Of Mice and Roentgen: Radiologist Satisfaction with a Non-conventional 13-Button Mouse—One Institution's Experience

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Abstract

Increasing radiologic exam volume and complexity necessitates leveraging advanced hardware solutions to optimize workflow efficiency. We evaluated radiologist satisfaction of a programmable 13-button non-conventional mouse compared to a conventional three-button mouse in daily interpretation workflow following a brief 2-day trial period. A prospective study was conducted with radiology staff and residents in a tertiary care center from 2015 to 2016. A survey was distributed prior to and after a tutorial and a 2-day non-conventional mouse trial period. The post-survey evaluated usage time, device settings, satisfaction, preferences, and perceived efficiency of both mice. Descriptive analyses, correlations, the Sign test, and the Wilcoxon signed-rank test were used to evaluate responses. Fifty-nine participants completed pre- and post-surveys. Several (41%, $n = 24$) had prior experience with a non-conventional mouse. Prior to the trial, one third of all participants (35.6%, $n = 21$) reported being satisfied or very satisfied with their conventional mouse. After spending an average of 9.8 h using the non-conventional mouse, there were no statistically significant changes in overall satisfaction with either conventional or non-conventional mice ($p = 0.84$ and $p = 0.39$, respectively). However, 76.3% ($n = 45$) agreed/somewhat agreed they preferred to use the non-conventional mouse in their daily workflow as opposed to the conventional mouse. The non-conventional mouse was also perceived as more efficient (66.1%, $n = 39$), required less time (62.7%, $n = 37$) and effort (74.6%, $n = 44$) to view images, allowed for easier manipulation of windows/images (76.3%, $n = 45$), and was more comfortable to use (78.0%, $n = 46$). Although there were no statistically significant shifts in overall satisfaction, participants reported a higher level of satisfaction, perceived efficiency, and preference for a non-conventional 13-button mouse compared to a conventional three-button mouse following a brief, 2-day trial period.

Keywords User interface device · Picture archiving and communications system · Mouse · Gaming-mouse · Interpretation efficiency

Introduction

Recent increases in radiology study volume and exam complexity require radiologists to streamline and optimize their workflow to keep pace. From 2006 to 2013, the annual volume of computed tomography (CT) and magnetic resonance

imaging (MRI) exams in the USA increased by 25 and 27% to 78 million and 62 million scans, respectively [1, 2]. Moreover, technological evolutions, such as advancements in CT post-processing techniques [3], have greatly increased image volume per exam. Together, these trends suggest that radiologists must adapt to interpreting more technically complex, image-dense exams, while functioning within the same time and resource constraints.

To begin addressing this growing problem, it is important to examine potential workflow improvement strategies in the radiology exam interpretation process, which begins after image acquisition with the uploading of exams to the Picture Archiving and Communication System (PACS). Images are then reviewed and manually manipulated by a radiologist on PACS workstations [4]. During this review, radiologists utilize sequential reading algorithms [5] to formulate medical opinions of the studies, culminating in the generation of succinct reports or interpretations [6]. Although the exam interpretation

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process can vary, this current study focuses only on the manual manipulation of images, as they can demand significant amounts of radiologists' time and effort.

Manual manipulation of images requires user interface devices (UIDs), such as a QWERTY keyboard, dictation microphone (Nuance PowerMic II, 2015), and mouse or other manual "pointing" device [7, 8]. Traditionally, radiologists have utilized a conventional (three-button) mouse to perform manual functions, such as retrieving data/image sets, advancing through images, taking measurements, or adjusting window/level [8]. Although research exploring radiologists' UID preferences is limited, several studies have confirmed that radiologists prefer to use the familiar mouse form factor in lieu of alternative UIDs, such as joysticks [9], jog wheels [10, 11], and tablets [12], as opposed to alternative device types which would require prolonged retraining with steep learning curves and high barriers-to-entry. Moreover, research has also found that radiologists have perceived greater efficiency when utilizing a specialized (non-conventional) mouse with either five or eight configurable buttons compared to a conventional three-button mouse [6]. However, these studies are limited by notably small sample sizes, ranging from five to nine participants each. Additionally, no prior research has explored radiologists' initial impressions or short-term satisfaction directly comparing conventional and non-conventional mice as a tool for daily task performance.

