Workflow dichotomization and the radiologist's workflow environment

By Dr John-Paul J. Yu

Workflow disruptions are ubiquitous within cognitively demanding and complex work environments and are associated with errors, workflow inefficiency, and task prolongation. The healthcare work environment is one such example of an intrinsically complex work environment that often finds individuals engaging in rapid task switching and task shortening with concomitant deleterious effects on patient safety, workflow efficiency, and other quality outcomes [1].

Not surprisingly, these phenomena have garnered significant interest throughout clinical medicine where the implications of workplace interruptions can include physical, emotional, economic harm, and even loss of life. By virtue of a dynamic and complex work environment and the myriad of responsibilities incumbent on radiologists, the radiology work environment is particularly susceptible to the effects of workplace disruptions [2] with radiologists often experiencing significant strain in maintaining a streamlined, efficient workflow [3, 4].

"... the radiology work environment is particularly susceptible to the effects of workplace disruptions..."

The complexity of the radiologist's workflow environment is largely a consequence of the multiple roles the modern radiologist balances as an imaging expert and diagnostician, physician consultant, educator, and interventionalist. While these responsibilities conceptually span a wide-range of clinical activities, they can be broadly categorized into image-interpretive (IITs) and non-image interpretive tasks (NITs). In a prospective, randomized, observational investigation at our institution, we observed that individuals spent nearly 40% of their total time throughout the day performing NITs including answering phone calls, returning pages, providing in-room consultative services for referring clinicians, technologists, and other radiologists, exam protocoling, and teaching [5]. Moreover, previous work at our institution demonstrated that the reading room work environment is highly fragmented with an average of 14.9 task-switching events (TSEs) per hour, yielding a rate of approximately one interruption every four minutes. The significant time and effort commitment to NITs – in addition to the inherent disruptive nature of these tasks – spurred efforts to better organize and handle these NITs in both an efficient and thoughtful manner.

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THE IMPACT OF RADIOLOGIST WORKFLOW DICHOTOMIZATION

Imaging interpretation is one of many components that constitute the full scope of responsibilities in a modern radiology practice. Even as image interpretation remains our most tangible clinical deliverable, it reflects one of many links in the imaging value chain. Additional links in the imaging value chain include consultative services provided to our referring clinical colleagues, exam protocoling, patient scanning, and other activities previously identified as NITs; however, in spite of the disruptive nature of NITs, they are an essential component of providing value in today's clinical environment. The intrinsic value and importance of NITs belies the frustration encountered with NITs throughout the workday where NITs – with their stochastic and disruptive nature – often occur as unanticipated interruptions to the radiologist's primary duty of high-quality image interpretation. At our institution (and anecdotally at numerous other academic institutions), the sheer number of NITs and frequency of associated task switching served as an impetus for a more thoughtful approach to reading room workflows, with the goal of a more efficient, streamlined practice that leverages existing opportunities for imaging value chain optimization. Towards these ends, we separated our reading room tasks into two discrete workflows — IIT and NIT — to

	Preintervention			Postintervention			
	Average Rating	Standard Deviation	Response Count	Average Rating	Standard Deviation	Response Count	*P* Value
To what degree do interruptions in the neuroradiology reading room adversely affect:							
Your ability to interpret imaging studies?	3.78	0.53	18	2.21	0.86	14	<0.0001
The quality of your image interpretations?	3.39	0.83	18	2.00	0.76	14	<0.0001
Your ability to address non-imaging interpretation tasks (consultations, protocols, monitoring studies, procedures, etc)?	3.28	0.56	18	1.79	0.67	14	<0.0001
The quality of consultations you are able to provide to referring providers?	3.06	0.62	18	1.71	0.70	14	<0.0001
The quality of trainee education?	3.61	0.76	18	1.93	0.70	14	<0.0001

Likert scale: 1 = none, 2 = minimal, 3 = mild, 4 = moderate, 5 = severe.

Table 1. Interruptions

facilitate the division of responsibility for these tasks [6].

After the implementation of IIT and NIT workflows in our reading room, an evaluation of our results clearly demonstrate that workflow dichotomization yields successful outcomes along multiple dimensions of analysis. Implementing discrete IIT and NIT workflows resulted in a precipitous decrease in time spent on NITs by our image interpreting radiologists, falling to less than 25% of pre-intervention level furthermore and moreover, representing less than 5% of the radiologists overall time in the post-intervention period. Perhaps more importantly, the decrease in time spent on NITs was nearly equally matched with a concomitant increase in time spent on image interpretation (up to a total of 73.2% post-intervention from 53.8% pre-intervention) suggesting a nearly-complete direct transfer of NIT-time to IIT-time. The delineation of a discrete NIT workflow also resulted in a 40% reduction in TSEs experienced by the primary radiologist. The marked reduction in TSEs is particularly important and encouraging as numerous previous studies have demonstrated the deleterious effects of interruption on the quality of image interpretation [7]. The reduction in TSEs and increase in image interpretive time was reflected throughout our data with the mean time between TSEs more than doubling from 05:44 to 11:01. With average head CT interpretations times reported in the range of 3.2-4.7 minutes [8], workflow dichotomization would now conceivably and comfortably allow for the interpretation of a standard head CT without interruption and by extension, would reduce the number of interruptions our radiologists could expect when interpreting more time-intensive, complex imaging.

