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Radiologist Digital Workspace Use and Preference: a Survey-Based Study

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Abstract Literature regarding the heterogeneity of and preferences for radiology workstation design—and, in particular, the digital workspace of the radiology workstation—is scant. The purpose of this study was to determine the nature of the digital environments across the specialty and the degree of satisfaction users associated with the particular facets of those environments. A survey was sent to the membership of the Association of University Radiologists in February 2015. The survey comprised 10 questions establishing demographics, current typical workstation setup, perceived satisfaction with that setup, and preferences for potential altered setups. A total of 336 radiologists responded, with a cross-section similar to that described in the 2015 ACR annual workforce survey (1). Although there was a rough split in the number of radiologists using one or two non-diagnostic monitors (46 vs. 51%, respectively), the strong majority (75%) of radiologists use two diagnostic monitors. Users of two non-diagnostic monitors were more likely to keep open the case info (87 vs. 68%) and EMR (84 vs 68%). More senior radiologists tended to find the current setup easy more frequent than younger radiologists, and the latter group was more likely to believe additional monitors would be helpful. Although many radiologists are comfortable with their computing workflows, a significant number indicate dissatisfaction and may be interested in being able to specify the amount of monitor space with which they can work. Additional monitors may promote improved quality in addition to any potential productivity gains.

Keywords Workflow · Ergonomics · Productivity · Diagnostic display monitors

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Introduction

While many prior studies [1–4] have examined the ergonomic and physical aspects of the radiologist's workspace—temperature, sounds, ambient light, seating, etc.—very little research has peered into the digital workspace in which radiologists find themselves. Few medical specialties—or professions, for that matter—are as reliant on the interaction of a single human with so vast an expanse of digital real estate. As such, investigation into how radiologists manage their workspace and windows is merited.

As the profession transitioned to digital image display in the 1990s and early 2000s, radiologists began to experiment with multiple monitor (MM) setups. Indeed, it would be some years after Bennett et al. reported in 2002 radiologists' preference for two monitors over four monitors that other specialties would begin to discuss the potential utility of additional monitors [5]. In spite of radiology's history of research and innovation in digital imaging, however, research on optimal configurations of monitors has been very limited and best practices have not yet been established. Consequently, a large degree of workstation heterogeneity pervades the specialty.

In this survey-based study, we aim to determine the variation in physical and digital workspace at radiology workstations across the country. We further seek to determine the

ways in which information and applications are managed across the digital workspace and the degree to which that management is influenced by users' demographics, existing setups, and stated preferences.

Materials and Methods

An anonymous 10-question online survey (Appendix 1) built using Google Forms (Google Inc., Mountain View, CA) was sent to the membership of the Association of University Radiologists in February 2015. The survey initially comprised 30 questions but was reduced in size and complexity to encourage participation. The final survey required approximately 5 min to complete. A reminder to complete the survey was sent to the membership after 3 weeks.

Two questions established basic demographic information: radiologist age and subspecialty. Additional questions posed requested:

- Number of unique workstations used in a week
- Number of diagnostic monitors at the workstation
- Number of non-diagnostic monitors used at the workstation
- Software that dominates the non-diagnostic screen
- Different applications typically kept open (checkboxes with multiple selections allowed)
- Perceived difficulty using their current setup (five-point Likert scale)
- Degree to which additional possible monitors were felt to be potentially helpful or deleterious (five-point Likert scale)
- Home computing setup

Respondents were instructed to treat single-unit monitors that reproduce the functionality of two monitors as two diagnostic monitors per individual unit.

Results were exported as a spreadsheet and analyzed in Microsoft Excel (Redmond, WA). After simple analysis observing the frequency of responses, relational data were analyzed to establish possible links between answers to different questions. Because of the low frequency within some response categories, the five-point Likert scales were treated as three groups, effectively representing "strongly or weakly disagree," "neutral," and "weakly or strongly agree."

Results

Demographics

Three hundred thirty-six unique respondents completed the survey out of 1333 to whom the survey was sent (25%). Of those, 5% were under age of 30, 36% between age 31 and 40, 19% age 41–50, 24% age 51–60, 11% age 61–70, and 4% above the age of 70. Of the 336 respondents, 275 listed just one subspecialty; 34 listed two subspecialties and the remainder listed three or more. Overall, 28% identified as body radiologists, 16% as musculoskeletal, 13% as neuroradiology, and 10% as breast.

Frequency Analysis

Forty-one percent of radiologists report using just one workstation in a given week, while 36% report using two and 23% report using three or more.

A workstation with one diagnostic monitor is used by only 2% of radiologists, while 75% report using two, 10% report using 3, and 13% use 4 or more.

