Aalto University
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Sticky Fingers: The effect of sticky interaction patterns on the design and adoption of a Radiology Information System upgrade

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ABSTRACT OF THE
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Upgrading any business-critical software can be a cause of stress and uncertainty for both the daily users and administrators of a system. Upgrades can have technical ramifications for the systems used in an enterprise, requiring new hardware, supporting software, and upgrades to security packages in the system. One consequence of upgrading that is less well defined is the human factor, yet the reduction in productivity and increased error rates that often results from updates can have large effects on the efficiency, confidence, and daily activities of employees. Common actions are often the most difficult processes for users to shake as they move to a new system.

This thesis explored which actions and processes are the most difficult for users to learn anew and explore the psychological reasons for this. The results showed the stickiest interaction patterns fall into a few general psychological and phenomenological categories. Cognitive mapping, automation and procedural memory provide the baseline by which users experience build their understanding of the systems they use. These are usually informed by the familiarity of interfaces, the affordances they make use of, and how they allow for users to cope with changes. Negative transfer occurs when learning a new interface, as users try to bring their existing expectations with them. The self-efficacy and confidence of users are affected by how the new interface is introduced to users, the support it has, and speed at which they can learn the new system. The individual, specific interaction patterns that will be sticky will depend on the product and context of use. However, the interaction patterns observed through the course of the research outlined in this thesis fell squarely within the psychological and phenomenological constructs determined through the literature. Based on these theories and the supporting evidence, ten design recommendations are laid out for use when upgrading a system interface. Following these recommendations allow the designer to reduce the effects of negative transfer and reduced self-efficacy by leveraging the previously constructed cognitive mapping, cognitive automation, and procedural memory of the user.

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Terminology

Radiology Specific

Appointment	The date and time a patient is requested to be at a clinic for an exam to be completed with them
Client	An organization that has purchased access to the products that are produced by my company
Clinic	A physical location belonging to a client at which patients are served by medical staff
EMR	Electronic Medical Record
Exam	The act of a patient being scanned by a technologist while at a clinic
HL7	Health Level 7 - a standardized digital protocol to communicate information between Healthcare applications
Modality	The type of scanner used to produce the images which the radiologist will read and interpret eg. Ultrasound, CT, MRI
Procedure	A specific group of images the physician has requested from a modality eg. left ankle (x-ray)
PACS	Picture Archiving and Communication System
Protocolling	The process of analyzing a requisition received by a radiology clinic to determine if and how a procedure may be completed with a patient. Usually done before booking by a qualified technologist or radiologist.
Radiologist	Specialized medical practitioner who reads and interprets medical images to diagnose patients with a range of illnesses, diseases, disorders, and assess the severity of wounds
Requisition	Request for imaging of a patient to diagnose something a family physician or non-radiology specialized doctor believes a patient has. Usually printed by radiology clinics and given to doctors, containing a list of procedures the clinic can complete.

RIS	Radiology Information System – a software application that helps clinics schedule appointments, manage resources, distribute reports, and bill patients.
Prior Reports (Priors)	The report of a diagnosis made by a radiologist pertaining to a study completed in the past on a patient. Used for comparison for a new study to view changes or disease progressions.
Study	The images and reports generated based on an exam conducted with a patient.
Technologist	Trained specialists who interact with patients and operate the imaging modalities.
Worklist	A list located in the RIS that indicates what a user needs to do next, for clerks this usually involves schedule exams for which they will check in patients. For technologists, the worklist indicates which patients are in the clinic and ready to be imaged.

Interface Terminology

Browser-based Application (Cloud, Zero-footprint)	An application or software that does not need to be installed on a computer as it can be accessed through an internet browser with a specific URL.
Dialog/Modal	Small windows of interactive content that appear in the middle of a screen to concentrate the user on a specific set of actions
Wizard	An interactive screen that divides the steps of a complex procedure by breaking the procedure into the a series of discrete steps that are presented one at a time.

1 Introduction

Upgrading any critical software can be a cause of stress and uncertainty for users and administrators of a system. Upgrades can have technical ramifications for the systems used in an enterprise, requiring new hardware, supporting software, and upgrades to security packages in the system. However one consequence of upgrading that is less well defined is the human factor. Users of a system, over time, develop a sense of competence within the system (Heyer, 2018; van Hooij, 2016; Oulasvirta, 2005); upgrades can disrupt these competences and affect the self-efficacy of users (Shu, 2011; Carroll, 1986; Scarr, 2011) as well as the time it takes users to complete their tasks, costing the company more money than just the tangible costs of computer upgrades (Bergman, 2018, Jazayeri, 2007; Bellissimo, 2006).

As users become more comfortable with technology in general, they have become more comfortable with the upgrades that are inherent in an industry that never stops moving forward (Murnane, 2019; Kelly, 2019; Kirby 2017; Gibbs, 2019). However it is one thing for Instagram, Google, or Spotify to update their consumer products with a new font or button to access a feature, and quite another for an enterprise-critical tool to be updated as it may disrupt how that enterprise functions (Bellissimo, 2006; Vaniea, 2014; Vaneia, 2016). Adding to this difference is the general upgrade habits of enterprise software in the past, where software is left in a stable condition for a long time before a major upgrade is introduced every few months or even few years (Bellissimo, 2006). This kind of staged release, instead of continuous deployment, may sound like a better option to enterprises because of the stability and familiarity they could have with the software. However this has also meant that the updates users face when an enterprise finally does update are more disruptive to their processes with large changes to their workflows, the interfaces they work with, and the responses of the system to their input. Therefore, instead of the continuous updates and small changes to their interaction patterns that users are accustomed to in their consumer software, the software at work tends to update less but be more disruptive when it does.

