the structural models beneath the earth's surface" (www.petropedia.com, 2017).

Figure 2.2

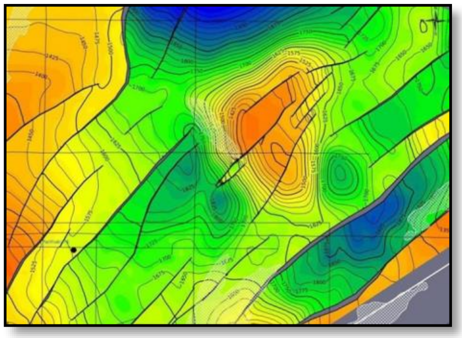
Example of Seismic Interpretation (www.google.com)



A base map is "created using geological theory and field observations of geologists. It is the starting point for prediction, especially in exploration geology" (Marjoribanks, 2010).

Figure 2.3

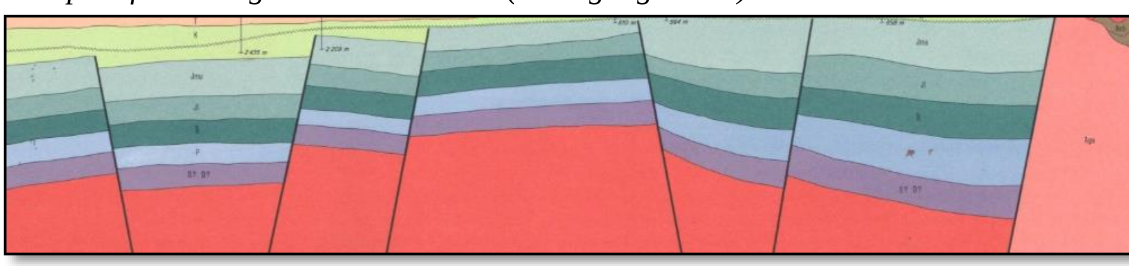
Example of a Base Map (www.google.com)



A geological cross section is "an interpretation of a vertical section through the Earth's surface, usually a profile, for which evidence was obtained by geologic and geophysical techniques or from a geologic map" (www. Encylopedia.com).

Figure 2.4

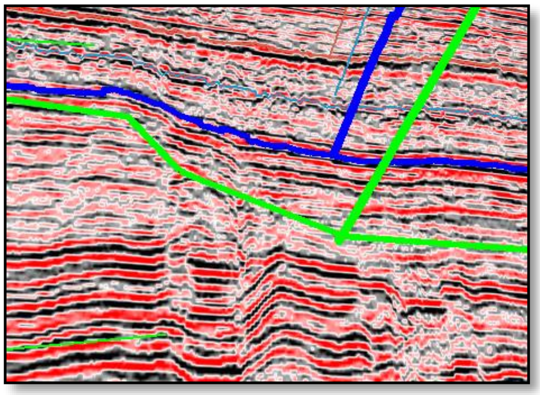
Example of a Geological Cross Section (www.google.com)



A geological horizon (in horizon picking) can be defined as "surface in or of rock, or a distinctive layer of rock that might be represented by a reflection in seismic data" (http://www.glossary.oilfield.slb.com, 2017).

Figure 2.5

Example of a Geological Horizon as Part of Horizon Picking (www.google.com)

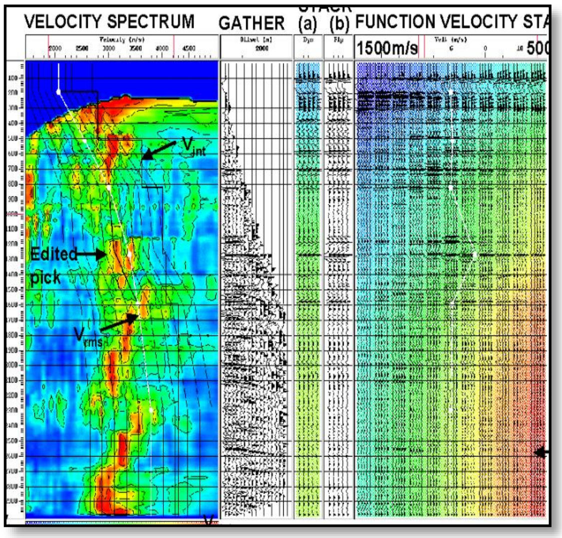


Velocity picking, or velocity analysis is "the process of calculating seismic velocity, typically by using common midpoint data, in order to better process seismic data. Successful stacking, time migration and depth migration all require proper velocity inputs. Velocity or stacking velocity can be calculated from normal moveout, or the change in arrival time produced by source-receiver offset".

(http://www.glossary.oilfield.slb.com, 2017)

Figure 2.6

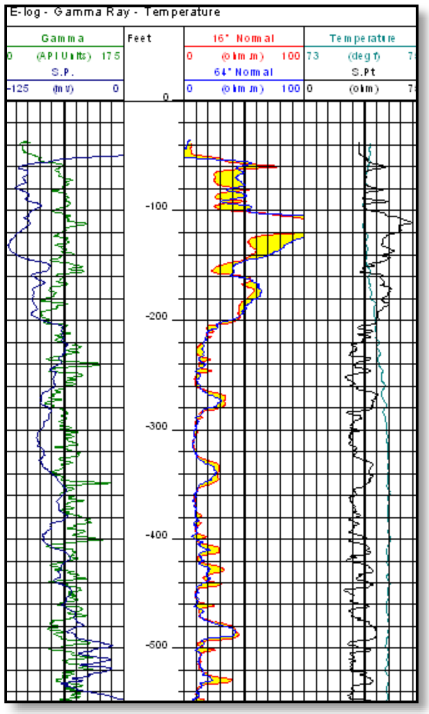
Example of Velocity Picking (www.google.com)



Crain's Petrophysical Handbook defines a well log as "a record displayed on a graph with the measured physical property of the rock on one axis and depth (distance from a near-surface reference) on the other axis. More than one property may be displayed on the same graph**."** (https://www.spec2000.net/01-whatisalog.htm. 2017)

Figure 2.7

Example of a Well Log (www.google.com)



CHAPTER III: METHODOLOGY

Participants

Thirty five (35) geoscientists participated in this research. Fifty six percent (56%) were male and 44% were female. Participants were of multiple ethnicities, and ranged in age from early twenties to mid-sixties, *m* = 30 – 39 age group, were across a range of career levels, and whose educational levels ranged from B.S. to PhD. Four participants were excluded from this study because they either had a display configuration or display/touchscreen configuration that was outside the boundaries of this study. In all four cases, their configuration was not clearly defined during the screening process and the discrepancies were identified at the interview leaving 35 active participants. An additional participant was disqualified during the interview process as the researchers found that this participant only used the touchscreen as a display and was unable to answer any of the interview questions about its use.

Participants were solicited in advance of the study based solely on whether they were geoscientists using dual non-touch displays or geoscientists using a Wacom Cintiq® Touchscreen plus one 30" non-touch display. They were recruited in person or by email. Geoscientists with differing display configurations were excluded. For all participants, historical Certified Professional Ergonomist (CPE) evaluation records were researched and any discomfort prior to the implementation of either the second non-touch display or the touchscreen was captured.

There was a low population, and an uneven number of participants in each group with there being more in the Dual Group than the TS+ group. In this study setting, it was not unexpected that there be a larger population of dual display users than non-touch display + touchscreen users from which to solicit volunteers. Demographically, in both groups, more participants were in the 31- 40 age range (Figure 3.1) and there were more female participants using touchscreens (Figure 3.2). Neither of these demographics affected the results of this study, but are documented to provide a clearer understanding of diversity of the participant pool. Also, this was a non-random sampling as volunteers had to be sought from a limited pool of geoscientists.

Figure 3.1

Demographics by Age

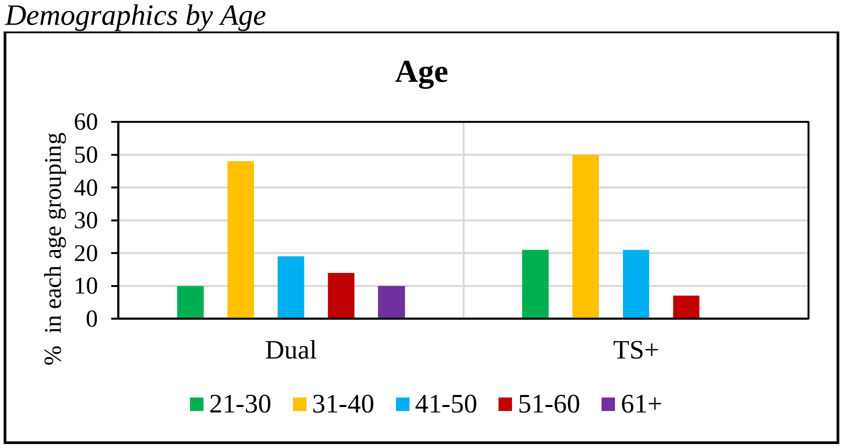
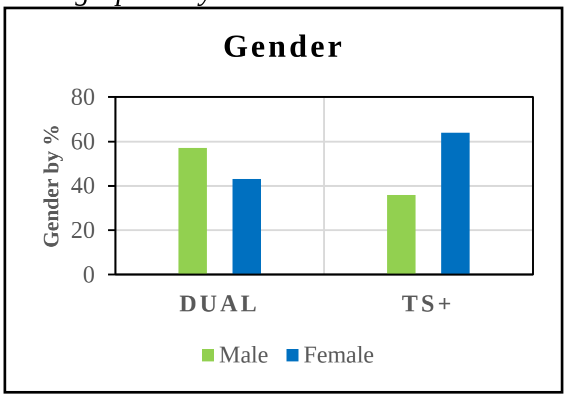


Figure 3.2

Demographics by Gender



Equipment

All participants were either users of dual non-touch displays, varying in size from 24” to 30” (Dual Group) or users of a single touchscreen (21” to 27”) plus a single 30” non-touch display (TS+ Group). Participants received no remuneration for their time.

For still photography and video, an iPad was used. A standard tape measure was used to measure the participants seated and standing eye heights. Overall body height was provided by the participant when queried. Data was collected by hand on data collection forms for both the TS+ Group and the Dual Group (Appendices A-K). See Table 3.1 for appendices breakdown.

Table 3.1

Appendices Breakdown

Appendix	Group	Presented Work	Larger Research Study
A – Demographics	Dual	Yes	Yes
B – Dual Display Configuration	Dual	No	Yes
C – Perceived Discomfort	Dual & TS	Yes	Yes
D – Perceived Productivity	Dual	Yes	No
E – Perceived Task Satisfaction	Dual	Yes	No
F – General Questions	Dual	No	Yes
G – Demographics	TS+	Yes	Yes
H – Touchscreen & Keyboard Location	TS+	No	Yes
I – Perceived Productivity	TS+	Yes	No
J – Perceived Task Satisfaction	TS+	Yes	No
K – General Questions	TS+	No	Yes

This is a breakdown of Appendices by group and research team.

Procedure Overview

This study was conducted as part of a collaborative study and comprehensive research effort. An IRB was done for this study using the company's human subject research protocol, Human Research Ethics Committee (HREC). This study had to pass two levels of review by HREC before being approved. The study was reviewed annually by HREC until completed and closed. All subjects were provided an informed consent that they were asked to sign prior to the interview.

Some data from the larger study has been included in this article for clarification purposes. The larger study methodology was included to assist in a comprehensive understanding of the study. This study was qualitative in nature with a contextual interview component, a portion of which is the subject of this paper. The participants were separated into two groups. The Dual Group was the control group, including 21 participants. The remaining 14 participants comprised the TS+ Group. Each participant was interviewed, photographed, videotaped, and measured while working on their usual projects using a specific method defined for each group.

Condition 1: Dual Group

Each participant was given an informed consent and an explanation of how the interview would proceed. Once the participant agreed to the interview and signed the informed consent the interview began. The interview took approximately 30 minutes. Participants were digitally videotaped and photographed during the interview and while they worked.

Video recordings and still photographs were taken in such a way as to obscure any data on the non-touch displays. Audio was captured during the videotaping to ensure nothing was missed during the interview and to provide any necessary clarification during analysis. When offered, no participant declined to have audio captured. During the process, digital still photographs were taken to capture equipment locations and types, as well as user-adopted postures. For each participant, eye heights, measured from the corner of the eye to the floor, were measured when sitting and standing. The participants provided their actual heights during the interview.