The reported numbers of non-diagnostic monitors at the typical workstation were 46% for one, 51% for two, and 3% with three or more.

Sixty-seven percent of radiologists report that their dictation software dominates the screen time for the non-diagnostic monitor, while for 21%, that space is dominated by case information, and for 10%, it is the EMR. Note that "case information" was defined "order information, series lists, comparison lists, and/or worklists" which many PACS arrange together.

Although 33% of radiologists find their current setup neither difficult nor easy (Likert 3), more found the setup easy (39%) than found it difficult (28%). On the other hand, while 33% again think additional monitors would be neither helpful nor harmful (Likert 3), 35% felt more monitors would be helpful and 31% felt it would be harmful.

The frequency of home setups (arranged roughly from least to most complex/spacious) was as follows: no home computer 2%, laptop only 42%, desktop with single monitor 25%, desktop with two monitors 15%, laptop with external monitor 11%, and desktop with more than two monitors 6%.

Charts are provided showing the rate at which various applications are kept open on non-diagnostic monitors (Fig. 1), and the frequencies with which different numbers of programs are kept open at once (Fig. 2). Users of two non-diagnostic monitors were more likely to keep open case info (87 vs. 68%), the EMR (84 vs. 68%), and browser (61 vs 56%).

Relational Analysis

Additional analysis was performed to establish relationships between the responses to the questions.

More radiologists find their current workstation to be easy to use (Likert 1 or 2, 40%) than difficult (Likert 4 or 5, 28%), particularly the more senior practitioners over age 60 (49 vs. 16%). Younger radiologists, however, are more bimodal in their opinions of the workstation ease-of-use.

Correspondingly, the age of the radiologist was indirectly related to the degree to which she believed

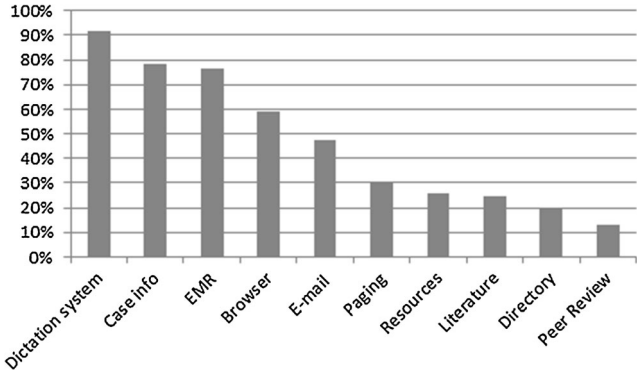

Fig. 1 Rate at which each application is typically kept open

additional monitors would be helpful (Fig. 3). Forty percent of radiologists under 50 felt additional monitors would be helpful compared to 25% who felt that they would be harmful. In contrast, only 18% of those above the age of 60 felt additional monitors would be helpful, while 49% thought they would bring harm.

Expectedly, as perceived difficulty with the current setup rose, so too did the belief that additional monitors would help (Fig. 4).

As the radiologist age increases, the likelihood of having multiple applications (or webpages) open appears to decrease. Fifty-nine percent of radiologists over the age of 60 have three or fewer applications open, and 77% of those over the age of 70 have two or fewer open. By contrast, only 12% of radiologists under 30 had three or fewer applications open, while 71% routinely kept open five or more.

A direct relationship was noted between the number of applications kept open and the perceived difficulty-of-use of the workstation.

Relationships between home setup and other polled questions were weak. However, there was a trend for users of more complex home computer setups to have decreased perceived ease-of-use of the diagnostic workstation and also to believe additional monitors would be helpful.

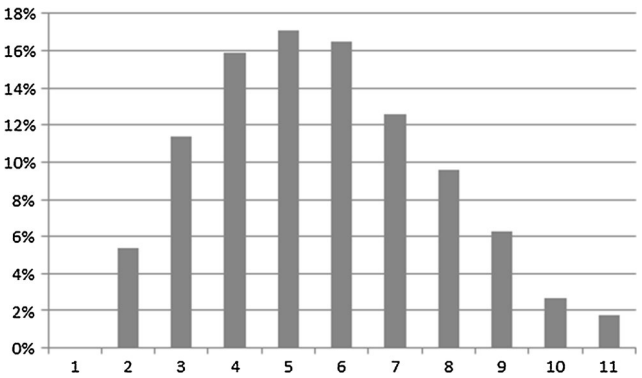

Fig. 2 Rate of users by number of applications kept open

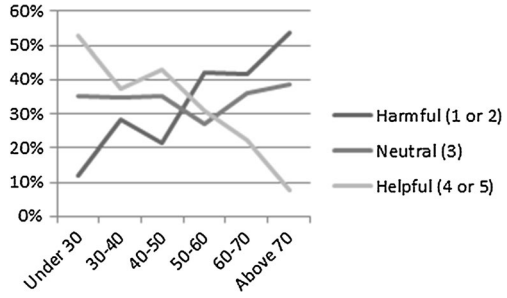

Fig. 3 Utility of additional monitors as a function of age

Discussion

The majority of radiologists (75%) use two diagnostic monitors in their setup. As such, this discussion will focus on the non-imaging monitors.