Given the rapidly evolving nature of UID technology, driven primarily by industries outside of radiology, gaining insight into radiologists' satisfaction with these devices could help alleviate future technological hurdles radiologists may experience. Furthermore, using the standard mouse design with iterative improvements may help circumvent the typically high barrier-to-entry which new technologies experience resulting in shortened user adaptation periods and improving short-term user satisfaction. Therefore, this study sought to investigate academic radiologists' user experience comparing a non-conventional "gaming" mouse with 13 customizable buttons to a conventional three-button mouse in daily exam interpretation workflow. The primary objective was to compare participant satisfaction with each device following a brief two-day trial period, while secondary objectives focused on identifying radiologist preferences, perceived efficiencies or workflow improvements, perceived barriers to non-conventional mouse use, and the most commonly used PACS imaging functions.

Materials and Methods

This prospective cohort study was performed in the radiology department of a tertiary care medical center from August 1, 2015, to April 30, 2016. A waiver from the institutional review board (IRB) was obtained for radiology staff, fellows, and

residents to participate in this study. Participants completed electronic surveys (REDCap Software, Version 6.11.5, Vanderbilt, TN) before and after a brief 2-day trial period designed to evaluate their knowledge, experience, and satisfaction with using both conventional three-button and non-conventional 13-button mice in their daily exam interpretation workflow [13]. Testing was performed in a standard reading room setting with departmental Centricity™ PACS workstations (General Electric Company, Boston, MA and GE Healthcare, Chicago, IL) and PowerScribe® 360 dictation software (Nuance Communications, Inc., Burlington, MA) [14, 15]. For the mammography section, SecurView™ DX (Hologic, Bedford, MA) was used with the non-conventional mouse buttons mapped to mimic the mammographic keypad.

The non-conventional "gaming" mouse used in this study was the Logitech G700s (Logitech, Newark, CA), released in 2013, which uses infrared (IR) laser tracking and 2.4-GHz wireless signal or wired-USB and has 8200 Dots Per Inch (DPI) max resolution with on-the-fly DPI adjustment, on-board memory to retain profile settings, and 13 customizable buttons with multi-profile capability (Fig. 1; 15). Logitech Gaming Software (Versions 8.70.315 and 8.82.151) was used to customize at least five of 13 buttons of each participant's mouse [16, 17] with personalization settings stored in the on-board memory module of the mouse providing personalized plug-and-play functionality independent of a specific reading workstation. This mouse was selected for testing because it is widely available, is reasonably priced, and has ongoing customer support and hardware warranties (Logitech, Newark CA, 2016; [18]). For evaluation purposes, this non-conventional mouse was compared to a conventional three-button workstation manufacturer-provided mouse—the Dell Optical Mouse MS116 (Dell, Round Rock TX, Dell Optical Mouse MS116, 2016; [19]).

Pre-surveys were first emailed to all faculty, fellows, and residents in the radiology department. The surveys gathered information about user demographics, knowledge, experience, and satisfaction with both types of mice. Participants were also asked to rank the following 12 PACS functions in order of personal use from greatest to least: selection arrow, region of interest Hounsfield unit (ROI/HU) measurement/level, grayscale invert, manual cine, magic glass (focal magnification), window/level, arrow annotation, reset to last saved state, continuous zoom, measure distance, and other.

Following completion of the pre-survey, each participant received a brief, standardized educational tutorial from one of five trained instructors on the non-conventional mouse prior to his or her trial period. Participants were instructed on button arrangement, wireless functionality, USB receiver manipulation, wired-charging, dual-mode metered and unlocked scrolling, and individualized customization of their five most utilized PACS functions. Participants also received hard-copy

Fig. 1 Logitech G700S 13-button gaming mouse (“non-conventional mouse”) and Dell MS116 3-button optical mouse (“conventional mouse”). **a** Button diagram for “non-conventional” Logitech G700S 13-button mouse. All customizable buttons are labeled, in addition to scroll wheel, left/right tilt, and middle click functionality. Customizable button function includes single-press toggling of programmable

functions, translating to one [1] fewer button press per performed function (G700s: 1st press: toggle on, 2nd press: function performance, Dell MS116: 1st press: access menu, 2nd press: select function from menu, 3rd press: function performance). **b** Button diagram for “conventional” Dell MS116 three-button mouse

maps of their customized PACS functions and corresponding button assignments for reference during the trial period.