Participants were first asked a series of demographic questions. These questions included their job type, gender, age range, and type of corrective eyewear worn

(Appendix A). The dual display configuration was documented. This configuration included the whether the displays were symmetrical (centered on participant) or asymmetrical (one display used predominantly), and whether either or both displays were oriented landscape or portrait. Finally keyboard location was documented (Appendix B). The various types of ergonomic equipment, such as anti-fatigue mats, footrests, mice, keyboards, pen tablets, etc., were captured on the data form as well.

Next, the participants, all with electric sit/stand desks as part of their workstation setups, were videotaped for five minutes working first in a standing posture and then again for five minutes while working in a sitting posture, for a total of 10 minutes of uninterrupted video. In both instances, they were asked to work as usual. The researchers occasionally interacted with the participant during this time if a task was being done that warranted additional questions.

Finally, a formal interview was conducted. The interview phase was broken down into four categories: 1) perceived discomfort, 2) perceived task productivity, 3) perceived task satisfaction and, 4) a series of general interest questions.

For the first category each participant was asked if they have any current discomfort, and if so, which body part was affected, and at what frequency, quality, and intensity (Appendix C). Of the 35 participants, 13 self-reported some level of current discomfort. This data was compared to any discomfort noted before the second display for those participants with a previous record. The previous records were CPE evaluations conducted after discomfort was noted, whether thru an electronic ergonomic self-assessment, and ergo contact observation. The discomfort level was self-reported. Of the 35 participants, 34 had reported some level of discomfort in the past, but not all provided frequency, quality, and intensity. Some of the historical records only documented the body part in discomfort.

The second category of the interview focused on perceived task productivity targeting the ease of use and speed of tasks as measurements relating to the dual displays. Participants were asked to respond as to how the addition of a second display affected the ease of use of common tasks via a 5-point Likert Scale survey ranging from Much Easier to Much Harder. Participants were asked to provide a qualitative percentage for the ease of use as well. Next, the participants were asked to respond as to how the addition of a second display affected the speed of their common tasks via a 5-point Likert Scale survey ranging from Much Faster to Much Slower. Again, participants were asked to provide a qualitative percentage (Appendix D). In both ease of task and speed of task, the information was captured for all major tasks the participants do during a normal work day. These tasks included seismic interpretation, well log correlation, presentations, spreadsheets, etc. (Table 3.2).

Table 3.2

Tasks Analyzed

Geological Tasks	Non-Geological Tasks
Base Maps	Email & Calendaring
Cross Sections	File Transfers (FTP)
Data Loading	Presentations
Digitizing	Spreadsheets
Horizon Picking	
Seismic Interpretation (overall)	
Velocity Picking	
Well Logs	

There are some of the most commonly done tasks by geoscientists at this oil and gas company.

The third phase capture of perceived task satisfaction data, utilized two components, 1) overall task satisfaction on a 7-point Likert scale from Very Satisfied to Very Dissatisfied, and 2) if the dual displays were removed how would that affect overall task satisfaction, utilizing the same scale. As part of the larger study, the participants were also asked how satisfied would they be if their new technology were removed and they had to work using just a single 24” non-touch display (Appendix E). Note, a single 24” non-touch display was the original technology that the majority of the participants used prior to receiving the new technology. The final portion of the interview was a series of general questions designed to get more information from the participant. Some of this information has been included in this paper (Appendix F), but was not used in the analysis as it was part of the greater research.

Once the interview was complete, the videotaping and still photography were stopped. The participants were asked if they had any questions, were thanked for their time, and reminded that they would be informed of the results at a later date.

Condition 2: TS+ Group

The interview process and configuration documentation were identical to Dual Group. Except for the addition of questions about touchscreen shortcut use. Specifically, these shortcuts refer to unique capacities of the touchscreen including Wacom Cintiq® ExpressKeys, Touch Ring, and Virtual Keyboard, etc. (Appendix G).

Although the postures adopted by the users and the touchscreen/monitor configurations were not part of the study, but part of the larger study, it was included here so that an understanding could be gained of how geoscientists work, the workstation constraints they have, and the possible postural risks they are exposed to on a daily basis. This difference in setup may have had an effect on reported discomfort as some postures cause more strain on body parts, for example, reaching with arm outstretched. It may have also had an effect on perceived productivity in that, if the participant was comfortable with the tablet/display set up, they may have felt the task to be both faster and easier. Conversely, if they had a tablet/display set up that caused them to be uncomfortable or that they did not find to be optimal, it could likely have impacted how they perceived productivity in a negative way. Postures were certainly a confounding variable which was unable to be controlled for in a live, working environment.

Appendices I & J are the same two 5-point Likert Scale surveys for Perceived Ease of Task and Perceived Speed of Tasks as in Condition 1. The videotaping and still photography were also replicated. Questions about training, or the lack thereof, were added for the TS+ Group (Appendix K).

CHAPTER IV: RESULTS

Factors

The main factors evaluated in this study included: 1) perceived task productivity, 2) perceived task satisfaction, and 3) perceived discomfort. Perceived task productivity was broken down into two categories, perceived ease of task and perceived speed of task. These data were used to determine how the participants felt about their new technology as compared to what they used prior to current display setup. Perceived overall task satisfaction was a comparison of how satisfied the participant was in the use of their current setup across all tasks. Finally, participant's perceived discomfort was compared for their current equipment setup versus their prior equipment setup.

Perceived Productivity – Ease of Tasks

An Independent Samples *t*-Test was used to test the following hypotheses:

H_0: The Dual Group and the TS+ Group have the same perceived productivity perceptions;

H_1: (alternative hypothesis): The two groups have different perceptions of productivity.

Each geoscientist was asked to provide their perception of how much easier it was to do a given task with their new display configuration using a 5-point Likert Scale survey, whereby they rated each task from much easier (1) thru much harder (5). The Dual Group was considered the control group and the TS+ Group was considered the experimental group. It is important to note that not every geoscientist did every task.

Based on the results of the 5-point Likert scale survey, and using the above two referenced *t*-tests, 2 out of 12 tasks were found to have statistical differences between the control and experimental groups. The two tasks were 1) Cross Sections (t(26) = 3.168, *p* = 0.004), and 2) Well Logs (t(24) = 3.437, *p* = .002). No significance we found for the other ten tasks. Table 4.1 provides basic descriptive statistics and test results for all 12 tasks.

Table 4.1

Perceived Ease of Tasks – 5 Point Likert Scale

Tasks	df	t	Sig.	N Dual	*m* Dual	*sd* Dual	N TS+	*m* TS+	*sd* TS+
Base Maps	29	1.861	.073	17	1.53	.877	14	2.00	.877
Cross Sections	**26**	**3.168**	**.004**	**15**	**1.00**	**.000**	**13**	**1.54**	**.660**
Data Loading	18	.726	.477	12	2.25	.754	8	2.50	.756
Digitizing	18	-1.931	.069	9	1.89	.782	11	1.27	.647
Email & Calendaring	30	-.982	.334	21	2.57	.507	11	2.36	.674
Spreadsheets	30	1.479	.149	21	1.76	.831	11	2.18	.603
File Transfers (FTP)	25	-1.336	.193	18	2.78	.428	9	2.44	.882
Horizon Picking	26	.149	.883	15	1.13	.352	13	1.15	.376
Presentations	33	.702	.487	21	1.67	.949	14	1.86	.949
Seismic Interpretation	26	.724	.476	15	1.07	.258	13	1.15	.376
Velocity Picking	4	-1.000	.374	3	1.33	.577	3	1.00	.000
Well Logs	**24**	**3.437**	**.002**	**15**	**1.27**	**.458**	**11**	**2.00**	**.632**

Note: Not all participants did all tasks.

It was thought that more of the extremely click intensive tasks, such as Horizon Picking, would have yielded significantly different results in the group with touchscreens. However, it is possible that factors such as the highly menu-intensive nature of the software being used (e.g., Petrel) has the effect of offsetting or diluting the advantages of using a stylus or direct touch with the touchscreen. Nonetheless, for the two factors with significant results - working with cross sections and analyzing well logs - it appears that touchscreen functionality is perceived by users to have an even greater advantage than basic dual monitors. Menu navigation may not have been as much of a factor allowing users to spend a greater deal of time interacting with the maps and well logs for these task and therefore have a greater opportunity to experience the differences between input devices (i.e., mouse versus stylus).

Another factor, and most the likely, was the skewed nature of the results using Seismic Interpretation and Cross Sections as examples. There was no statistical difference between the Dual and TS+ Groups for Seismic Interpretation because for both groups the responses to the surveys were heavily skewed to the response of "Much Easier" (Figure 4.1), while for Cross Sections, a task with significance, there was greater distribution of responses for the Dual Group, while all of the TS+ Group responded with Much Easier (Figure 4.2).

Figure 4.1

Comparison of Means – Seismic Interpretation

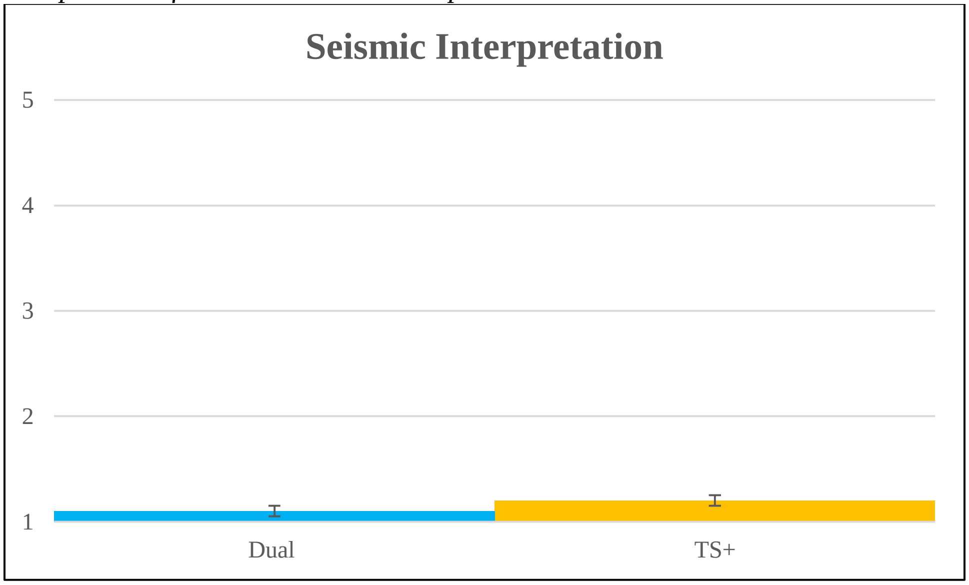
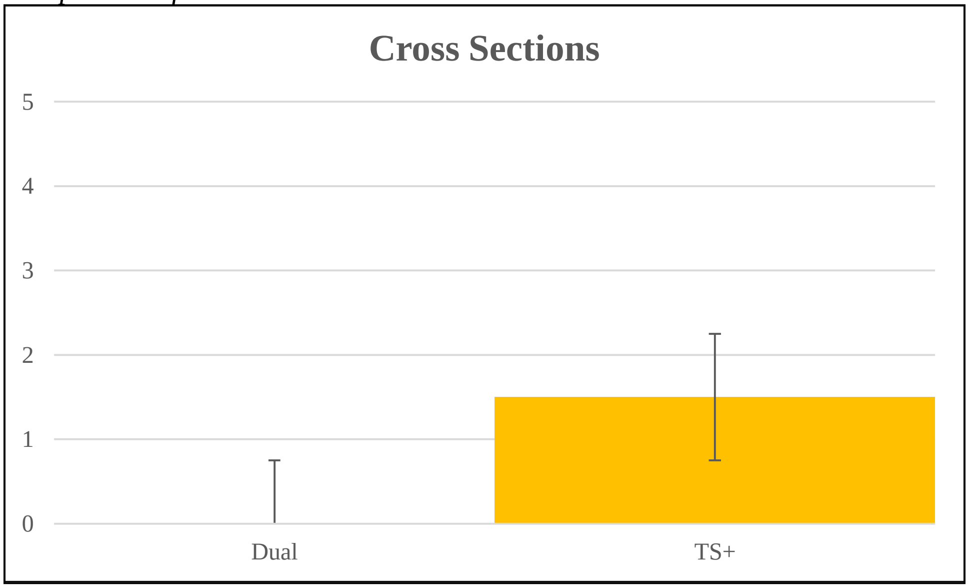


Figure 4.2

Comparison of Means – Cross Sections



The same geoscientists were also asked to give an absolute percentage of how much easier or harder they found the task immediately after they answered the Likert

Scale survey. This approach appeared to have greater sensitivity as the analysis conducted with the percentage data resulted in five tasks, rather than two, showing statistically significant results, including: 1) Bases Maps ($t(29) = -2.785$, $p = .009$), 2) Cross Sections ($t(26) = -3.144$, $p = .004$), 3) Digitizing ($t(18) = 2.273$, $p = .014$), 4) Email and Calendaring ($t(30) = 2.268$, $p = .031$), and 4) Well Logs ($t(24) = -2.715$, $p = .012$). Table 4.2 provides results for all 12 tasks.