Outside radiology, studies have demonstrated increased productivity tied to the use of multiple or larger monitors of 44% [6], 39–74% [7], and 9–50% [8]. However, these studies have been criticized for industry influence or poor methodologies [9, 10]. As the price of consumer-grade monitors has fallen, the use of multimonitor computing setups in the workplace has become quite common; indeed, some companies have been reported to offer extra monitors as a recruiting tool [9]. Such setups both increase the number of pixels available for information display and also allow the assignment of dedicated virtual space to disparate tasks. However, this rise in multimonitor use has also led to a debate in popular media of the tension between increased accessibility to information and the potential for distraction [10].

On one hand, toggling data streams and window management make for a cumbersome workflow, costing time, and stress. Examining multiple display setups, Beale and Edmondson suggested that multitasking is itself a task that should be optimized and keeping those tasks or information sources always concurrently in the foreground is one way to do so [11]. Larger monitors showing more information at once have been shown to decrease the time spent managing windows by 90%

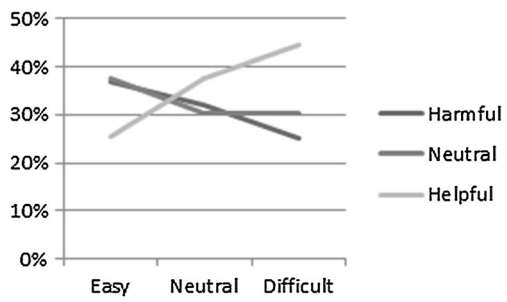

Fig. 4 Utility of additional monitors as a function of perceived difficulty

[12] and are associated with significantly improved winning percentages among computer gamers [13].

On the other, there is a concern that the bottleneck in productivity is not accessibility to information but rather the number of distractions that riddle a radiologist's day [10]. To this end, increased digital space may serve only to increase the number of interruptions a user may experience while providing the illusion of multitasking. Studies have shown that while younger viewers prefer such multitasking and news channels with multiple simultaneous data streams [14, 15], these formats come at the cognitive cost of reduced comprehension and recall [16, 17]. Supporting this idea, telephone call interruptions in the reading room have been associated with increased diagnostic error rates [18].

Our results suggest that although most radiologists are comfortable with their current setup, many may be interested in additional non-imaging monitors. Relational analysis further suggests that these users who would be interested in additional monitors are likely: Users of a single non-imaging monitor, younger, find their current setup difficult and often keep multiple applications or web-pages open on the non-imaging monitors. As noted above, that younger users appear to prefer extra monitors and keep more applications and webpages open is perhaps to be expected.

One surprising finding was the roughly equal number of workstations employing a single non-imaging monitor versus two. At our institution, a single non-diagnostic monitor is used and frequent switching between the dictation software and worklist or case information can be cumbersome. These results reveal that users of two non-imaging monitors tend to find their workflow easier than do those with a single monitor. Although authors have questioned whether additional monitors would simply be used for such distractions as e-mail [10], the different rates at which applications were reported open in 1- and 2- monitor setups suggest that the second non-imaging monitor is most commonly used for case information, worklist, or the EMR rather than for a web browser. Given the American College of Radiology recommendation that radiologists have full access to EMR to allow for more informed interpretations [19], we therefore suggest that additional non-imaging monitors may promote improved quality in addition to any potential productivity gains.

Most radiologists keep three to five applications open during their workday, typically comprising dictation software (92%), case information or worklist (78%), EMR (77%), and browser (59%). We suspect that part of the reason some users reported not using dictation software may be the use of transcriptionists or report-generating tools such as those sometimes seen in mammography.

Corroborating Bennett's results [5], workstations with greater than two non-diagnostic monitors and/or two diagnostic monitors are uncommon and unpopular. We suspect that there is a threshold at which the benefit of additional visible information is overshadowed by the cost of increased visual "noise" and the inconvenience of moving the mouse over greater distances.

The age and subspecialties of respondents were similar to those reported by the 2015 annual radiology workforce survey [20], allowing for overlapping age categories. We believe this portends some generalizability to our results at least with regard to those two parameters, as selection bias is an inherent weakness of survey-based studies.