In addition to dealing with the perceptual issues surrounding upgrades and the real effects they have on the efficiency, efficacy, and interaction of users, the subjects of this research are undergoing a software upgrade in a medical context. Due to the high standards of patient safety required in the medical industry, updating software is a slow process and depending on the use of the software, it may need to be assessed by various medical regulatory agencies (ISO 13485: 2016). This regulatory environment has contributed to the slow, risk-averse development processes involved in upgrading medical softwares, a contributing factor in the dislike users have for upgrading. High levels of regulation have also contributed to the development of stricter testing of medical devices (Schmettow, 2013). Although randomized controlled trials are considered the gold standard for medical device, drug, and service testing (Bloor, 2011), it is not the only methodology that may be employed to evaluate various systems associated with the medical industry. Indeed, it is a rather difficult methodology to employ when working on a product that is not fully developed, and therefore not in a position to replace the previous or existing option.

The purpose of this thesis is to explore the psychological factors around the adoption of updated software systems in the context of a radiology practice. By understanding the cognitive processes behind the problems users experience when interacting with an updated system, we can learn how to design to reduce the friction users experience when they adopt the new version of the software. Reducing friction, frustration, and confusion due to upgrading will not only make the work of users easier, but also reduce the resources lost in the transition for the enterprise updating its system. By designing to take advantage of prior knowledge, software companies will need to dedicate fewer resources to re-training users, and radiology practices will need to spend less time training their users, less money paying for the training, and experience fewer user errors as a result of the update. The work completed in this thesis will focus on the context of a radiology practice; however, the findings will be generalizable to other contexts in which the continuity of practice and the maintenance of high levels of accuracy are very important. Further exploration of other practical applications will take place in the discussion and conclusion sections of this thesis.

1.1 Radiology Information Systems in Context

Radiology is a relatively new medical field, X-rays having been discovered only in 1895 (CME, 2019; Hassenbruch, 2002; Feldman, 1989). In 1901, the inventor, Wilhelm Roentgen received the Nobel Prize for his invention and the advancement of the capabilities of the medical community. X-rays proved invaluable to help diagnose fractured and broken bones among many other ailments and diseases. The diagnostic capabilities of radiologic tools have only expanded in the years since Roentgen's first glass plate X-ray (Sunnybrook,2019; NDT, 2019; Hassenbruch, 2002; Feldman, 1989). Today we have many types of medical imaging - X-rays, ultrasounds, magnetic resonance imaging, nuclear imaging, and computed tomographies. Many of the major advancements in radiology have been tied to the advancements in computing power, with significant new forms of radiology like 3D ultrasound, CT scans, and interventional radiology only becoming possible with high-powered processors (Feldman, 1989; DICOM, 2019).

The radiographic devices and their capabilities are only one side of the equation. In addition to capturing images, radiologists and other medical practitioners required a way to store, share, and access the images after they were taken. The first X-rays were stored on glass plates (CME, 2019; NDT, 2019b) but were rapidly replaced by film storage. Films remained the dominant storage and viewing mechanism for radiology images until computers became a common resource in hospitals and clinics. The 90s began a migration from film image storage to digital storage aided by the standardization of image communication through DICOM (DICOM, 2019).

Prior even to the digital image retrieval systems being introduced into radiology practices, radiology information systems (RIS) were adopted as a digital solution to aid in the report distribution process (Nance, 2013). These computer systems were designed to increase the efficiency of running clinics or radiology departments around radiologists, acting as the backbone of radiology practices. These systems are now responsible for scheduling appointments, maintaining patient records, and submitting billing claims to responsible parties. They ensure that a radiology clinic has patients coming in the door and that radiologists get paid. This makes them the third most important piece of software in the company, only behind the Picture Archiving and Communication System (PACS) and image viewer of the radiology clinic which is responsible for storing, accessing, and often displaying the images taken in the clinic for the radiologist to read and diagnose. Due to the critical nature of the RIS to the functioning of a radiology practice, it is a software that is both sprawling in its functions and incredibly risky to replace or upgrade.

The day to day use of an RIS can be broken into four distinct sections, each used by a distinct type of users. Interacting directly with patients are front desk clerks (FDC) and booking clerks (BC). Billing clerks (BiC) and administrators (Admin) generally don’t interact directly with patients, but have critical functions in the RIS nonetheless. Front Desk and Booking Clerks handle booking appointments, pre-arrival requirements for patients, and checking patients into the clinic upon arrival. These tasks are facilitated through appointment searches, calendar views, worklists, and patient searches. Billing clerks and Admin personnel complete more diverse tasks in other interfaces, handling things like claim submission to various payers, adjusting billing information on claims, inputting procedures, clinics, and modalities, and keeping track of any other resource that can be input into an RIS. Report distribution is generally handled automatically by the system when all information is entered correctly, though clerks often need to check in and fix issues that arise. In many cases, the work completed by front desk clerks is repetitive in task and varied in content: all patients need to be booked and checked in with the same method, only the content of the action changes. With a good RIS, this means that the system really can fade into the background, allowing users to focus on the information they are inputting rather than how they need to input the information.

The advancement of any and all technology in radiology clinics is reliant on strong security measures to protect patient privacy, and - in diagnostic tools - adherence to all region- or country-specific medical device regulations. Although radiology practices are inherently reliant on new and changing technology to take, store, and access images, there is a sense that this high pace of change either doesn't happen or doesn't need to happen for clerical tasks in the clinic. Indeed most of the research completed within the company has revolved around the radiologist, their workflows, and how to improve efficiency in their tasks. And yet, a common concern in our research among administrators of radiology clinics is the lack of transparent information on how their clerical and technical staff are doing in terms of efficiency. This lack of knowledge at the technologist and clerical level may very well be hiding real potential for clinics. In fact, any efficiencies that may be gained at the clerical or technologist level may improve patient outcomes, either by increasing the number of patients seen by staff, or by improving processes which can improve consistency for patient interactions. With rapidly aging populations in North America and Europe, the demand for diagnostic imaging will only increase (Perez, 2019), making it more important for clinics to grow, and more important that they not waste resources to inefficiencies. However, to properly monitor and understand how the staff other than the radiologist might contribute to efficiency, they must be researched, their systems must be updated to capture their metrics. This thesis is exploring one project at one company that aims to do just that.