Table 4.2

Perceived Ease of Task - Percentages

Tasks	df	t	Sig.	N Dual	*m* Dual	*sd* Dual	N TS+	*m* TS+	*sd* TS+
Base Maps	**29**	**-2.785**	**.009**	**17**	**64.94**	**27.817**	**14**	**35.00**	**32.046**
Cross Sections	**26**	**-3.144**	**.004**	**15**	**82.67**	**19.718**	**13**	**57.69**	**22.325**
Data Loading	18	-.233	.818	12	22.92	.26.838	8	20.00	28.284
Digitizing	**18**	**2.723**	**.014**	**9**	**40.56**	**33.768**	**11**	**78.64**	**28.818**
Email & Calendaring	**30**	**2.268**	**.031**	**21**	**11.33**	**19.921**	**11**	**28.18**	**20.034**
Spreadsheets	30	-1.940	.062	21	49.81	37.878	11	25.18	24.887
File Transfers (FTP)	25	1.726	.097	18	6.94	14.465	9	19.67	23.948
Horizon Picking	26	.111	.913	15	76.67	24.905	13	77.62	19.658
Presentations	33	.277	.783	21	51.90	29.769	14	48.93	33.119
Seismic Interpretation	26	-.455	.653	15	84.00	18.342	13	81.08	15.196
Velocity Picking	4	1.588	.187	3	46.67	46.188	3	90.00	10.00
Well Logs	**24**	**-2.715**	**.012**	**15**	**62.00**	**27.242**	**11**	**32.37**	**28.050**

Note: Not all participants did all tasks.

Despite the increase in the number of tasks with significance, neither Seismic Interpretation nor Horizon Picking were included among them. Again, participants in both groups rated the tasks nearly the same. When rated by percentages, Cross Sections and Well Logs again were among the tasks showing a significant difference between the two groups. The TS+ Group found both tasks not nearly as easy to do as did the Dual Group. Again, this may have been related to the menu driven aspect of the application. Participants may have found going between the touchscreen and keyboard more complicated or time consuming than just using the keyboard and mouse for these tasks. This confirms that even though the Likert Survey didn't have as many tasks showing a significant difference, the two that did, were replicated in the absolute percentage questions. Figures 4.3 and 4.4 illustrate the findings.

Figure 4.3

Comparison of Means – Seismic Interpretation and Horizon Picking

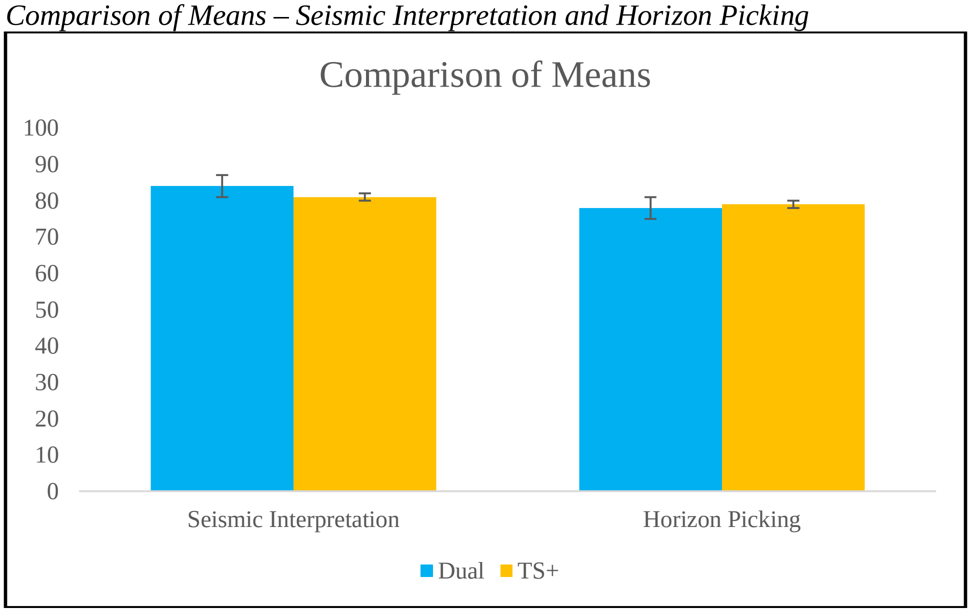
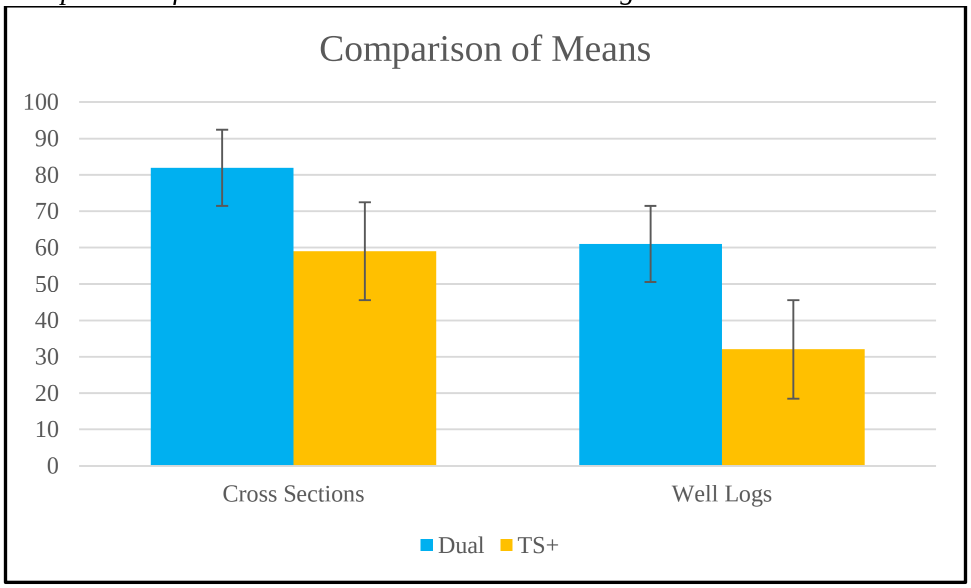


Figure 4.4

Comparison of Means – Cross Sections and Well Logs



Perceived Productivity – Ease of Tasks Summary

A larger number of tasks were found to have a significant difference between the groups when perceptions of ease of task was provided in absolute percentages rather than by a Likert Scale even though during the interviews it was obvious that most of the participants struggled to quantify ease of task into a percentage. Most hesitated and thought a bit initially, but they were all finally able to provide a percentage. Only cross sections and base maps were found to have significance in both percentages and Likert scale, while base maps, digitizing and email & calendaring only had significance when participants were asked to quantify their perception of ease of task by percentage.

One reason that may have caused the differences in results between the two survey types, Likert and absolute percentage, may have been the difficulty participants found in quantifying ease of task. Some participants reported that a task was "Easier" while giving that task a score of 85% while other were just the opposite, a task may have been perceived as "Much Easier" but only by 40%. A reminder, both the percentage response and Likert scale response was based on how much easier it was to do the task in question after getting their new technology. In other words, how much easier is it to do the new task with the new technology as opposed to the old technology, whether single display in the case of the Dual Group or dual display in the case of The TS+ Group? During the interview process the researchers felt that the percentages weren't lining up with the scale provided in the first survey. This may have had an impact. The researchers did not provide a range of percentages that matched each scale so as not to lead the participants.

Another reason could also have been that a scale of 1-5 didn't provide the granularity to report the participant's perception of ease of task, thus allowing results to be skewed more to the "Much Easier" or "Easier" end of the scale for both groups. Conversely, being able to provide an absolute percent value allowed participants to refine their perception of ease of task to something closer to their perceived reality. As stated above, for some a response of "Much Easier" equated to 40% easier than the same task with their old technology, while for others it was 85% easier than with their old technology, yet both participants responded with "Much Easier". This quickly illustrates how a skewed response to "Much Easier" was translated to a much wider spread in ease of task creating greater significance between the groups when queried on absolute percentages.

It is not possible to know how much the actual application used impacted how much easier they found the task. Did the menu driven aspect impact how touchscreen users felt about ease of task? For the TS+ group, this would be an aspect of the application where the touchscreen was not able to be used, but not part of the task we were actually asking them to report upon. Were the participants able to separate the mechanics of the application from the actual task?

Perceived Productivity – Speed of Tasks

The results for perceived speed of task for the two groups differed from the results for perceived ease of tasks. The speed of task survey was a 5-point Likert survey ranging from “Much Faster” to “Much Slower”. There was one task found to be of significance, Digitizing. When comparing the mean scores of the Dual Group to the TS+ Group a significant difference between the means of the two groups was found ($t(18) = -3.501$, $p = .003$). No significance was found for the other 11 tasks. Table 4.3 provides results, both descriptive and analytical for all 12 tasks.

Table 4.3

Perceived Speed of Tasks – 5 Point Likert Scale

Tasks	df	t	Sig.	N Dual	*m* Dual	*sd* Dual	N TS+	*m* TS+	*sd* TS+
Base Maps	29	.245	.808	17	2.00	.866	14	2.07	.730
Cross Sections	26	.750	.461	15	1.57	.646	13	1.77	.725
Data Loading	18	.911	.374	12	2.50	.674	8	2.75	.463
Digitizing	**18**	**-3.501**	**.003**	**9**	**2.33**	**.000**	**11**	**1.18**	**.405**
Email & Calendaring	30	2.018	.053	21	2.67	.483	11	3.09	.701
Spreadsheets	30	1.871	.071	21	2.10	.625	11	2.55	.688
File Transfers (FTP)	25	-.729	.473	18	2.72	.461	9	2.56	.726
Horizon Picking	26	-1.176	.250	15	1.67	.617	13	1.38	.650
Presentations	33	.536	.596	21	2.00	.548	14	2.14	1.027
Seismic Interpretation	26	-.814	.423	15	1.60	.737	13	1.38	.650
Velocity Picking	4	2.00	.116	3	1.67	.577	3	2.00	.000
Well Logs	24	-.349	.731	15	2.00	.707	11	1.91	.339

Note: Not all participants did all tasks.

The TS+ Group had the highest mean for the task of digitizing, 1.18 (much easier), while for the Dual group the mean of 2.33 indicated the task was easier to do. For the other tasks the data was heavily skewed to “Much Faster” and “Faster”, making any significant differences between the two groups impossible. Also, as with ease of task, the many levels of menus to navigate before being able to complete tasks like horizon picking or well logging may have impacted how fast participant’s perceived the task to be.

For the Dual Group, all 12 tasks were perceived as faster to do with their new technology than with their previous technology, ranging from “Much Faster” to “Faster”. Overall, the TS+ Group perceived the speed of the tasks as slightly higher, ranging from the “Same” speed to “Much Faster”. In both groups all of the tasks were perceived as being faster to do with their respective technologies with the exception of email and calendaring. The Dual Group perceived email and calendaring, mean 2.67, to be slightly faster with their new technology than their old technology while the TS+ Group, mean 3.09, found email and calendaring to be slower to do with their new technology than with their old technology. E-mail and calendaring was the only task noted to be slower to do with their new technology for either group.

The geoscientists were asked to provide an absolute percentage of how much faster or slower they found the task to complete immediately after they answered the corresponding Likert Scale survey. This analysis found only two tasks with a significant difference between the two groups – digitizing and email & calendaring. 1) Digitizing: when comparing the mean scores of the Dual Group to the TS+ Group a significant difference between the means of the two groups was found ($t(18) = 2.848$, $p = .003$). The mean of the TS+ Group was lower ($m = 76.36$, $sd = 23.462$) than the Dual Group ($m = 36.67$, $sd = 38.406$), and 2) Email & Calendaring: when comparing the mean scores of the Dual Group to the TS+ Group a significant difference between the means of the two groups was found ($t(30) = -2.046$, $p = .053$). The mean of the TS+ Group was lower ($m = 9.09$, $sd = 24.271$) than the Dual Group ($m = 27.86$, $sd = 24.828$). No significance was found for the other ten tasks. Table 4.4 provides results for all 12 tasks.