Next, participants were asked to use the customized, non-conventional mouse in their daily exam interpretation workflows for 24–48 business hours. During this time, they were encouraged to continue their usual work activities of manipulating and interpreting radiologic examinations as much as possible while utilizing the customized mouse functions, though adherence to appropriate use of the customized functions was not directly observed during the trial period. Each participant was responsible for tracking total time spent using the non-conventional mouse. Post-surveys, gathering participant feedback on knowledge, experience, and satisfaction with both types of mice, were then sent via email within 72 h of each participant’s trial period completion.

Categorical variables were summarized using frequencies and continuous variables were summarized using descriptive statistics. Correlations and Wilcoxon signed-rank tests were performed to compare pre- and post-survey data examining

differences in knowledge, satisfaction, and perceived workflow efficiencies of both mouse types. Statistical analyses were completed using SAS software version 9.4 (SAS Institute, Inc., Cary, NC) and statistical significance was determined using p values < 0.05 .

Results

Fifty-nine (43 males, 16 females) right-handed radiology personnel, including 30 faculty members (50.8%), 24 residents (40.8%), and five fellows (8.5%) participated in this study (Table 1). All participants were self-reported right-handed mouse users. All radiology subspecialties were represented, with the greatest number of faculty participants self-identifying as body (16.9%), interventional (13.6%), breast (11.9%), and neuroradiology imagers (10.2%). Post-residency faculty experience ranged from 1 to 39 years, with a median time-in-practice of 9 years. During the trial period,

Table 1 Participant characteristics ($n = 59$)

Characteristic	<i>N</i> or median	% or range
Gender		
Male	43 (72.9%)	72.9
Female	16 (27.1%)	27.1
Service year		
PGY-2	6 (10.2%)	10.2
PGY-3	6 (10.2%)	10.2
PGY-4	6 (10.2%)	10.2
PGY-5	6 (10.2%)	10.2
Fellow	5 (8.5%)	8.5
Faculty	30 (50.8%)	50.8
Fellow and faculty subspecialty*		
Body	10 (16.9%)	16.9
Breast	7 (11.9%)	11.9
Cardiothoracic	4 (6.8%)	6.8
Interventional	8 (13.6%)	13.6
Musculoskeletal	5 (8.5%)	8.5
Neuro	6 (10.2%)	10.2
Nuclear medicine	3 (5.1%)	5.1
Pediatrics	1 (1.7%)	1.7
Ultrasound	5 (8.5%)	8.5
Years of staff experience post-residency		
Median (range)	9 (1–39)	(1–39)

*Participants may have selected more than one subspecialty area

participants spent an average of 14.2 h (SD = 8.3 h) reading exams, with an average of 9.8 h (SD = 6.5 h), or 69.0% of that time, using the non-conventional mouse (Table 2).

Prior to the trial period, one third of participants (35.6%, $n = 21$) reported being satisfied or very satisfied with their conventional three-button mouse, while nearly 40% ($n = 23$) were dissatisfied or very dissatisfied, and one quarter were neutral (25.4%, $n = 15$). Two thirds (64.4%, $n = 38$) reported having prior general awareness of non-conventional mice, while 40.1% ($n = 24$) used or had previously used a non-conventional mouse in a reading room setting. Among the 24 participants who had prior or current experience using a non-conventional mouse, nearly all were satisfied or very satisfied (87.5%, $n = 21$) with it. After the trial period, there were no significant changes in participants' overall satisfaction with both conventional and non-conventional mice ($p = 0.84$ and $p = 0.39$, respectively; Table 2 and Fig. 2).