2 Research Question

2.1 Scope

To guide the research of this thesis, the scope should be outlined in more concrete terms. As discussed in the introduction, this thesis is being conducted while the author is working at a medical software development company. This company focuses exclusively on radiology software, including a PACS, a viewer, and a RIS software, among a series of other solutions that clients (radiology practices, hospitals, and clinics) can use to book, store, view, and share diagnostic images. For the purposes of this thesis, the research will be looking specifically at a project the company is working on to replace an existing (old) RIS solution with a new, browser-based (or zero-footprint) solution. The existing solution, a desktop application, grew over many years with new functions being added organically, much like Microsoft Office before its redesign in 2012, resulting in a bloated application (Greene, 2012). The cloud solution is in the development phase and will not be complete before this thesis is submitted, so all research completed for this thesis will become actionable feedback for the development team. The scope of this project is confined to the design and development phase of the new RIS, with the findings of the research in this thesis having a real impact on the outcome of the project.

2.2 Questions

Within the scope of this thesis then, is to answer the following questions:

1. What are the interactions that remain most ingrained and difficult to overcome when being asked to upgrade to a new version?
2. Are there underlying psychological or mental models that explain which interactions are most difficult to learn anew and why that is?
3. How can we design and develop a system that facilitates the adoption of the new solution?

The answers to these questions, when combined, will offer the company with a set of recommendations and guidelines for upgrading the interfaces of their applications. By basing the recommendations in the psychological theories of human-computer interaction, the company will be able to confidently benefit from the recommendations in a variety of projects outside of the RIS upgrade. The recommendations will also be generalizable outside of the context of the company, providing designers in the process of upgrading enterprise solutions with guidelines that reflect their intentions.

3 Theoretical Background

Upgrading is not always a simple process, requiring changes in user interfaces and, in some cases, also changes in computing hardware. These two parts of upgrading have real consequences on how users perceive upgrading, with software usually being the easier of the two. In general, upgrading is seen by users through two lenses. On the one hand, users have resigned themselves to updating their personal software and hardware when their software providers tell them to and when their hardware no longer meets the minimum recommended specifications for new software (be it operating systems, certain applications, or games). These updates are made in spite of stories in the media about problems ranging from Nest thermostats draining their batteries and no longer controlling the temperature (Bilton, 2016) to locking users out of banking accounts (Chapman, 2018), and Samsung and Apple software updates slowing down old phones (Gibbs, 2018; Kirby, 2017). At this point, users are rather used to these stories. Users are still paying attention to the updates; they just don't feel they can do much about them.

The second perspective users have of updates and upgrades is on the business and enterprise software level. Unlike personal software, enterprise software can have huge repercussions on how users complete their jobs. Though most industries will have their own specific software, there are some common systems, such as the Microsoft Office Suite (and now Google's GSuite), email software, scheduling software, and human resource software. These enterprise software solutions are some of the most stable software solutions out there. Not that there have never been issues associated with past updates. Microsoft, specifically, has faced criticism a few times, both for problems with their operating system (Hanson, 2019; Kelly, 2019) and for their office software (Chester, 2014; Greene, 2012; Schifreen, 2011). The introduction of the Ribbon Menu was a source of great discontent among users who thought that the screen space eaten up by the ribbon could have been put to better use (Chester, 2014; Schifreen, 2011). Yet years later, when announcements came from Microsoft about moving or changing the ribbon, users again confronted the company with an outcry of decreased usability (Brandon, 2018). The only difference? 10 years of experience with the feature that was being altered. This high level of familiarity and reliance on a software that could affect a worker's productivity can be a huge source of anxiety for users of various types of software, not only Microsoft Office.

Beyond bad stories in the press, and a general sense of unease with upgrades and updates, why do users dislike them? To understand how and why users find updating software to be so difficult, we must establish how users interact with software they already use.

3.1 Users Using Software

Before going in depth on specific interaction theories, consider first the psychological and philosophical underpinnings of those theories as they have real implications on the understanding of how and why these theories of interaction function. The theories discussed fall into two categories: some come from the perspective of cognitive psychology, while the others are grounded in phenomenology. Those theories based in cognitive psychology rely on an understanding of the human mind that is rational, logical, and reasoned. These theories, while they explain much of the interactions that users have with their software, do not capture some of the less rational actions that users take.

For a more fluid understanding, one can turn to phenomenology and theories of embodied interaction. These theories concern themselves with situated interactions, always interested with the interaction of the user with technology in context. Embodied interaction builds on the work of Merleau-Ponty (Merleau-Ponty, 1970), Dreyfus (Dreyfus, 1998) and going back to the work of Heidegger. This line of theoretical thinking doesn't seek to understand the specific cognitive actions that lead to learning or complicate adapting to a system, but rather focuses on a more holistic view of the way that people interact with the world around them. In an ideal world, the tools of a user function as an extension of their body and their desires such that they do not need to think or theorize about the tool itself; it is "ready-to-hand". In many ways, the use of word processing software, the monitor of the computer, and the keyboard of the computer are all "ready-to-hand" to a user who is writing a document on the computer. When a user moves from the flow phase of writing the document to take a discrete action on it, like formatting or a spell check, the software becomes "present-at-hand": something the user must consider and theorize about to understand the results. The computer itself, the monitor, the keyboard, and the mouse, however, stay "ready-to-hand", as they continue to function without requiring theorization on what actions taken on them will bring.

In the case of upgrading a known interface, we are removing the product from its place as a "ready-to-hand" tool and forcing the user to re-evaluate how they need to interact and what the consequences of each action are. Using this understanding of embodied interaction, both van Dijk (2018) and Heyer (2018) developed design strategies that would facilitate users' interaction patterns with various digital technologies. These design strategies will be helpful in determining how to design an updated interface that it will disrupt user interaction patterns the least.

On the other side of human-computer interaction theories are the theories based on cognitive psychology. Like phenomenology and embodied interaction, cognitive psychology has theories that look to explain how users interact with technology, learn skills and patterns, and why updating interfaces cause so many issues for users. Theories of learning, like SKR (van Hooij, 2016), where users work their way up from knowledge-based use to skill-based use, can help to explain how users learn a system. As users gain familiarity with an interface, they need to expend less cognitive processing power on interacting with the system, allowing them to work faster and more efficiently. Spending less time thinking about the system itself also allows users to increase the care and attention they give to the actual task or job that they want to complete (Navon, 1979; Rice, 2008).