Table 4.4

Perceived Speed of Tasks – Percentages

Tasks	df	t	Sig.	N Dual	*m* Dual	*sd* Dual	N TS+	*m* TS+	*sd* TS+
Base Maps	29	-.410	.685	17	42.94	35.003	14	37.86	33.611
Cross Sections	25	-.177	.861	15	52.86	34.122	13	50.77	26.524
Data Loading	18	-.979	.340	12	17.08	24.722	8	7.50	14.880
Digitizing	**18**	**2.848**	**.011**	**9**	**36.67**	**38.406**	**11**	**76.36**	**23.462**
Email & Calendaring	**30**	**-2.046**	**.050**	**21**	**27.86**	**24.828**	**11**	**9.09**	**24.828**
Spreadsheets	30	-1.454	.156	21	28.81	24.078	11	25.832	7.789
File Transfers (FTP)	25	.770	.448	18	12.22	23.962	9	19.44	20.683
Horizon Picking	26	.500	.621	15	57.00	34.111	13	63.38	33.225
Presentations	33	.544	.590	21	39.52	29.364	14	45.36	33.596
Seismic Interpretation	26	.371	.713	15	58.00	38.905	13	63.00	31.164
Velocity Picking	4	.894	.422	3	46.67	46.188	3	73.33	23.094
Well Logs	24	-.378	.709	15	46.54	39.496	11	40.91	32.079

Note: Not all participants did all tasks.

For perceived speed of tasks participants from the Dual Group found seismic interpretation tasks to be 58% faster, to complete than with their previous technology while the task of file transfer was only 12% faster, a very small improvement. For this group seismic interpretation, horizon picking and cross sections were the tasks perceived to be fastest, all in the 50% range. The tasks perceived to have the lowest improvement in speed were file transfer and data loading, both in their teens. Even though not of statistical significance, the perception of speed of task for seismic interpretation, horizon picking, and cross section being over 50% faster to do with the new technology, is encouraging.

The TS+ Group found the tasks associated with digitizing to be the fastest at 76%, when compared to their original technology and data loading was only 7.5% faster. The tasks with the highest speed improvements were digitizing, velocity picking, horizon picking, and seismic interpretation. Among the tasks with the lowest improvement in speed was data loading and email & calendaring.

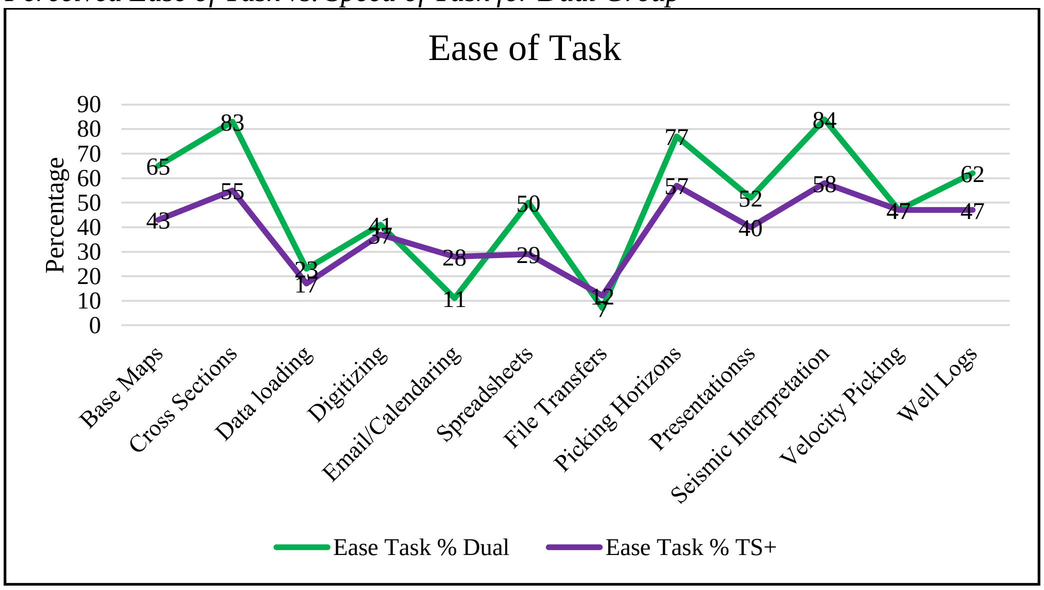
As with ease of task, there is no real way of knowing how the participant's measure speed of task and what was actually included. Were they able to exclude any peripherals they may use along with their new technology? How much did the application itself impact their perception of speed of task?

Perceived Ease of Task vs. Perceived Speed of Task

It was interesting to note that across the board for both groups their new technology made the tasks easier to do but not necessarily faster to do. As the percentages gave more robust data, it will be used for this discussion. The Dual Group perceived ease of task to be greater than speed of task for all tasks except email & calendaring, file transfer, and velocity picking. Email & calendaring was perceived to be 17% easier than faster, file transfer had a 5% difference in ease vs. speed, and velocity picking was equal for ease and speed. The largest difference between ease and speed were noted in cross sections and seismic interpretation. Participants found cross sections to be 28% easier than faster, while seismic interpretation showed and 26% difference between ease of task and speed of task.   The smallest difference for the Dual Group with ease of task being greater than speed of task was data loading and digitizing with a 6% and 4% difference respectively (Figure 4.5).

Figure 4.5

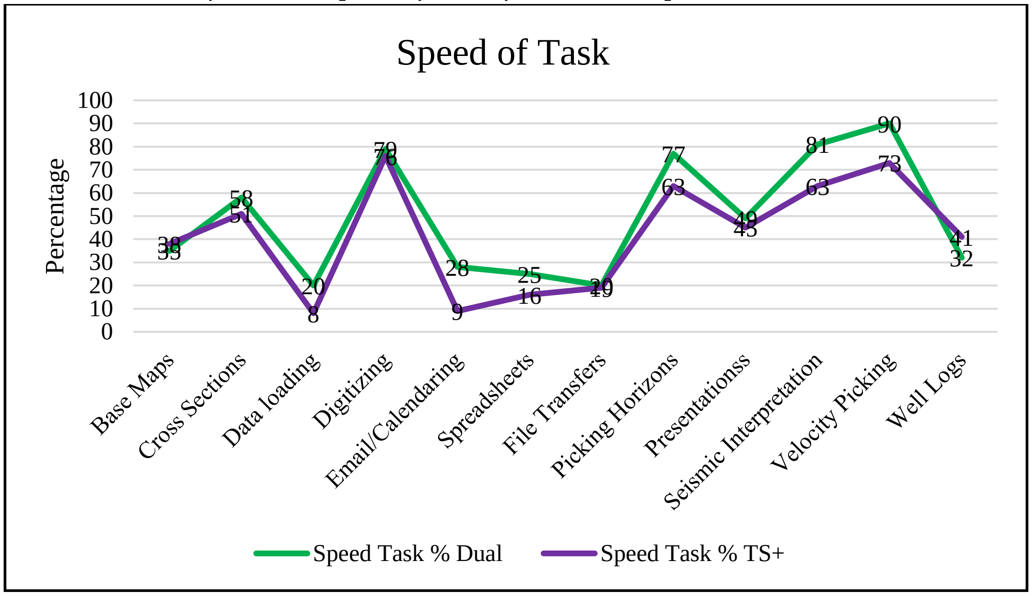
Perceived Ease of Task vs. Speed of Task for Dual Group



For the TS+ group only two tasks were perceived to be faster to do than easier to do: base maps and well logs. The perception of base maps showed a 3% difference in speed over ease and well logs showed a 9% difference in speed over ease. The tasks that has the largest difference in percentage of ease being greater than speed were email & calendaring at 19% and seismic interpretation being 18%. The tasks with the lowest difference between ease and speed were digitizing and presentations. Digitizing was perceived to be 4% easier than faster and presentations were 3% easier than faster (Figure 4.6).

Figure 4.6

Perceived Ease of Task vs. Speed of Ttask for TS+ Group



Perceived Productivity - Summary

Overall, it was heartening to find any significant difference between the two groups due to the confounding variables that are difficult if not impossible to control outside a laboratory environment as well as operating as part of a larger team. Sometimes what was needed for this study was over ridden or circumvented by the larger team. Several times this researcher had to adapt on the fly. It certainly encourages further study in this area.

As a reminder, for ease of task significance was found 1) 5-point Likert Scale Survey: cross sections and well logs, and 2) Percentage Survey: base maps, cross sections, digitizing, email & calendaring and well logs. Cross sections and well logs were the only tasks showing significance in both areas. The significant tasks found in the

5-point Likert Scale survey were all geologic in nature while the results of the Percentage Survey was split with one standard task and four geologic tasks.

Perceived Speed of Task 5-point Likert Scale survey showed only one task as being significant, digitizing. For the Percentage Survey two tasks had significance: digitizing and email & calendaring. Only digitizing was to be significant in both areas for speed of task. For the first survey, two tasks were geologic in nature and two were standard tasks. Both tasks identified in the second survey were geologic in nature.

Perceived Task Satisfaction

Perceived task satisfaction data was gathered in two ways, a 7-point Likert Scale survey focusing on the participants overall level of task satisfaction and a second 7-point Likert Scale survey asking about the participant's satisfaction level if their current display technology were removed and replaced with a single 24" monitor. A single 24" monitor used to be standard for all geoscientists. The responses were so heavily skewed to very satisfied for the first survey and very dissatisfied for the second survey that there was no reason to run statistics and this line of research was abandoned.

During the development of the methodology, the researcher did look at several job satisfaction surveys to determine if any portion or all of a job satisfaction survey could be tailored to fit for task satisfaction. The job satisfaction surveys reviewed were deemed to be not fit for purpose. (Spector, 1985; van Saane, Sluiter, Verbeek, & Frings-Dresen, 2003) This led the researcher, with the guidance of the larger research team, to go with the very simple 7-point Likert Scale surveys referenced in the above paragraph.

The researcher's thesis advisor did caution the researcher that the data most likely would be skewed, and unusable, because employees may not be completely honest with a co-worker as to how they truly feel about their work environment. Even though the participants were assured that the data would be completely anonymous and not shared at a name level, they may still have had reservation about being completely honest.

The results of the overall task satisfaction survey question had 28 participants saying their overall task satisfaction was rated as very satisfied. There were five participants whose overall task satisfaction was rated as satisfied. Of that five, two were from the Dual Group and three were from the TS+ Group. For the three from the TS+ Group their lower level of overall task satisfaction stemmed not from the touchscreen itself, but rather from the instability of the touchscreen's drivers. Every time the IT department pushed an update to the system the drivers would become disabled. The individuals affected would then have to wait until an IT technician came to their workstation to manually reload the drivers. This happens fairly regularly. Despite this problem overall task satisfaction for the TS+ Group was high. The two Dual Group participants provided no real information on why their overall task satisfaction was only satisfied.

For the second survey question concerning the loss of the participant's current equipment, 32 participants would be very dissatisfied if it were to happen and one would be dissatisfied. Most would consider looking for another job as it would be next to impossible, in their view, to be able to do their job to their standards and the standards of the company. No participant was willing to go backwards with their technology to the extreme of having just one 24” monitor in the future. Some TS+ participants commented that they would be dissatisfied if they were asked to go back to dual displays.

Perceived Discomfort Overview

There were a number of problems found while collecting the perceived discomfort data. The first was that the historical data from the company’s contract Ergonomic Specialist evaluation reports varied greatly. Not all reports noted the intensity, the quality, or the frequency of discomfort while some did contain all of the required data at the time the participant was evaluated (Appendix C). During the interview process many participants weren’t able or willing to articulate all three responses for their current discomfort level, if presented. So in both the perceived pre-discomfort and perceived post-discomfort categories, the data was incomplete.

A second issue was the fact that the population of touchscreen users was very small to begin with and heavy workloads prevented a number of touchscreen users to participate. The overall volunteer population for both groups was smaller than expected, producing population of 14 for the TS+ group and 19 for the Dual Group. An issue related to a small volunteer population was that not all participants had discomfort before being given their new technology and the participant pool was too small to discount those individuals. This added a number of confounding variables that the researcher was unable to control for adequately.