Other limitations include the potential for confusion in questions posed and the limited granularity that could be achieved while keeping the survey reasonably short. As all respondents are members of the Association of Academic Radiologists, these results may not reflect the work settings and preferences of private practice and tele-radiologists.

Direct observational studies may be able to overcome some of these limitations in the future. We would be interested in determining whether there is true variance in the time spent accessing patient data in the EMR or accessing online radiology references and educational resources based on availability of dedicated monitor space. Interesting, too, would be a cross-over study in which radiologists are placed in groups assigned to one-monitor and two-monitor setups, then switched, and then surveyed for their preferences with an auditing of their productivity.

Conclusion

Literature regarding the heterogeneity of and preferences for radiology workstation design—and, in particular, the digital workspace of the radiology workstation—is scant. Except during vendor selection, individual radiologists rarely have control over the specific nature of the computing environments in which they spend the majority of their workdays. Although many radiologists are comfortable with their computing workflows, a significant number indicate dissatisfaction and may be interested in being able to specify the amount of monitor space with which they can work. This latter group tends to include radiologists who are younger, who keep more programs open at once, and who think more monitors would be better. Further investigation is needed to determine if inexpensive interventions such as the addition of an additional non-imaging monitor can increase productivity or the quality of care provided.

Compliance with Ethical Standards

Sources of Support None.

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

Appendix

The objective in this study (10 questions, 1 page) is to determine the variability in radiology workstation arrangement and determine how radiologists use their "virtual deskspace."

Conversely, how many monitors are used predominantly for displaying or managing non-imaging data?
For example, to view the order information, worklist, EMR, or dictation system?

- (•) 1
- ( ) 2
- ( ) More than 2
- ( ) N/A

At a typical workstation, how many monitors do you typically use specifically for reading images?
For example, given a chest XR with comparisons or a multi-sequence MR, across how many monitors will you display the images themselves? For Barco Seamless"Fusion"monitors and other single unit monitors that reproduce the functionality of two monitors, please count one unit as 2 monitors.

- ( ) 1
- ( ) 2
- ( ) 3
- ( ) 4
- ( ) More than 4
- ( ) N/A

With how many unique workstation setups do you work in a typical week?
Identical workstations in a department should be treated as 1 total.

- ( ) 1
- ( ) 2
- ( ) 3
- ( ) 4
- ( ) More than 4

While reading studies, which most dominates the screen time for your non-imaging monitor(s)?

- ( ) Case info (order info, series, comparisons, worklists)
- ( ) Dictation system
- ( ) Electronic medical record
- ( ) Other

What is your impression of the current ease of use in accessing and managing information on your non-imaging monitor(s)?
i.e., arranging programs and switching between them as needed

	1	2	3	4	5	
Not difficult; easy	○	○	○	○	○	Extremely difficult/cumbersome

Which of these do you typically have open on non-imaging monitors while reading cases?
Select all that apply.

- ☐ Case info (order info, series, comparisons, worklists)
- ☐ Dictation system
- ☐ Electronic medical record
- ☐ Web browser
- ☐ Hospital or department phone number directory
- ☐ E-mail
- ☐ Paging system
- ☐ Radpeer or other peer evaluation method
- ☐ Radiology resources including “decision support” guidelines, criteria, calculators, and websites such as StatDx
- ☐ Literature search page (Pubmed, Google Scholar, Yottalook, etc.)
- ☐ Other: [ ]

Would additional non-imaging monitors make workflow more or less difficult?
For example, having EMR, dictation software, and worklist each on its own screen.

	1	2	3	4	5	
Would make workflow more difficult	○	○	○	○	○	Would make workflow easier

Which best describes your primary home computer setup?
If you have both a desktop and laptop, please answer with respect to the where you do most of your work.

- ○ No home computer (or tablet/iPad only)
- ○ Laptop alone
- ○ Laptop with external monitor
- ○ Desktop with 1 monitor
- ○ Desktop with 2 monitors
- ○ Desktop with more than 2 monitors

Subspecialty, if any:
Please indicate your main area(s) of clinical expertise.

- ☐ Body
- ☐ Cardiac
- ☐ Chest/thoracic
- ☐ Emergency
- ☐ General or plain
- ☐ Interventional
- ☐ Mammography
- ☐ Musculoskeletal
- ☐ Neuroradiology
- ☐ Nuclear Medicine
- ☐ Pediatric
- ☐ Ultrasound/Vascular

Your age
To determine if workspace preference varies by age.

- ○ Under 30
- ○ 30–40
- ○ 40–50
- ○ 50–60
- ○ 60–70
- ○ Above 70

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