How do these perspectives function in reality? In the case of a clerk at a radiology clinic, when they are first hired they spend time being trained, taught not only their job, but also how they must interact with the systems that support their job clinic. In any radiology clinic, there are many rules clerks must learn about: which procedures are available in which rooms, for which patients, and with which technologists. These rules and how they are applied is further complicated when clerks are required to learn the system they will use to input the information. Here, the clerks are exposed to an additional layer of knowledge necessary to perform their job - what terms are required for each action, where in the system each action is performed, and what items they need to complete for each patient interaction.

Over time, clerks working at a clinic can turn the knowledge they learn into rules they can follow or even expert skills that verge on intuition (van Hooij, 2016). Because clinic rules, procedure requirements and specifics of procedures change regularly - often the only consistent element clerks experience in the clinic is the RIS they are using. Having this single constant can result in accelerated learning of the system through concurrent changes and a greater hesitancy to uproot that constant. Being experienced with the system means the system can fade into the background, allowing the user to focus on fluctuating, day to day interactions. From a phenomenological perspective, the clerks, over time, experience the software they are using as ready-to-hand (Merleau-Ponty, 1970), with coping strategies firmly in place allowing them to work as efficiently as they need to (Heyer, 2018). Psychologically speaking, these users build cognitive maps (Jacobs, 2003), developed cognitive automations (Gupta, 2002), and procedural memories (Carroll, 1986) that offload the cognitive load (Navon, 1979) of interacting with the system.

3.2 Using Current Software

Users constantly interact with software in their lives, learning and adapting its processes to different contexts as needed. However, certain unifying factors contribute to a baseline understanding of the technology users need to interact with.

3.2.1 Cognitive Mapping

Familiarity

Research into visual search has shown the importance of familiarity (Todi, 2016), prototypicality (Tuch, 2012) and fluency (Nazareth, 2014) for fast and efficient search interactions. Users rely on prior interactions with interfaces to perform tasks in other similar technologies and interfaces. Where Tuch et. al (2012) looked specifically at the first impression of a website based on prototypicality, Todi et.al. (2018) looked at visual search patterns. Nazareth (2014) went further and explored what lies beneath the subjective perceptions of users of their improved abilities in familiar and prototypical interfaces. Prototypicality refers to the similarity that a certain interface has with other interfaces of the same purpose, so a retail website that looks like other retail websites is more prototypical than a retail website that displays none of the same elements. Users were more likely to find very prototypical websites appealing where appeal, goodness, or beauty can be indicators of usability (Tractinsky, 2000). Though this research focused specifically on prototypicality influencing the appeal of many different sites, exposure to the same site should have a similar effect, with increased exposure leading to a sense of prototypicality and increased appeal of a specific site. Updating the interface, then, must keep some of the broad stroke prototypical features for users to find it appealing.

Indeed, the work done by Todi (2018) and Oulasvirta (2005), looking at search time in visually similar sites offers a promise of this kind of elevated appeal based on prototypicality in site design. Todi showed that there are a few elements that increase the sense of familiarity experienced by users. They found that the basic frequency of encountering one type of website increases the speed at which users could pick out important details. Secondly, they found that users subconsciously engage in statistical learning; users will remember best the first and last things they see in a site and have an internal sense of how likely it is that something is positioned in a certain location based on prior views. Finally, users do build up a cognitive model of interaction patterns upon which they base many of their actions. This kind of familiarity and the reinforcement of it through further interaction with similar sites breeds a certain kind of visual search pattern that users rely on. When updating interfaces, it is very important to remember this kind of search pattern as changes to it will have an impact on the efficiency of users as they try to locate elements on the page.

However, it is important not to generalize these kinds of prototypicality too far. What is prototypical for a retail site is not the same as what as familiar in the screens of a RIS. Work done by Sarcar (2016) in optimizing interfaces for aging users was very clear to point out that users with different requirements and different goals will use any interface differently; to try to design for the ‘universal’ user or to design a completely prototypical site would result in something that ends up being useless for most. When designing for familiarity and prototypicality, we must realize that the familiar and prototypical should remain within the realm of other RISs, rather than trying to imitate the users’ favourite application. And even in the RIS redesign and update that retains some of the markers of familiarity with the old design, the sim should be to increase accuracy and reduce the error rates (Sarcar, 2016) of users in the updated interface, as no user can become an expert in everything.

Cognitive Mapping

Taking familiarity one step further, various researchers have explored the extent to which users develop not only familiarity with an interface, but something akin to a cognitive map. Cognitive maps, as described by Jacobs (2003), are a cognitive model or representation of a known space. A lot of research into cognitive mapping has been done in real world spatial mapping—how someone can know their way home or a rat can learn a maze (Jacobs, 2003). Along with the exploration of the physical world and the cognitive maps drawn there, researchers have studied the cognitive maps that users draw of the virtual world (Tversky, 1993; Hornof, 2003). In both Tversky (1993) and Hornof (2003), cognitive maps or similar cognitive constructs are the form through which they explain the increased speed and accuracy of user interactions over time. Hornof takes the research further with eye tracking data, like that of Todi (2018) which reinforces the theory that users of a system build a mental model of the virtual landscape so when they return, they may more easily locate the information they need. Omanson (2010) was comparing keyboard and mouse efficiency in command execution. They found in their analysis that both menu- and toolbar-mouse interactions outperformed theoretically predicted execution times and although menu-mouse interactions were not as fast as toolbar-mouse interactions, there was a lower cognitive burden in both as users were able to develop cognitive mappings of where commands were located rather than needing to know the actual command they wished to use.

Just like navigating a physical space, cognitive maps allow users to more efficiently navigate a virtual space. Familiarity and Cognitive mapping are a way users can improve their efficiency and accuracy at various tasks they need to complete within an interface. The eye tracking of Hornoff (2003), showed that users not only make use of hierarchies (landmarks), but will anticipate the location of information once they know where it should appear. It is important that these cognitive maps be understood both as how they are functioning with the old RIS as well as how they will be disrupted when switching to the new one.