The third issue was that not all participants had the same technology before they got the new technology. Not all participants in the Dual Group had a single 24” display, some participants had single displays but they were of sizes other than 24”. For example, some participants had dual displays but they were 19” in size. For the TS+ Group, not all had dual 24” displays as their original display technology. Some had smaller sized dual displays while some began their career with a touchscreen and/or a single display. Some participants couldn’t remember the technology they had before and the historical records did not capture that data. The historical records may have been the ergonomic specialist evaluation reports or ergonomic contact (co-workers assigned to assist with basic ergonomic needs) reports (Figures 4.7 & 4.8)

Figure 4.7

Ergonomic Specialist Evaluation Report with Complete Discomfort Data

CONFIDENTIAL ERGONOMICS EVALUATION REPORT FORM

Employee Name:	Department:	Supervisor's Name:
Evaluation Date: 07-27-2016	Reason for Evaluation: Discomfort	Supervisor's Email:
Evaluation Format: in person	Ergo Consultant	Office Location:
Assessed By:	Building	Ergo Contact:
	Corporation:	Ergo Contact Email
	Gender: Male	

Executive Summary

I met with concerning discomfort issues with his shoulders and neck. In discussing this situation, feels like he can not get his shoulders back enough in his current set up causing him to lean forward toward his work. This leaning forward is causing significant discomfort in his shoulders, upper back and neck. We discussed both standing and seated postures. There seems to be no obvious solution to this issue. What seeks is a desk that would provide extra support for his arms. I also took a video to share with the team to see what creative solutions we could come determine. I am working to set up a follow up appointment to present one alternative solution.

Photo Evaluation

Indicators

Body Part	Body Part	Quality	Intensity	Body Part	Body Part	Quality	Intensity
Neck	Right	Soreness	3				

Discomfort Evaluation

Neck	**Constant**	**Upper Back**	**Constant**
Left Elbow	None	Right Elbow	None
Lower Back	None	Left Upper Leg	None
Right Upper Leg	None	Left Lower Leg	None
Right Lower Leg	None	Head	None
Eyes/Blurred Vision	None	**Right Shoulder**	**Constant**
Left Shoulder	**Constant**	Left Foot	None
Right Foot	None	Left Knee	None
Right Knee	None	Left Hand/Fingers	None
Right Hand/Fingers	None	Left Hip	None
Right Hip	None	Left Wrist	None
Right Wrist	None	Right Forearm	None
Left Forearm	None		

Figure 4.8

Ergonomic Specialist Evaluation Report with Incomplete Discomfort Data

CONFIDENTIAL ERGONOMICS EVALUATION REPORT FORM

Employee Name:	Department	Supervisor's Name:
Evaluation Date: 09-09-2016	Reason for Evaluation: Move	Supervisor's Email:
Evaluation Format: in person	Ergo Consultant	Office Location:
Assessed By:	Building	Ergo Contact
	Corporation:	Ergo Contact Email
	Gender: Male	

Executive Summary

recently moved again and after completing his SAC, recommended an evaluation. has things set up correctly and is moderating use of input devices, as well as sitting, standing, and propping throughout the day to self mitigate discomfort. Todays evaluation centered around synergistic muscle movement, maintaining appropriate postures and strengthening core muscles through corrective exercise - all things is doing well individually to help prevent future flare ups. Otherwise is using learned ergo principles to his advantage and moving continuously throughout the day to minimize strain on any one muscle/group of muscles in his body.

Recommendations for the Employee

Discomfort Evaluation

Neck	Occasional	Upper Back	Occasional
Left Elbow	None	Right Elbow	None
Lower Back	None	Left Upper Leg	None
Right Upper Leg	None	Left Lower Leg	None
Right Lower Leg	None	Head	None
Eyes/Blurred Vision	None	Right Shoulder	Occasional
Left Shoulder	None	Left Foot	None
Right Foot	None	Left Knee	None
Right Knee	None	Left Hand/Fingers	None
Right Hand/Fingers	None	Left Hip	None
Right Hip	None	Left Wrist	None
Right Wrist	None	Right Forearm	None
Left Forearm	None		

or the oil and gas company's internal ergonomic tracking application (Figure 4.9).

Figure 4.9
Oil and Gas Company's Internal Historical Data for an Individual

ODate	Comment
4/14/2016	Observations and actions items have been reviewed.
4/14/2016	Observation completed. Individual didn't have a full size keyboard to work while at home or while traveling. I gave the individual an extra keyboard I had access to.
4/13/2016	Self-assessment has been reviewed.
4/13/2016	Self-assessment has been reviewed
5/15/2015	Self-assessment has been reviewed.
5/14/2015	Observec after 6 months of working in new campus is working in a safe manner/environment. No follow up necessary.
12/12/2014	Self-assessment has been reviewed.
12/8/2014	Observe in new office environment. Equipment fits well. ordering standing mat and foot rest. No follow up necessary.
11/25/2014	Self-assessment has been reviewed.
11/25/2014	Self assessment has been reviewed
9/16/2014	For ' evaluation complete. ACTIONS: adjusted seat pan depth, raised chair, adjusted lumbar support, adjusted table.
9/9/2014	Self-assessment has been reviewed.
9/9/2014	Observed in work room and office locations. Her mouse in the work room was not adequate and a new one is being ordered. Additionally her rolling laptop bag was broken and will be replaced. She follows good posture. Requesting follow up by ergonomist due to history.
9/9/2014	Discussed assessment witl and urged her to take frequent rest breaks and plan her day to allow variation in tasks. Requested have a professional ergonomist review
9/18/2013	For evaluation complete. ACTIONS: drop arms & relax shoulders, roll hands upwards & outwards when not working on computer, develop behavioral cues that will assist in creating better habits. ORDER: HandShoe Mouse large, Steelcase Details (or similar) footrest, Steelcase Details Series 5 single suface sit/stand table 46".

Again, the small population and reduced volunteer capabilities hindered this study.

The participants, when asked about their discomfort, both pre-new technology (historical) or post-new technology, responded with individual body parts, e.g. right wrist, low back, left pinky finger. This level of specificity was unusable due to the low population of this study. To be able to have some level of usable data, body parts were grouped into four categories for analysis, 1) head, neck, and shoulders, 2) back, 3) upper extremities, and 4) lower extremities (Table 4.5).

Table 4.5

Discomfort Collapsed Body Part Groupings for Discomfort Analysis

Collapsed Groupings	Body Parts
Head/Neck/Shoulders	head, neck, and shoulders
Back	upper, mid, and lower
Upper Extremities	upper arms, elbows, forearms, wrists, hands, and fingers
Lower Extremities	hips, thighs, knees, calves, ankles, and feet

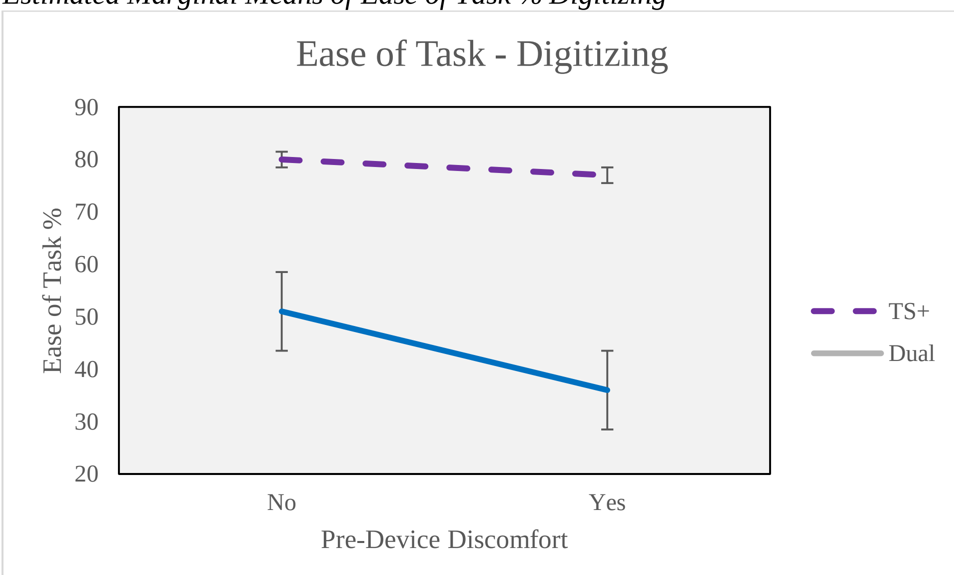
Note: Sporadic or missing historical discomfort information caused the researcher to collapse for analysis.

Perceived Discomfort – Ease of Task (%)

Due to the flawed nature of the data a Univariate Analysis of Variance was run on the ease and speed of task percentage results only. This provided a way to find patterns in the discomfort data. A within subject, mixed factorial ANOVA was calculated comparing whether the pre-discomfort levels of the participants were improved by the introduction of the new technology for each task (DV).

Three tasks were found to have a main effect for Group (Dual or TS+), where Group equates to new technology. 1) Ease of Task (%): Digitizing $F(1,33) = 4.447$, $p = .05$) (Figure 4.10),

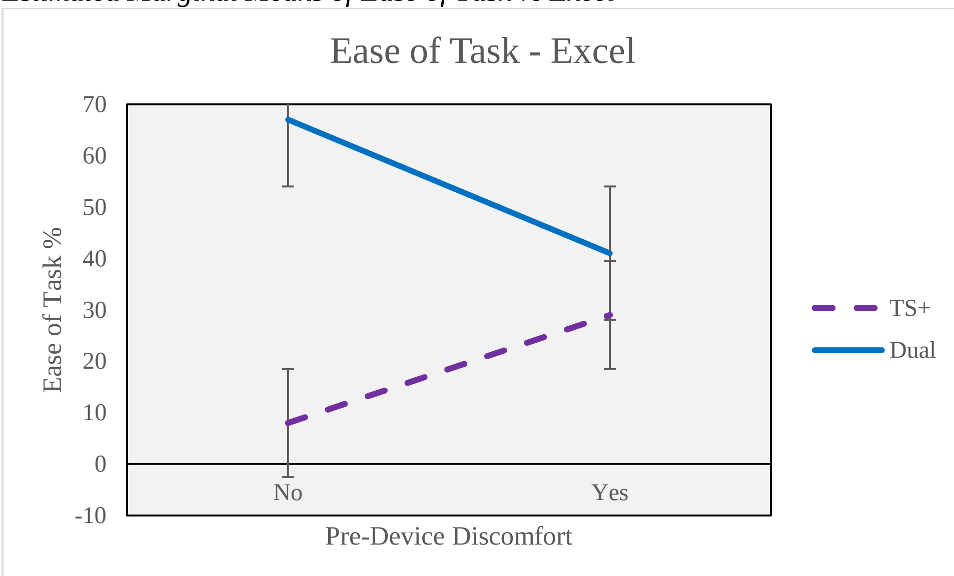
Figure 4.10
Estimated Marginal Means of Ease of Task % Digitizing



2) Ease of Task Excel %: $F(1, 33) = 5.16$, $p = .031$ (Figure 4.11), and

Figure 4.11

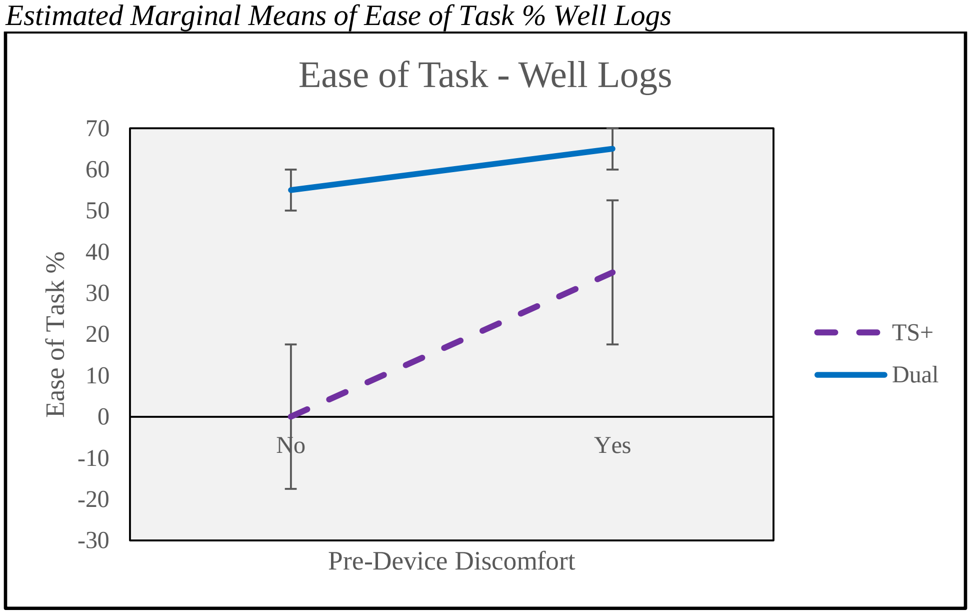
Estimated Marginal Means of Ease of Task % Excel



3) Ease of Task Well Logs %: F(1,33) = 7.13, p = .014 (Figure 4.12).