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WORKFLOW DICHOTOMIZATION IMPROVES WORKPLACE SATISFACTION

Beyond the aforementioned positive quantitative impact of workflow dichotomization, there are less tangible but no less important perceptive benefits derived from separating reading room tasks into IIT and NIT workflows. As with other medical specialties, radiology has experienced diminishing levels of professional satisfaction over time and excessive workload is among the most commonly reported reasons for provider dissatisfaction [9]. The intrinsic and extrinsic risk factors associated with career-related burnout specifically amongst radiologists is summarized in a recent report released by the American College of Radiology (ACR) Commission on Human Resources [10]. Identified risk factors for burnout often manifest as descriptions of job dissatisfaction that include work overload, difficult shifts, lack of control, and severe time constraints for work output (e.g, exam turn-around times). We postulate that a highly disrupted radiology work environment is a key culprit underpinning many of these sources of job dissatisfaction, which may in turn lead to radiologist burnout. Workflow optimization efforts, such work dichotomization, to improve reading room efficiencies may also have the added benefit of decreased mental burden, workload, related improved provider career satisfaction. The analysis of and subsequent improvements to the radiologist's workflow environment also requires a careful analysis of individual workloads and the impact individual workloads have on the overall efficiency of a workflow process. These examinations also afford a more nuanced exploration of the impact workflow design has on individual operators. Whereas workflow represents the sequence of processes through which a piece of work passes from start to finish, workload represents the actual amount of work to be done. Workload, on the individual level, is not an absolute quantity and is variably dependent on numerous intrinsic factors (such as individual experience and skill) and extrinsic factors (such as interruptions and system failures), which all contribute to the overall perception of individual workload.

	Preintervention			Postintervention			
	Average Rating	Standard Deviation	Response Count	Average Rating	Standard Deviation	Response Count	*P* Value
Please rate the following as they apply to your work in the current neuroradiology reading room setting:							
Mental effort required to concentrate on your work	3.71	0.82	17	2.79	0.77	14	0.0034
Stress experienced while performing your work	3.24	0.64	17	2.36	0.61	14	0.0005
Effort required to achieve your desired level of performance	3.65	0.68	17	2.79	0.67	14	0.0006
Effort required to accomplish everything you're asked to do in the reading room	4.12	0.68	17	2.79	0.67	14	0.0001

Likert scale: 1 = very low, 2 = low, 3 = medium, 4 = high, 5 = very high.

Table 2. Workload

	Preintervention			Postintervention			
	Average Rating	Standard Deviation	Response Count	Average Rating	Standard Deviation	Response Count	*P* Value
In the current neuroradiology reading room setting, how satisfied are you with:							
Your ability to interpret imaging studies?	3.29	0.82	17	4.38	0.49	13	0.0002
The quality of your image interpretations?	3.41	0.84	17	4.31	0.46	13	0.0017
Your ability to address non-imaging interpretation tasks (consultations, protocols, monitoring studies, procedures, etc)?	2.35	0.59	17	4.54	0.50	13	0.1768
The quality of consultations you are able to provide to referring providers?	3.35	0.59	17	4.46	0.63	13	0.0358
The quality of trainee education?	3.00	0.84	17	4.31	0.61	13	0.0849

Likert scale: 1 = completely dissatisfied, 2 = somewhat dissatisfied, 3 = neutral (neither satisfied nor dissatisfied), 4 = somewhat satisfied, 5 = completely satisfied.

Table 3. Satisfaction

EVALUATION OF THE IMPACT OF WORKFLOW DICHOMOTIZATION

To evaluate the impact of workflow dichotomization on perceptions of workload, workplace interruptions, and workplace satisfaction, survey data were collected before and after workflow dichotomization at our institution; data are summarized in Tables 1-3 [11]. Following implementation of separate dedicated image-interpretive and non-image interpretive workflows, our work demonstrated a measurable uniform improvement in workplace satisfaction with a concomitant decrease in perceptions of the workplace disruptions and effort required to complete workplace tasks. Beyond the quantitative impact of workflow dichotomization, these data reflect the perceptive changes that occur in the workplace and capture important benchmarks that might otherwise go unnoticed in quantitative measurements (and improvements) in workflow dichotomization.

As clinical imaging volumes continue to increase, an understanding of workplace disruptions and their impact of radiologist productivity and global measures of radiologist workload and workplace satisfaction have become increasingly salient. Implementation of separate dedicated image-interpretive and non-image interpretive workflows resulted in improved radiologist perceptions of workplace disruptors and mental effort with a concomitant improvement in overall workplace satisfaction. These and other similar efforts highlight the importance of workflow design not only on workplace efficiencies but also in the positive secondary gains observed in individual workload levels and offers a potential practice model that offers outstanding patient care while also providing radiologists an opportunity to engage in a rewarding clinical practice.

"....Implementing discrete Image Interprteive Tasks (IIT) and Non-Image Interpretive Tasks (NIT) workflows resulted in a precipitous decrease in time spent on NITs by our image interpreting radiologists,

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