3.2.2 Cognitive Automation and Procedural Memory

Cognitive Automation and Procedural Memory

Familiarity breeds not only cognitive mapping of an interface, but also cognitive automation and procedural memory (Gupta, 2002; Carroll 1986). Based in cognitive psychology and the understanding of cognitive processing as a finite resource to be allocated and managed (Navon, 1979), cognitive automation and memory are a kind of temporal- or task-based mapping. The development of automation and procedural memory are a strategy users engage in to reduce cognitive load on repetitive tasks. While both cognitive automation and procedural memory are offload processes for tasks, cognitive automation refers to an automation of the decisions and interactions that users must complete to succeed in their task (Altmann 2008, Mosnell 2003, Raskin 2000). Bergman (2018) discusses cognitive automation in the context of users not needing to think about how they last saved a document in a word processor. The 'ctrl+s' command or mouse click on the 'save' icon is used so often that the user doesn't need to think through each keystroke or mouse press to complete the action. Another example would be when someone plays a computer game: the more experience the player has with a game, the more automatic their in-game actions become, until they think in goals rather than individual steps. Procedural memory on the other hand, refers to motor or skill memory (Ryle, 2009; Gerrig, 2015). While procedural memory is often associated with physical activities, like riding a bike (Gerrig, 2015), there is evidence that users of interfaces can also develop some motor memory of common interface sequences (Quinn, 2016).

Coping

Software, and RIS in particular, are never used in 'optimal' conditions. There are always distractions, changing contexts, and interactions that don't match the happy path envisioned by the designer. The constant upheaval users experience in their day-to-day interactions leaves them constantly seeking some kind of equilibrium—but they cope (Heyer, 2018). Heyer sees coping as the user becoming just skilled enough for a few critical paths of interaction to be offloaded from the cognitive backlog, allowing the user to be that much more focused on the interaction they are attempting to complete. Moreover, coping is only possible where this kind of interaction is promoted and exposed in the software. Coping in this sense comes from a more phenomenological background, based on the works of Dreyfus (1998) and Merleau-Ponty (1970). To describe coping as a way to reduce the cognitive backlog is not technically accurate. Rather, coping is a way that users are constantly, unconsciously responding and adapting to the situation in which they find themselves. Whether that situation is holding an over-full glass of water or interacting with a patient while working with a RIS, the goal is a functional equilibrium. Coping is less a specific and executable strategy of interaction and more a way to understand holistically how users are adapting and learning to interact with systems beyond their conscious learning and application of the knowledge and rules that they need to operate it.

Coping is also a good way to explore the concept of affordances. If coping is a way of responding to changes in an environment, affordances are a piece of this interaction.

Affordances

Affordances, as discussed by Gaver (1991), are “properties of the world that are compatible with and relevant for people’s interactions”. Therefore, affordances are something that gain and lose their relevance to users as they interact with a system, allowing them to cope with or adjust their interactions for the specific situation (Heyer, 2018). A ffordances are also sometimes discussed as ‘perceived affordances’ (Norman, 1999), with a focus on the *signalling* they do to facilitate user interaction, rather than what the user can actually do with the system at the time of interaction. In the description of perceived affordances, Norman looks to use these elements as signposts to signal or guide users towards a specific action or outcome, where the system dictates to the user what it is allowing to happen. From Gaver’s perspective, affordances are only valuable when the user can truly grasp what is being afforded by a signal in context. Coping is best served by affordances as described by Gaver, as the system offers users affordances in ways that compliment and respond to the context in which the user finds themselves (Heyer, 2018; van Dijk, 2018). Gaver (1991) also describes affordances as sequential or nested, in which each user interaction can reveal or expose a new affordance. It follows that affordances may need to be grouped together to properly signal an action is possible. The examples he gives are of a scroll bar in which one affords grabbing, then dragging; and a door with a handle, where either the door or the handle alone would not afford much interaction. The concepts of sequential and nested affordances demonstrate a particularly close relationship with coping, as it is by first perceiving one affordance that the user becomes aware of a new possibility or disequilibrium in their environment, leading to or necessitating the second or third affordance offered by the system.

Affordances allow users to grow and adapt within a system without having to rely on a general metaphor of interaction or cognitive map of the situation, which can make coping a method to lean on when introducing a new interface. On the other hand, as users become used to certain affordances in their interactions, they may begin to expect these same affordances to be available moving forward. The signalling and existence of affordances in the old interface must therefore be carefully considered moving forward into the new interface as users may have associated certain visual cues with the affordances offered in the old system. Using these visual cues and the understanding that users build over time, they can develop a kind of cognitive map of the interface, something that can be very difficult to disrupt.

3.2.3 Negative Transfer

As users gain familiarity, build their cognitive maps, automate their actions and develop procedural memories, they entrench these interaction patterns. As a user learns to automate an action or their hands learn to guide a mouse to a specific location on a screen, these actions and motions become associated with the intention the user has: the goals of the video gamer (Bergman, 2018). This learned interaction often makes it more difficult for users to learn a new way to complete the same task; in fact, the previous learned pattern of interaction can actively interfere with learning something new (Carroll, 1986; Anderson, 1987; Finstad, 2008; Altman, 2008). This negative transfer can take place when a system resembles another on the surface but functions differently below (Finstad, 2008). In this situation, a user may falsely assume the same function will involve the same processes as one they have encountered before. Carroll (1986) also refers to negative transfer in the context of cognitive mapping, either a spatial mapping of an interface or the mapping of specific terminology to specific functions. Here a user may move their mouse to the location on the screen they are used to finding a specific command, only to find that there is nothing there for them to use. Carroll (1986) and Anderson (1987) both found that once a mapping is developed or an interaction learned, users are less likely to anticipate functionality outside what they have learned. Users may at times be using a system in a way that they think is proper or efficient, only to have completely missed out on the optimal method. Not perceiving these other options may also contribute to the phenomenon of “satisficing”, where users of a system are content to work with whatever solution they have at the moment due to a perception that the cost of finding a better option would outweigh the benefits of that better option (Simon, 1959; Tak, 2013).