Figure 4.12

Estimated Marginal Means of Ease of Task % Well Logs



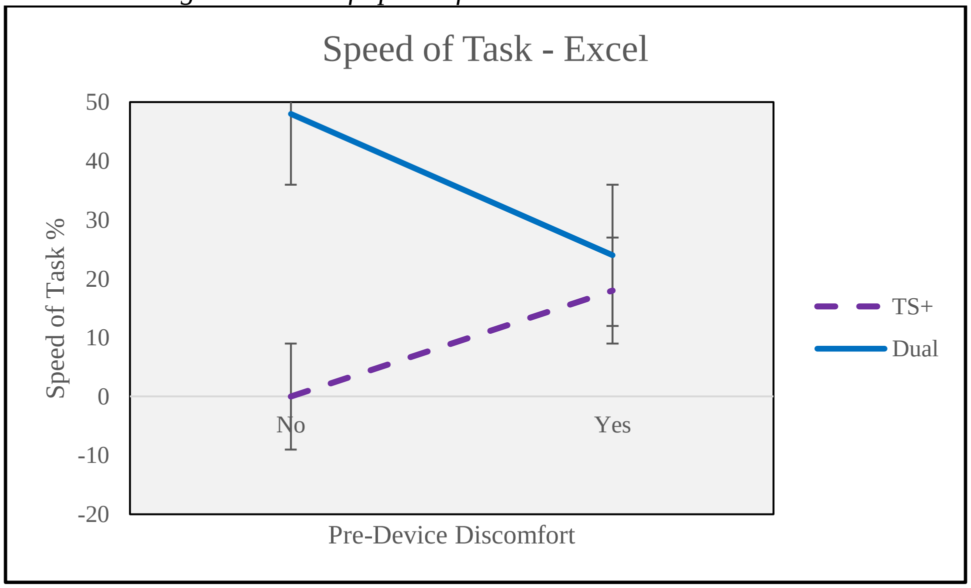
In all three tasks, participants showed a main effect of Group. The other 9 tasks did not show a main effect of either Technology.

Perceived Discomfort – Speed of Task (%)

For Speed of task only one task was found to have a main effect for Group (Dual or TS+), 1) Speed of Task Excel (%): F(1,33) = 4.97, p =.034) (Figure 4.13).

Figure 4.13

Estimated Marginal Means of Speed of Task % Excel



In this task, participants showed a main effect of Group (Technology). The other 11 tasks did not.

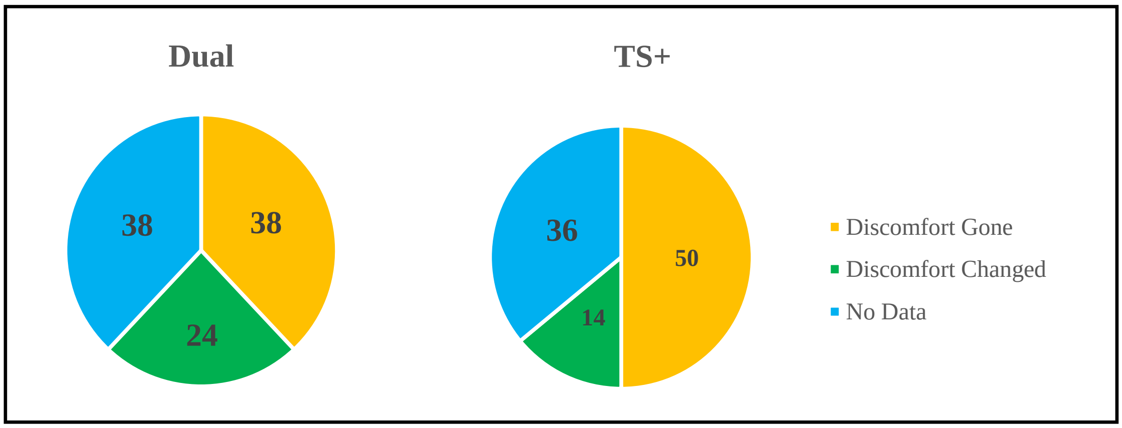
As all previous cases, it can be difficult to determine the drivers behind the participant’s responses to speed of task. Many factors could have impacted their responses including the application they were using at the time, IT issues, other peripherals in use, as well as their postures and behaviors.

Perceived Discomfort Summary

The pre- and post-discomfort was difficult to effectively analyze due to the small population of the study, the variation in discomfort data, and the missing discomfort data. The data had to be analyzed in a more descriptive fashion, allowing for the identification of a main affect for Group (Dual or TS+) for 4 of the 24 tasks, 3 in Ease of task and one in speed of tasks. Graphically, from the raw data one can see how discomfort changed between pre- and post-new technology (Figure 4.14).

Figure 4.14

Perceived Changes in Discomfort Pre- and Post-New Technology



Many confounding variable existed in this study that prevented this data from having greater statistical significance. A small population stemming from a small amount of touchscreen users as well as reduced volunteerism due to high workloads at the time the data was being gathered. Another factor was poor historical discomfort data and poorly captured perceived discomfort data during the interview process. Finally, there was no single technology for either group that they moved from to the new technology, so an equal comparison did not exist. All of the confounding variables dealt with by this researcher can be controlled in a lab environment, unfortunately, a real-world setting comes with variables that can’t always be mitigated or even identified in advance of the study.

CHAPTER V: DISCUSSION

Limitations of the Study

The research was done in a corporate setting and was part of a larger study. This inclusion into an existing touchscreen study was the only way the company would permit this research. The company required that the participant's involvement be as minimal, yet impactful, as possible. The limitation to the research being part of a larger study is that the research was tied to what was already being done by the larger group is that it changed the methodology.

Guidance was provided by the researchers of the larger group that may or may not have been of value, but certainly had to be taken into greater consideration than might have otherwise occurred. The goals of each research team needed to be melded into a cohesive methodology that allowed for a single 30 minute interaction with each participant. Because of these constraints, the research had to be subjective and contextual in nature with only a small attempt at quantitative measurements of perceived task productivity and perceived task satisfaction. Time did not permit the participants very long to really think about how much the display technology alone affected their task productivity or satisfaction. It also did not allow the researchers to delve into the applications they used and how they used them.

Confounding Variables

It was extremely difficult to plan for and mitigate all possible confounding variables in a non-laboratory setting. The research team attempted to control for as many variables as possible by ensuring that both groups worked with two displays and discounting other display arrangements. It was recognized during the interviews, and confirmed during the analysis phase, that a number of confounding variables existed that were unaccounted for during the methodology development. These confounding variables may have had a large impact on the perceptions of ease and/or speed of tasks.

There were several confounding variables related to the workstation itself. The first being the postures adopted by the TS+ participants. Many of these postures were driven by where the touchscreens were place on the worksurface and the subsequent physical interactions with the touchscreens (Figures 5.1 – 5.7). The various placements of the touchscreens had an impact on postures, in some cases cause neck flexion, arm extension, leaning forward, and sitting on the edge of their chair, all of which can lead to discomfort as they are typically out of what is considered a neutral posture and can increase the risk of an ergonomic injury if the discomfort persists. There were configurations that were relatively neutral and this lack of discomfort may have had an impact on the participant's perceptions of productivity or speed as much as any level of discomfort could have impacted how the participant perceived ease and speed of task. If the participant was unhappy with the touchscreen configuration in that it felt awkward to use, that too, may have impacted the perception of ease or speed of tasks.

If participants had been provided only one configuration for their touchscreen as related to display rather than being allowed several alternatives, this confounding variable would have been removed. Those in the Dual Group had no confounding variables where posture was concerned as both the mouse and keyboard were located in the same location on the worksurface, relatively centered on the dual monitors with the mouse located to either the right or left of the keyboard depending on the participants' dominant hand allowing a more neutral posture when sitting or standing. When sitting a neutral posture can be considered to be feet flat on the floor, knees at ~90°, thighs approximated parallel to the floor and supported by chair seat pan, back ~90° - 130°, arms close to the sides with forearms parallel to the floor, wrists straight with not no contact stress on the desk, head and neck straight and aligned with the torso (Figure 5.1).

Figure 5.1

Seated Neutral Posture

Standing neutral posture includes the legs being shoulder width apart, knees relaxed, body in line with legs, arms, hands, and wrists in the same position as when seated, head and neck in the same position as when seated as well (Figure 5.2).

Figure 5.2

Standing Neutral Posture

A second confounding variable that the researchers had no control over was the number and type of peripheral devices being used in conjunction with the respective display configurations of each participant (Table 5.1). This variability was equal between the two groups, both having a number of peripherals that may have impacted both comfort and productivity in the eyes of the participants. As participants go between peripherals in their everyday tasks, the changes in postures and muscle groups used can provide a level of relief to the body. Using voice recognition software, in particular, allows the users to rest both hands not use them at all. Foot pedal mice offer relief in that basic tasks like copy and paste can be done by the feet, of course this increases the exposure of the lower extremities to ergonomic injury. Changing hand positions from flat to vertical reduces pronation and contact stress of the wrist area when mousing. Keyboards can go from flat to split and tented encouraging a more neutral hand posture. Although multiple keyboard use was not as prevalent as multiple mouse use, it did occur in a couple of cases. Pen tablets allow one to use a stylus to work, but doesn't provide a tie between the visual system and the tactile system. Geoscientists seem to find this one-to-one tie between the two systems to be a positive, although they find the use of a pen tablet superior to a mouse. The other peripherals noted in Table 5.1 assisted in comfort related to sitting, standing, and propping. All of these may have been factors in how the participants rated their productivity.

Table 5.1

Peripherals and Other Equipment

Equipment at Workstations
Keyboards, sometimes multiple used
Mice, sometimes multiple used
Pen tablets
Speech recognition software
Foot pedal mice
Detachable key pads
Footrests
Anti-fatigue mats
Different chairs
Prop stools

Note: This table of peripherals was were garnered during the interviews and represented what was being used in conjunction with displays at the time of the interviews.

A third confounding variable related to workstation and behavioral issues, in particular the amount of time the participants spent between sitting, standing, and propping (Table 5.2). Since all participants had the same electric sit/stand table, going between these postures were totally up to the participant. Some stood all day, some sat all day, and some participants went between sitting and standing during the day and some used prop stools in lieu of sitting.

Table 5.2

Time Spent Sitting, Standing, and Propping

% Time Sitting	% Time Standing	% Time Propping	# Participants
100	0	0	4
90	10	0	4
80	20	0	12
70	30	0	3
60	40	0	1
50	50	0	5
40	60	0	0
30	70	0	1
20	80	0	0
10	90	0	1
0	100	0	4
70	30	10	1
50	10	40	1
0	50	50	1
Percentage not reported			1

Note: Participants had a wide range of behaviors around sitting vs. standing vs. propping.

Standing, and occasionally propping, do have health benefits that could also have unconsciously influenced how the participants responded to the queries. Standing at work has benefits that we are just now learning about, 1) standing for just 2.5 hours each day can burn an extra 350 calories a day, 2) 10 days of this daily calorie burn can result in the loss of one pound, and 3) this activity can typically cause a weight loss of 20-25 pounds per year (Benden, 2008). This weight loss comes with health benefits, including decreased cardiovascular and endochrinological risks, reduction in LDL and triglycerides, increases in HDL, reduction in sleep apnea, decreases in joint degeneration, and increased life spans (Benden, 2008). Besides the health benefits of standing, it is a more natural posture and may have contributed to the participant's feelings of increased productivity.

The change between postures alone, could have been a great impact on perceptions of task productivity and comfort, even at a subconscious level. It may have prompted the participants to include this aspect of their workstation and behaviors into their productivity and discomfort responses this may have had an effect on the responses given during the interviews.

Due to the time constraints previously discussed, it may have been difficult for the participant to tease out the exact amount of task satisfaction and productivity changes brought about by the introduction of a new display technology while discounting the other peripherals or behaviors that may have been unknowing contributors to their responses.