Multiple secondary endpoints were explored, including participants' preference for a conventional or non-conventional mouse. More than three quarters of participants (76.3%, $n = 45$) agreed or somewhat agreed that they preferred to use the non-conventional over the conventional mouse in the daily image interpretation workflow (Table 3). The non-

Table 2 Radiologist usage, awareness, and satisfaction of conventional and non-conventional mice ($n = 59$)

	<i>N</i> or mean	% or SD
Total reading time		
Mean hours (SD)	14.2	8.3
Total time using non-conventional mouse		
Mean hours (SD)	9.8	6.5
Pre-trial satisfaction with conventional mouse		
Very satisfied	2	3.4
Satisfied	19	32.2
Neutral	15	25.4
Dissatisfied	12	20.3
Very dissatisfied	11	18.6
Pre-trial awareness of non-conventional mouse		
Yes	38	64.4
No	21	35.6
Non-conventional mouse use (only participants with awareness, $n = 38$)		
Never used	14	36.8
Have used	15	39.5
Currently use	9	23.7
Pre-trial satisfaction with non-conventional mouse (only participants with prior use, $n = 24$)		
Very satisfied	10	41.7
Satisfied	11	45.8
Neutral	3	12.5
Dissatisfied	—	—
Very dissatisfied	—	—
Post-trial satisfaction with conventional mouse		
Very satisfied	2	3.4
Satisfied	21	35.6
Neutral	15	25.4
Dissatisfied	10	16.9
Very dissatisfied	11	18.6
Post-trial satisfaction with non-conventional mouse		
Very satisfied	32	54.2
Satisfied	17	28.8
Neutral	5	8.5
Dissatisfied	3	5.1
Very dissatisfied	2	3.4

conventional mouse was also perceived as more efficient (66.1%, $n = 39$), required less time (62.7%, $n = 37$) and effort (74.6%, $n = 44$) to view images within a study, allowed for easier manipulation of windows/images (76.3%, $n = 45$), and was more comfortable to use (78.0%, $n = 46$).

Finally, participants reported their five most commonly used GE Centricity PACS functions as follows: measure distance (96.6%, $n = 57$), window/level (93.2%, $n = 55$), arrow annotation (57.6%, $n = 34$), ROI/HU measurement (52.5%, $n = 31$), and continuous zoom (47.5%, $n = 28$). Participants liked having single-button access to their frequently used PACS functions rather than having to either put down the dictation microphone to press the corresponding keystroke

Fig. 2 Participant pre- and post-trial satisfaction with conventional and non-conventional mice. Pre- and post-trial radiologist satisfaction utilizing conventional and non-conventional mice. Pre-trial non-conventional participants were limited to those actively using a non-conventional mouse or who are aware of its existence. No statistically significant change in pre- and post-trial satisfaction was found with either the conventional ($p = 0.84$) or the non-conventional mouse ($p = 0.39$)

* Only participants who were aware of the non-conventional mouse prior to the trial period were included in the pre-trial satisfaction calculation.

or going through additional mouse clicks to access their desired function. Participants who had previously used ($n = 15$) or were aware of but not currently using a non-conventional mouse ($n = 14$) reported utilizing a conventional mouse in their daily exam interpretation due to comfort with it (37.9%, $n = 11$), limited availability of non-conventional mouse (34.5%, $n = 10$), and too much additional required training for non-conventional mouse (24.1%, $n = 7$, Table 4).

Discussion

This study found that academic medical center radiologists, across most training levels and subspecialties are equally satisfied using either conventional or non-conventional mice in their daily exam interpretation workflow. However, when the two mice were directly compared, participants had a significantly stronger preference for using the non-conventional over conventional mouse despite only a brief 24–48-h trial period. Moreover, participants reported increased perceived work efficiency with the non-conventional mouse, including superior image manipulation and comfort during the brief trial period.

The results of this study corroborate prior research findings that radiologists prefer to use mice with additional functionality (non-conventional) over conventional mice [9], but with a significantly larger study population ($n = 59$ compared to $n = 9$). Secondary endpoints, including perceived efficiency gains associated with the non-conventional mouse also corroborate previous research [9]. However, this study extends prior research by also reporting short-term, new user perception and preference information, including their most commonly used PACS functions.