3.2.4 Erasing Self-Efficacy

Though not a specific visual element, self-efficacy, or the promotion thereof, means a lot to how users perceive a system. Self-efficacy refers to a users perception of their own ability to complete tasks (Shu 2011). Higher levels of self-efficacy are strongly associated with a more positive perception of systems and less stress in users (Ariff, 2012; Shu, 2011; Eastin, 2006). Self-efficacy is tied to a user’s sense of autonomy and control; users who feel like they are in control of their situation usually exhibit higher levels of self-efficacy (Ryan 2000). In the context of upgrading enterprise software systems, changes may make users feel out of control (Vaneia, 2014). The upgrades that happen at work are not decided by most of the users, the reasons for changes are often unclear, and in some cases there is very little training on the new system. Users who judge themselves less confident in their skills generally experience 'technostress' and are unable to cope with, learn from, or concentrate on systems they find stressful (Shu, 2011). Training has been used in the past to mitigate some of the stress that users feel towards new technologies with some success (Torkzadeh, 2002). However, training is not the only solution to increasing user's perception of their own self-efficacy.

3.3 Designing for Adoption

Understanding the way that users build models of interaction and their self-efficacy in using systems helps designers build solutions that facilitate these developments. While some designs focus on how to train users to improve their confidence (Torkzadeh, 2002; Carroll, 1984; Lane, 2005; Davis, 1998), many others attempt to design interfaces in such a way that training is either not or minimally necessary (Cockburn, 2014; Darejeh, 2013; Scarr, 2011) . The research on adoption explored here is generally split between research done on encouraging new users to learn a software (Darejeh, 2013; Carroll, 1984; Davis, 1998) and how to support users as they transition from novice to expert users (Scarr, 2011; Cockburn, 2014; Lane, 2005; Telles, 1990). In the case of upgrading a system, the support needed by users falls somewhere between these two categories. Users are not learning a new type of software: they have already established patterns of interactions, and understand the tasks they are required to complete like an expert user. However, the specific actions they need to take to complete these tasks may be different in the new interface, making them similar to novice users on their first encounter with the system.

3.3.1 Designing for New Users

Designing for new users involves a few different strategies. Darejeh (2013) discusses three main strategies to help novice users understand a system: a. Limit the number of features available, b. Use easy-to-understand terminology, and c. Be careful in the graphics and icons used. Carroll (1984) also used a 'training wheels' interface that limited the features users had access to when they started using a system. They found users made fewer mistakes and recovered better when they had access to fewer uncommon actions and clear error messages when they took a wrong turn. Furthermore, Davis showed that exploratory training did not prove useful to learning a new product when only a short period of time is available to users. Targeted instruction and prior exposure to similar interaction styles produced the greatest improvements in user confidence and how much users were able to learn. Though terminology has an impact on a users' understanding of a system when they first encounter it, it can have a compounded effect when changing the interface the users are using (Telles, 1990; Carroll, 1986). Upon first encounter, clear terminology can direct user interactions based on metaphors or instructions, guiding users through their interactions. However, as users get used to one set of terms, any change can bring them back to a novice level understanding of the interface. Finally, Darejeh (2013) discussed the graphical elements designers employ when updating an interface; however, these decisions must be made carefully as graphical elements often rely on metaphor (Rose, 2013; Jung, 2017). Though metaphors can facilitate the initial learning of a system by referencing a physical function or action, incorrectly chosen metaphors can obscure the actual function of an action and its place in a system. In some cases obscuring the actual function of the system is not a problem, but with complex systems, for a user to truly understand what they are doing, they need to clearly know what is happening (Gross, 2014).

3.3.2 Designing for Learning and Evolution

The goal of any interface is to be used by users. Lane (2005) goes further to assert that interfaces should have three sub-goals: a. To be discoverable to novices, b. To be efficient for experts, and c. To be learnable to support the transition from novice to expert. Yet study after study has shown that this transition is uncommon among most users (Lane, 2005; Scarr, 2011; Cockburn, 2014). The transitions from novice to expert within a single interface are a good analogy for what users are going through when they are presented with a new interface after working with its predecessor for a long time. Not only are the users trying to circumvent the cognitive automation and procedural memory they have built from the previous interface; they are encountering the negative transfer that makes learning the new interface or the new interaction method within the interface more difficult. One more contributing factor to the slow rate of interaction style change stems from the cognitive practice of satisficing, in which users will find one kind of interaction method that works for them. It may not be optimized, but they may not even notice that something else might be better or consider the cost of learning the new system higher than the benefit of the new system. Learning a system does take time. Work by Heathcote (2000), Scarr (2011), and Cockburn (2014) explore the time it takes users to learn interaction patterns. Both Scarr and Cockburn work with the Power Law of Learning based on Crossman (1959) and Card (1983), while Heathcote makes an argument for a slightly different line of best fit (exponential rather than power based learning) to reflect the ways in which users learn, yet the general trend of learning is the same. All of these researchers found that users need to spend time learning a system, that they generally learn more and faster in the first interactions with the system, and that their performance and learning taper off after a while. Once users have spent some time with the system, they find that they have settled into a method that is efficient enough for them. As users are asked to switch their interaction method to complete the same tasks, both Scarr (2011) and Cockburn (2014) found that there is a sharp dip in the performance of users, though they do not drop all the way to where they started when they were first given the interface and tasks. Both of these authors suggested a few design practices to help mitigate the effect of this drop. They suggest that 'calm notifications' (Scarr, 2011) are an acceptable and efficient manner to facilitate adoption of new interfaces. Calm notifications provide helpful, contextual information about possible actions or ways to complete a task that do not interfere with the user's interaction. The notifications were only explored in a learning environment, so it's unclear how long these notifications should remain available to users, but while learning, they offered the user a smoother transition to more effective interactions. Cockburn also found that it's important to ease into the perception of a new system as faster, better, or more efficient. The design of the interface should also take into account the methods users have to learn and remember interactions (mapping, automation, memory). It should be task oriented and have a flat architecture that allows for exploration without users getting lost.