Several confounding variables were found relating to the discomfort aspect of this research. From a historical standpoint, the CPE reports did not all contain the frequency, quality, and intensity of the discomfort. The body part in discomfort was captured. This issue made the original discomfort data very difficult to run as did the small population of participants. The researchers found that many of the participants when interviewed, were comfortable with providing body part(s) in current discomfort, but unwilling to provide the three other aspects of the discomfort. This missing data in both the historical discomfort record and the current discomfort data resulted in an abandonment of the discomfort analysis of any aspect other than body part. The researchers expected all of the touchscreen users to have had some level of discomfort prior to their being given the technology, that was not the case. A small group was given touchscreens without prior discomfort.

Another confounding variable may have been the applications the participants typically use while doing their daily tasks. Time constraints did not allow the researchers to ask questions about the applications in use during the interview or during the work day as a whole. What aspect of the applications affect how quickly or easily a task can be done either by mouse, keyboard, or touchscreen. How might this affect responses?

These confounding variables could be controlled for very easily in a laboratory where they could not be controlled in a live work environment. The researchers do not know how much of the participant's feelings about productivity were impacted by postural aspects, peripherals, the applications, and behavioral aspects. The confounding variables around both the historical and current discomfort levels did not directly impact perceptions of productivity, but they may have. They certainly impacted how the data was analyzed.

A number of TS+ participants noted issues related to functionality of the touchscreens. These functionality issues were related to the IT support provided by the company as well as some issues with the touchscreen itself (Table 5.3).

Table 5.3

Issues with Touchscreens

Company Related	Touchscreen Related
Provide training for new users	Resolution poorer than standard displays
Create a touchscreen users group	Not precise enough to use finger
Drivers disappear several times a week	Virtual keyboard difficult to use
Drivers have to be reloaded by IT	Stylus must be configured often
IT response time	Useful keyboard/ and mouse placement
Provide more adjustable monitor arms	

Note: these comments gathered for use by other research team, but were appropriate to be included in this research.

These aspects may have resulted in lowered perceptions in all aspects of touchscreen use. There were no factors that negatively impacted the use of dual displays, although a couple of participants would have liked to have been able to use a single wider display rather than two displays. They saw a single wider display as beneficial from a screen real estate perspective - they could get more information on screen, especially when doing seismic interpretation or picking horizons as horizontal space is more beneficial than vertical space. As an example, well logging requires more vertical space than horizontal. For geoscientists who do well logging primarily, a single wider display would be of no use (Figure 2.1).

The confounding variable that impacted discomfort was that not every participant had pre-touchscreen or pre-dual display discomfort. This was an indication, that in some instances, the addition of dual displays or a touchscreen were proactive in nature, although a positive step for the participants, did not aid in this research. The population of touchscreen users was not large enough for those participants without historical discomfort to be disallowed. In other cases the discomfort was not documented in its entirety, either historically or during the interview phase. This inconsistency of discomfort data caused the researcher to have to collapse the data from individual body parts to several groupings of related body parts (Table 4.5). In addition, the frequency, duration, and intensity of pre- and post-discomfort was so sporadically collected in both cases, that it had to be discounted during the final analysis.

The touchscreen location as related to the non-touch display was noted as users can be very creative in touchscreen placement. However, two configurations were typical. Touchscreen set beside monitor and touchscreen brought down flatter and brought closer to user (Figures 5.3 & 5.4).

Figure 5.3

Touchscreen Located Beside Non-Touch Display at the Same Height

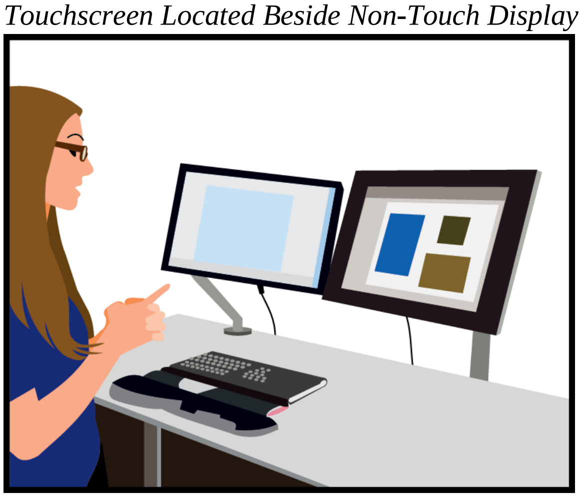
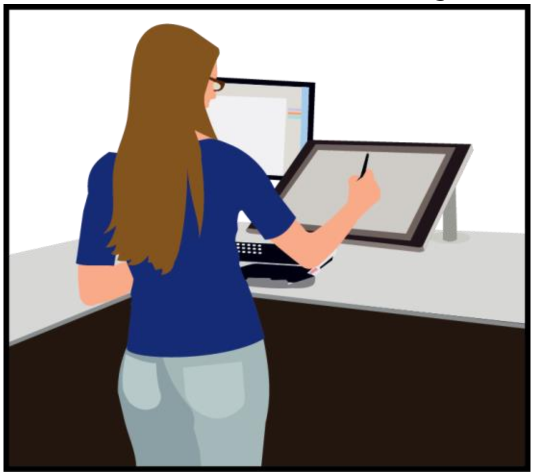


Figure 5.4

Touchscreen Positioned Low and Angled Toward User



The keyboard location can, on occasion, be problematic, (Figures 5.5 – 5.7) and was documented along with any keyboard movement required in order to interact with the participant's touchscreen (Appendix H). Appendix H was for the use of the other research team.

Figure 5.5

Keyboard Located Under the Touchscreen

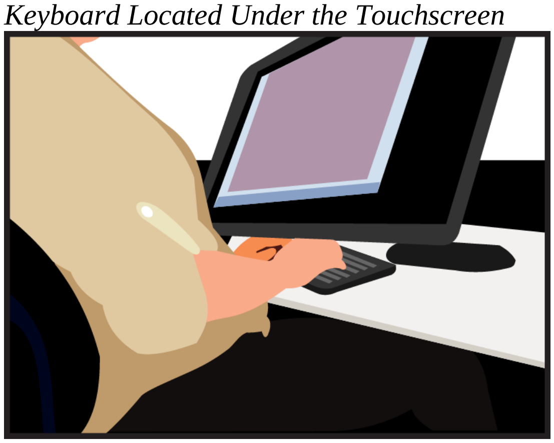
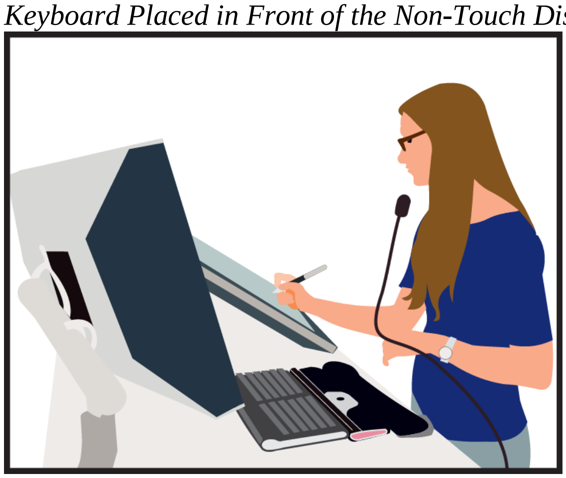


Figure 5.6

Keyboard Located on Top of the Touchscreen When in Use

Figure 5.7

Keyboard Placed in Front of the Non-Touch Display



Findings

This research did find statistical significance for perceived productivity as broken out into perceived ease of task and perceived speed of task. The statically significant findings for perceived discomfort were relatively strong and may be enough to encourage other pursuits of this research. Due to a lack of forethought, no data analysis was able to be done on perceived task satisfaction. Although the results were somewhat disappointing, there was enough qualitative information gathered from the TS+ participants to pass on to management as a case for progress when added to the statistically significant data obtained. Finally, a great deal was learned that can be applied to future research into the topic.

Significance was found for Perceived Ease of Task in both the 5-point Likert Scale survey and the Percentages survey. For Perceived Ease of Task, the 5-point Likert Scale survey yielded significance in two tasks: cross sections and well logs. For the Percentages survey five tasks showed significance: base maps, cross sections, digitizing, email & calendaring, and well logs. It was noted that of the two surveys, two tasks, cross sections and well logs showed significance in both analyses and four of the five significant tasks were geological tasks.

For Perceived Speed of Task, significance was found in both surveys, but with fewer tasks. The 5-Point Likert Scale survey yielded one task with significance: digitizing. The Percentages survey resulted in two tasks with significance: digitizing and email & calendaring. Of the two tasks with significance, one, digitizing, was geologic in nature.

When looking at the tasks with significance across both aspects of productivity, only digitizing and email & calendaring showed significance differences in both. Well log and base map activities showed significance differences for perceived ease of task only, while there was no task showing only significance in perceived speed of tasks.

From a qualitative perspective, it was resounding for both groups that the new technology surpassed the original technology of one 24" non-touch display in aspects of perceived task productivity, perceived task satisfaction and overall perceived discomfort reduction and that was backed up with statistical significance for some tasks and some discomfort, as well as for perceived task satisfaction. For some touchscreen users, they felt that all geoscientists should have touchscreens. For some dual display users, they saw no need to move to touchscreens.

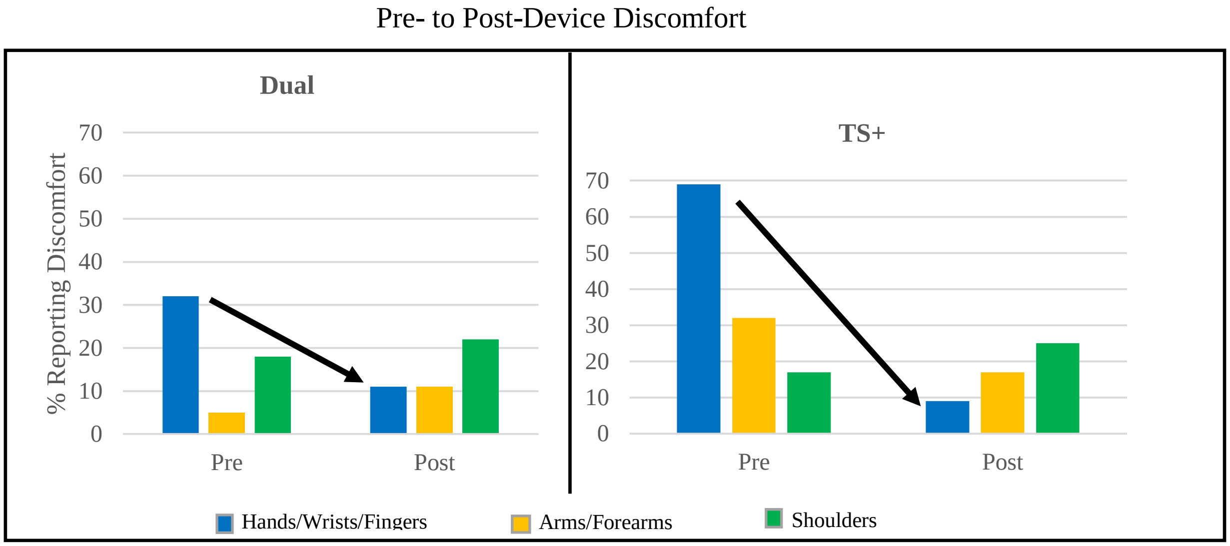
In order to gain an understanding of how some TS+ participants felt about the touchscreen technology, anecdotal comments gathered during the study for the other research team will be included. One participant reported that her intense bilateral hand and forearm discomfort was gone; she found that touchscreen use "reduces mouse clicking"; she switches between the touchscreen and speech recognition software; and finally, she reported that both seismic interpretation and presentation activities were 75% easier to use with the touchscreen than with a dual display configuration. A second participant reported that his bilateral forearm discomfort was gone; he switches between the touchscreen and a pen tablet; and he perceived seismic interpretation to be 80% easier and 90% faster than dual displays. A third participant reported that his right shoulder discomfort was gone; he felt that the touchscreen "is significantly better – I like to be able to put pen to surface – it provides a visual connection"; he switches between left and right stylus use; and he perceived seismic interpretation to be 99% faster and easier that his previous technology. A fourth participant reported that her upper back and left hand discomfort was gone, but she is currently experiencing mild neck discomfort; she reports that "non-touch monitors are way worse than touchscreen technology"; and she felt that "touchscreen use improved her ergonomic wellbeing by 1,000,000%!" Ergonomic postures, workstations, and peripheral equipment were confounding variables that may have caused a huge impact on this study.