This study has several limitations. First, utilizing only one model of a non-conventional mouse limits the generalizability of results. Second, we did not quantify workflow efficiency changes regarding the number of studies interpreted or relative value units (RVU) generated. Instead, we relied upon self-reported perceptions of the impact of the non-conventional mouse on each radiologist's personal exam interpretation workflow. Third, participant adherence to non-conventional mouse use was not observed during the trial period, such that an unknown number of participants likely did not consistently utilize device functionality appropriately as demonstrated during the training period. Fourth, despite timely administration of post-surveys (within 72 h of trial period completion), several participants ($n = 18$) completed their post-surveys up to 1 week later and four participants completed their post-survey up to 1 month later, which may have contributed to possible recall bias. Finally, further limiting generalizability is that all participants were self-reported right-hand mouse users, though no left-handed mouse users were excluded from this study. A disproportionate number of participants were abdominal/body imagers (16.9%, $n = 10$) and interventional radiologists (13.6%, $n = 8$). While these participant counts reflect current radiology practice trends, they may limit the generalizability of findings as practice demographics change over time. Moreover, a proportion of participants were breast imagers (11.9%, $n = 7$) who utilize a specialized image viewer with a dedicated keypad and the non-conventional mice were utilized as an alternative to the specialized keypad. Given the different style of mammography workflow, it is possible this may have differentially impacted their perceptions of the non-conventional mouse compared to other subspecialties. Future studies should further explore the specific needs and

Table 3 Radiologist preference and perceived efficiencies of conventional and non-conventional mice ($n = 59$)

	<i>N</i>	%
Prefer to use non-conventional mouse over conventional mouse		
Agree	36	61.0
Somewhat agree	9	15.3
Neutral	6	10.2
Somewhat disagree	4	6.8
Disagree	4	6.8
Non-conventional mouse is more efficient		
Agree	34	57.6
Somewhat agree	5	8.5
Neutral	10	16.9
Somewhat disagree	5	8.5
Disagree	5	8.5
Non-conventional mouse requires less time to view all images		
Agree	23	39.0
Somewhat agree	14	23.7
Neutral	16	27.1
Somewhat disagree	3	5.1
Disagree	3	5.1
Non-conventional mouse requires less effort to view all images		
Agree	29	49.2
Somewhat agree	15	25.4
Neutral	10	16.9
Somewhat disagree	2	3.4
Disagree	3	5.1
Non-conventional mouse is easier to manipulate windows		
Agree	31	52.5
Somewhat agree	14	23.7
Neutral	9	15.3
Somewhat disagree	2	3.4
Disagree	3	5.1
Non-conventional mouse is more comfortable		
Agree	33	55.9
Somewhat agree	13	22.0
Neutral	3	5.1
Somewhat disagree	5	8.5
Disagree	5	8.5
Most commonly used PACS functions		
Measure distance	57	96.6
Manual window/level	55	93.2
Arrow annotation	34	57.6
ROI/Hounsfield unit measurement	31	52.5

Table 3 (continued)

	<i>N</i>	%
Continuous zoom	28	47.5
Manual cine	23	39.0
Magic glass (focal magnification)	21	35.6
Selection	19	32.2
Reset to saved state	10	16.9
Invert grayscale	5	8.5
Other	9	15.3

preferences of individual radiology subspecialties and quantify actual changes in workflow efficiency.

Conclusion

The results of this study suggest that current radiologist workstations employ non-optimized user interface technology, specifically regarding the mouse, as participants demonstrated a significant preference for using the non-conventional mouse with enhanced functionality compared to the conventional mouse. Moreover, increased availability of and training in non-conventional mice may be well received by academic radiologists regardless of subspecialty and training level. Finally, in an era of decreasing radiologist reimbursement and increasing exam volume and complexity, it is imperative that radiologists explore multiple options to optimize workflow efficiency to meet the future demands of the specialty. If radiologists perceive greater efficiency in their daily exam interpretation workflow associated with their choice of UID following only a brief adaptation period, then using a

Table 4 Participants aware of non-conventional mouse at pre-training assessment ($n = 38$)

	<i>N</i>	%
Aware of, but have never used non-conventional mouse	14	36.8
Aware of and have used non-conventional mouse in the Past	15	39.5
Aware of and currently use non-conventional mouse	9	23.7
Reason for not using non-conventional mouse ($n = 29$)*		
“Fine” with current conventional mouse	11	37.9
Device availability	10	34.5
Training needed	7	24.1
Device cost	2	6.9
Other	6	20.7

*Participants may have chosen more than one reason

non-conventional mouse may translate to quantifiable improvements in the exam interpretation process and an enhanced user experience.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

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