3.4 Designing the New RIS

Though there is less research on the methods to promote adoption of upgraded interfaces, there are strong parallels between the adoption of new interaction styles and the theoretical background of how users learn to cope with their current interfaces. All of the research, though, boils down to three steps that are imperative to designing upgraded systems or interfaces:

1. We must observe users as they interact with the system that they are already using;
2. We must determine the elements of the system or interface that they are leveraging in their interactions—what spatial or temporal mapping and procedures are users building to facilitate their interactions? and
3. We need to design the new system to leverage these interactions where possible, and where this is impossible, we need to give users methods to adapt to the new interface which make use of the expertise they have already developed in the old interface.

4 Methods

4.1 Theoretical Research Background

To inform the research questions raised in this thesis and bound by the constraints of the context of inquiry (a medical software company), the empirical research conducted here focuses on central intentions. The first intention of the research is to explore and develop a theory of what interaction patterns are ‘sticky’ for users: which interaction patterns are the most ingrained and difficult to overcome when asked to adopt a new system. The second intention is to develop design elements and strategies that can leverage and mitigate sticky interaction patterns that users develop when working with existing interfaces. Both intentions are best served by approaching the research through the lens of grounded theory.

4.1.1 Grounded Theory

Grounded theory originates in the late 1960s with the work of Glaser and Strauss’ *The Discovery of Grounded Theory* (O’Reilly, 2012). Grounded theory affects research both at the data collection and the analysis levels. On the data collection level, who and when you sample for your research is guided by the theory you are developing while on the analysis level, general coding methods are well laid out (Eriksson, 2011). A good first step is to conduct a literature review, though this isn’t always considered part of grounded theory methodology. Martin (2019) and Thornberg (2019) expose the benefits of conducting this kind of review as a way to prevent the researcher from wasting time on proven false paths or recreating widely known theories. In the end, grounded theory, no matter the interpretation, includes the following steps, as outlined by Charmaz (2011):

1. *“Simultaneous data collection and analysis*
2. *Pursuit of emergent themes through early data analysis*
3. *Discovery of basic social processes within the data*
4. *Inductive construction of abstract categories that explain and synthesize these processes*
5. *Integration of categories into a theoretical framework that specifies causes, conditions, and consequences of the processes.”*

Essentially, the use of grounded theory in this research is a way to learn and adapt the author’s theory of sticky interactions as a way to collect and analyze the data, while being informed by the research as it is conducted. To support the development of this theory, two different data collection methods will be used: feedback sessions (the term used at my work to refer to semi-structured interviews) and observations.

Feedback Sessions and Semi-structured Interviews

The feedback sessions we conducted generally took the form of focus groups or semi-structured interviews. Most of the sessions were group discussions about a specific prototype or design idea that the design team wanted to test, while a few specific cases were targeted semi-structured interviews in which an expert explained a specific interaction and how it was completed in their current system. The focus group style sessions were used as described by Liamputtong (2015); they offered a way to expose participant perceptions of the new interface that may not have been apparent on their own, as well as providing efficient access to many expert users at the same time, filling in research holes at the company. There is some worry in using focus groups as users who do not feel comfortable do not provide useful or valid information (Stewart, 2011), however, in this case, this concern was controlled. The participants in the focus groups were generally of the same status in the organization and space was made for each member of the group to contribute.

The semi-structured interviews were designed as an opportunity to drill-down into specific topics exposed in focus group interactions. Following the general design of semi-structured interviews, each interview had a set of questions or topics determined beforehand to guide the discussion (Olsen, 2019; Ayres, 2012). Determining these topics in advance allows not only for more precise follow up questions, but also a better flow for participants in the interview. Where the semi-structured interviews generally explored user interactions with the current interface, the focus groups explored the upgraded interface. In both cases, the information would be analyzed to help understand those interaction patterns that will most strongly contribute to how users will adopt the new system.

Observations

The observations in this research were not strictly participatory or observatory. Instead, users were observed and asked clarifying questions where required. This places the observations somewhere closer to unstructured interviews (Olsen, 2019), however the intent was not to ask questions but to encounter situations in context and review the responses of users in situ, more like in observational methods (Caines, 2012; Gibson, 2011). Indeed, Gibson (2011) describes structured observations as observations that have a purpose and direction, though not necessarily a script or specific questions. This type of observation captures best the actions and intentions of the conducted observations. Observations were made of how users interacted with the old RIS to understand what patterns of interaction were most common and what would be sticky enough to make the adoption of the new system more difficult. This information would also be used to guide the development of the theory of sticky patterns.

Keystroke Level Modelling

To create benchmarks and compare workflows between the old interface and the new, Keystroke Level Modelling (KLM) as used by Omanson (2010) will be employed. Using KLM, it is possible to computationally predict the time it should take users to complete the tasks that we present them (Card, 1980). It can be used for direct comparisons between interfaces as well as comparing users' results to the benchmarks we predict. In this case it can also be used to differentiate between client-specific patterns and interface-specific patterns to locate the sticky patterns users have, predict where they might interfere, and expose inefficiencies that can be remedied before the new RIS is put into production. These comparisons will contribute to the developed theory of interaction patterns as it contrasts the optimal workflows between interfaces with the interactions of real users.

Usability Tests

The final data collection method that contributes to the aims of the grounded theory in this thesis is usability testing. Usability testing has been described by many people in many contexts, such as Steve Krug (2009), Jakob Nielsen (1994), and Antti Oulasvirta (2012). The aim of usability tests is to evaluate an interface for learnability, efficiency, memorability, errors, and satisfaction by having users complete specific tasks with the interface. These tests, if conducted before the implementation of an application, can greatly reduce the cost of development and help guide designs toward something that is more useful for users. In this context, usability tests fall mostly under the category of cognitive walkthrough (Nielsen, 1994) and is structured like those tests outlined by Krug (2009), among others. The tests are designed with a script, a series of tasks, and the written task summaries containing all of the required information for users to complete the tasks. Though not conforming to the strictest sense of think aloud protocol (Boren, 2000), users are asked to speak as they work and prompted to speak when they lapse into silence. These straightforward usability tests have proven a valuable resource in discovering usability issues efficiently and early in the development process, making them useful for companies wishing to improve their user experience (Schmettow, 2014). Usability tests, such as those conducted here, are also conducted with very little or no training in the software itself before users are asked to complete their tasks, making the results of the testing valuable to expose sticky interaction patterns based on user expectations of the design of the system.