For the upper body, where the majority of pre- and post-new technology discomfort was noted, it is interesting to note the changes in discomfort for both groups. There was a larger reduction in post-new technology discomfort for the TS+ Group for the hand/wrists/and fingers. This is to be expected and the touchscreen use reduces the amount of amount of mouse use. Arm/forearm discomfort was reduced as well. Shoulder discomfort increased post-new technology for the TS+ Group (Figure 5.8).

Participants attributed to an increase in reaching that could be mitigated by more adjustable monitor arms allowing for the touchscreen to be pulled low and close to the body. The Dual Group also showed a reduction in the hands/wrists/fingers, but not as much as for the TS+ Group. The participants attributed this to the reduction in having to maximize and minimize many windows. Discomfort increased for both the arms/forearms and the shoulders for this Group (Figure 5.8). Participants offered no insight into why this might be.

Figure 5.8

Discomfort Change with Focus on Hands/Wrists/Fingers



Suggestions for Future Research

This research has provided statistical evidence that a cohort of geoscientists perceived a decrease in discomfort and an increase in both task productivity and task satisfaction when using their current touchscreen technology. The same can be said for the participants in the dual display group. It may well be that any technology that is new is perceived by the user to be of more benefit that the older technology. It will be interesting to see what the next technology on the horizon for geoscientists is and how they feel about it.

This researcher feels that there is merit in research being done in a controlled lab setting in order to truly determine if touchscreen technology can really impact productivity as well as reducing existing discomfort. It will be important to have a random sampling of participants, an equal number of participants if more than one group is used, participants with well documented pre-technology discomfort, no extra peripheral that may confound the findings, the same office configuration, mouse-intensive tasks to be done, a clear understanding of any applications they use, and finally, enough time to gather quantitative data rather than qualitative data.

In conclusion, it was the expectation of this study to provide insight into how geoscientists feel about touchscreens and if positive, encourage the use of touchscreens in the oil and gas industry and in other industries with equally intensive computer tasks. If the perception of discomfort can be significantly reduced or, at best, eliminated while task productivity and task satisfaction are increased, it will validate a company's decision to invest in this technology and share their results with others in the industry. This study did find significance at levels that may lead to further investigation into touchscreens. It is important that future research be conducted in a lab setting in order to control for confounding variables, including past and current ergonomic discomfort, peripherals, and workstation setups, as examples.

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APPENDIX A: DEMOGRAPHICS

DEMOGRAPHICS

Job Title	Geoscientist			GeoTech		Other		
Gender	M				F			
Age	21-30	31-40		41-50	51-60		61+	
Stature								
Eye Height	Seated				Standing			
Glasses	None	Monofocal Computer	Monofocal Reading	Monofocal Standard	Occupation Progressive	Progressive	Bifocal	Trifocal

Appendix A. Demographic information for the Dual Group. Stature, eye height, and type of glasses was used by the other research team and was not part of this research.

Appendix B

DUAL DISPLAY CONFIGURATION

Displays	Symmetrical	Asymmetrical	Landscape D1 D2 Both	Portrait D1 D2 Both
Keyboard Location	Center	Right side	Left side	Movement

Appendix B. Dual display configuration including display location, orientation, and keyboard location. This information was used by the other research team and was not part of this research.

Appendix C

PERCEIVED DISCOMFORT

NONE

Body Part ___________________________

Frequency	None	Occasional	Frequent	Constant							
Quality	Burning	Discomfort	Pain	Soreness	Tightness	Tingling	Other				
Intensity	0	1	2	3	4	5	6	7	8	9	10

Appendix C. Discomfort ratings for both groups. To be replicated for each body part experiencing discomfort at the time of the interview. This information was used only for this research as was not part of the other research.

Appendix D

PERCEIVED PRODUCTIVITY

Ease of Tasks – How has this dual display technology impacted the ease of use of the following tasks as compared to a using single display?

Base Maps	Much Easier %	Easier %	Same	Harder %	Much Harder %
Cross Sections	Much Easier %	Easier %	Same	Harder %	Much Harder %
Data Loading	Much Easier %	Easier %	Same	Harder %	Much Harder %
Digitizing	Much Easier %	Easier %	Same	Harder %	Much Harder %
Email & Calendaring	Much Easier %	Easier %	Same	Harder %	Much Harder %
Excel	Much Easier %	Easier %	Same	Harder %	Much Harder %
File Transfer	Much Easier %	Easier %	Same	Harder %	Much Harder %
Picking Horizons	Much Easier %	Easier %	Same	Harder %	Much Harder %
PowerPoint	Much Easier %	Easier %	Same	Harder %	Much Harder %
Seismic Interpretation	Much Easier %	Easier %	Same	Harder %	Much Harder %
Velocity Picking	Much Easier %	Easier %	Same	Harder %	Much Harder %
Well Logs	Much Easier %	Easier %	Same	Harder %	Much Harder %
Other ____________________	Much Easier %	Easier %	Same	Harder %	Much Harder %

Speed of Tasks – How has this dual display technology impacted the time it takes to complete the following tasks as compared to a using single display?

Base Maps	Much Faster %	Faster %	Same	Slower %	Much Slower %
Cross Sections	Much Faster %	Faster %	Same	Slower %	Much Slower %
Data Loading	Much Faster %	Faster %	Same	Slower %	Much Slower %
Digitizing	Much Faster %	Faster %	Same	Slower %	Much Slower %
Email & Calendaring	Much Faster %	Faster %	Same	Slower %	Much Slower %
Excel	Much Faster %	Faster %	Same	Slower %	Much Slower %
File Transfer	Much Faster %	Faster %	Same	Slower %	Much Slower %
Picking Horizons	Much Faster %	Faster %	Same	Slower %	Much Slower %
PowerPoint	Much Faster %	Faster %	Same	Slower %	Much Slower %
Seismic Interpretation	Much Faster %	Faster %	Same	Slower %	Much Slower %
Velocity Picking	Much Faster %	Faster %	Same	Slower %	Much Slower %
Well Logs	Much Faster %	Faster %	Same	Slower %	Much Slower %
Other ____________________	Much Faster %	Faster %	Same	Slower %	Much Slower %

Appendix D: Perceived task productivity broken down between ease of completing tasks and speed of completing tasks for Dual Group. This was captured solely for this research.

Appendix E

PERCEIVED JOB SATISFACTION

Perceived Job Satisfaction – What is your overall level of job satisfaction?

Rating	Very Satisfied	Somewhat Satisfied	A Little Satisfied	Same	A Little Dissatisfied	Somewhat Dissatisfied	Very Dissatisfied

If you were asked to no longer use your dual display and use just one display, how would this impact your overall level of job satisfaction?

Rating	Very Satisfied	Somewhat Satisfied	A Little Satisfied	Same	A Little Dissatisfied	Somewhat Dissatisfied	Very Dissatisfied

Appendix E. Perceived task satisfaction for Dual Group. This was captured solely for this research.

Appendix F

GENERAL QUESTIONS

1) Has this dual display technology improved your ergonomic well-being?

2) What do you like most about this dual display technology?

3) What do you like least about this dual display technology?

4) What would make the use of this dual display technology better?

5) If you could have any additional technology what would it be?

6) Have you ever used a Wacom Cintiq© Touchscreen along with a single non-touch display? If so, how do you compare that technology with your current dual display technology?

Appendix F: General questions for Dual Group. This was captured for the benefit of the other study, but was for anecdotal purposes for this study.

Appendix G

DEMOGRAPHICS

Job Title	Geoscientist	GeoTech	Other					
Gender	M	F						
Age	21-30	31-40	41-50	51-60	61+			
Shortcuts	Cintiq ExpressKeys	Cintiq Touch Ring	Grip Pen Side Switches	Keyboard Shortcuts	Virtual Keyboard			
Stature								
Eye Height	Seated		Standing					
Glasses	None	Monofocal Computer	Monofocal Reading	Monofocal Standard	Occupation Progressive	Progressive	Bifocal	Trifocal

Appendix G. Demographic information for TS+ Group, note the addition of shortcuts. This along with stature, eye height, and glasses was used by the other research team and not part of this research.

Appendix H

TOUCHSCREEN & KEYBOARD LOCATION (in relation to non-touch display)

Touchscreen	Above	Below (front edge on desk)	Below (front edge off desk)	Right	Left
Keyboard Location	Below	Above	Right	Left	
Keyboard Movement					

Appendix H. Location of touchscreen in relation to non-touch display, as well as keyboard location and movement. This was only used by the other research team. It was used only anecdotally in this research.

Appendix I

PERCEIVED PRODUCTIVITY

Ease of Tasks – How has this touchscreen technology impacted the ease of use of the following tasks as compared to not having this technology?

Base Maps	Much Easier %	Easier %	Same	Harder %	Much Harder %
Cross Sections	Much Easier %	Easier %	Same	Harder %	Much Harder %
Data Loading	Much Easier %	Easier %	Same	Harder %	Much Harder %
Digitizing	Much Easier %	Easier %	Same	Harder %	Much Harder %
Email & Calendaring	Much Easier %	Easier %	Same	Harder %	Much Harder %
Excel	Much Easier %	Easier %	Same	Harder %	Much Harder %
File Transfer	Much Easier %	Easier %	Same	Harder %	Much Harder %
Picking Horizons	Much Easier %	Easier %	Same	Harder %	Much Harder %
PowerPoint	Much Easier %	Easier %	Same	Harder %	Much Harder %
Seismic Interpretation	Much Easier %	Easier %	Same	Harder %	Much Harder %
Velocity Picking	Much Easier %	Easier %	Same	Harder %	Much Harder %
Well Logs	Much Easier %	Easier %	Same	Harder %	Much Harder %
Other ____________	Much Easier %	Easier %	Same	Harder %	Much Harder %

Speed of Tasks – How has this touchscreen technology impacted the time it takes to complete the following tasks as compared to not having this technology?

Base Maps	Much Faster %	Faster %	Same	Slower %	Much Slower %
Cross Sections	Much Faster %	Faster %	Same	Slower %	Much Slower %
Data Loading	Much Faster %	Faster %	Same	Slower %	Much Slower %
Digitizing	Much Faster %	Faster %	Same	Slower %	Much Slower %
Email & Calendaring	Much Faster %	Faster %	Same	Slower %	Much Slower %
Excel	Much Faster %	Faster %	Same	Slower %	Much Slower %
File Transfer	Much Faster %	Faster %	Same	Slower %	Much Slower %
Picking Horizons	Much Faster %	Faster %	Same	Slower %	Much Slower %
PowerPoint	Much Faster %	Faster %	Same	Slower %	Much Slower %
Seismic Interpretation	Much Faster %	Faster %	Same	Slower %	Much Slower %
Velocity Picking	Much Faster %	Faster %	Same	Slower %	Much Slower %
Well Logs	Much Faster %	Faster %	Same	Slower %	Much Slower %
Other ____________	Much Faster %	Faster %	Same	Slower %	Much Slower %

Appendix I. Perceived task productivity broken down between ease of completing task and speed of completing task for TS+ Group. This was captured solely for this research.

Appendix J

PERCEIVED JOB SATISFACTION

Perceived Job Satisfaction – What is your overall level of job satisfaction?

Rating	Very Satisfied	Somewhat Satisfied	A Little Satisfied	Same	A Little Dissatisfied	Somewhat Dissatisfied	Very Dissatisfied

If you were asked to no longer use your touchscreen and use just one non-touch display, how would this impact your overall level of job satisfaction?

Rating	Very Satisfied	Somewhat Satisfied	A Little Satisfied	Same	A Little Dissatisfied	Somewhat Dissatisfied	Very Dissatisfied

Appendix J. Perceived task satisfaction for TS+ Group. This was captured solely for this research.

Appendix K

GENERAL QUESTIONS

1) Has this touchscreen technology improved your ergonomic well-being?

2) What do you like most about this touchscreen technology?

3) What do you like least about this touchscreen technology?

4) What would make the use of this touchscreen technology better?

5) If you could have any additional technology what would it be?

6) Have you ever used dual non-touch monitors? If so, how do you compare it to your current technology?

7) Did you have any training on this touchscreen technology?

8) What kind and when was it provided?

9) Did the training help?

10) What would you have like to have seen in the training?

Appendix K. General questions for TS+ Group. Note the addition of questions concerning training. This was captured for the benefit of the other study, but was for anecdotal purposes for this study.