4.2 Research Design

4.2.1 Prior Research

Prior research done by coworkers, benefitted the author’s development and expansion of research questions and inquiries. The research that had already been done fell into the categories of usability testing and observations. As there were no complete videos of these interactions, previously written reports on this research were used as a comparison point for the current research. This research had been conducted exclusively at one of the clients and was completed in the months prior to the author’s arrival at the company, so many of the small usability issues raised in those research sessions were already being addressed by the time testing was done for the demo environment. The usability tests did expose a few interaction patterns that were very sticky for users as they attempted to use the new interface, helping to focus some of the observations. The observation results of this clinic were added to those conducted for this paper, facilitating a more robust comparison of observational information.

4.2.2 Feedback Session Design

This company has a heavy focus on working with our clients to improve our products. To achieve this goal and that perception among our clients, we often organize information sessions with clients to demonstrate products they can purchase, review current product interfaces and potential product ideas, and validate product designs and prototypes. These sessions have a very informal setup and differ depending on the goal of the feedback session. The information nature of the feedback sessions meant that it was often unclear exactly who was in the room with the main speakers during the sessions. The conference software used by the company does not allow for video, so identifying each of the participants of the feedback sessions was difficult, and when they asked other participants to join them during the conversation, there was no official record of the new participants’ presence. The feedback sessions referenced in this thesis follow two types.

The first type are sessions which feature a product demonstration to show users the updated product in a demonstrational environment and elicit questions, comments, and feature requests. These sessions have one structured section-- the demonstration itself-- and one semi-structured section, the question and answer period after the demonstration. However, when clients commented on the interface during any phase, semi-structured follow up questions were asked to better understand their feedback.

The second type of referenced sessions are designed with a semi-structured interview style. There were four of these sessions, each conducted with a different client (C, D, E, and F). In each of these cases the session was organized around a central theme with a series of questions developed to gather usability information about this central theme or feature. In each case a few validation questions and extra conceptual questions were presented in case there was extra time. In two of these semi-structured interviews, specific client-based workflows were explored to better understand client-specific workflows, if those would become a source of sticky interactions, and how these workflows would impact the design of the end product.

4.2.3 Observational Research Design

In addition to the feedback sessions, semi-structured observations were used to build up an understanding of the workflows used in each of the clients' clinics. For these observations, a set of questions helped guide the observations where possible. However, the general purpose of the observations was discovery, so clarifying questions were asked when possible while observing the user's response to different, new, or confusing interactions. These observations were recorded through notes and audio for later analysis. Observations were conducted and documented at three clients, at between one and four locations for each client.

4.2.4 Keystroke Level Modelling Design

Keystroke level modelling was used to structure the comparison between the old and the new RIS workflows. To do this four of the critical clinic workflows were chose and assessed. The workflows consisted of the searching for and validating a patient, creating a new patient, booking a new appointment, and checking in a patient. The models used the formulas and constants of prior research but relied on measurements of the old and new RIS taken at the time of testing.

4.2.5 Usability Test Design

The author designed a series of usability tests that focused on the three central user personas that the first phase of development will be addressing. The personas used to determine the different types of users were sourced from the company. Though the official group of personas did not differentiate types of clerks, foundational research done by other UX researchers on the RIS project developed prototypes of new personas that did differentiate. Each usability test was designed based on the general testing process documentation from the company which followed the general models of usability testing procedures laid out by Krug (2009) and Nielsen (1994).The task and workflow bases of the usability tests were prior research, specified business requirements, and the capabilities of the test environment at the time of testing. Research done at the outset of the project indicated that each of the clerks had several workflows that were specific to them, but often overlapped. The business requirements indicated which workflows were critical to the success of a clinic, and were evident in the development timeline of the test environment. An overview of the workflows of both the front desk clerk and the booking clerk are available in Appendices 1 and 2.

Front Desk Clerk Usability Test

This usability test focused on the most frontline persona of the clinics, the front desk clerk. For this test, users were asked to complete a series of tasks they commonly complete in their day-to-day interactions. These tasks included: checking patients in, booking single procedure appointments, booking multi-procedure appointments, validating patient information, and navigating the interface of the new RIS.

Booking Clerk Usability Test

The usability test for booking clerks was focused almost exclusively on booking appointment for both single and multiple procedures. The test also explored patient information validation, reminders, and validating how much information to display and when. These tasks were also based on common tasks for the booking clerks.

Administrator Usability Test

The administrator test aimed to look at the configurations of RIS assets such as referring physicians, procedures, clinics, rooms, and so on. The administrator test also aimed to review more high level actions like schedule management.

The general setup of each of these designs was the same. First, the user was presented the demo environment interface, starting with the landing page for the first task each time. The user was then presented a scenario and an associated task. They were also presented with all the information they needed to validate the patient information for and book/cancel/check in that appointment. Each of the participants was asked to think aloud as they conducted the test, prompted only when they were silent for a long time or they had stalled in their interactions with the system (Boren, 2000). All prompts were in the form of questions that began with “what are you thinking now?” or “what are you trying to do?” and only in cases where the user was unable to move forward would more targeted questions be asked to help them move forward in the task. After completing tasks a few clarifying questions were asked, and at the end of each test the floor was opened to the user to ask questions, respond to any follow-up questions, or comment on their experience with the system. These usability tests were recorded for later analysis.

4.3 Analysis

Much of the analysis for this thesis was done in conjunction with the analysis of the findings for internal company reporting. The feedback sessions and observations were open-coded using atlas.ti and Dovetailapp software where transcripts or notes were available. For the purpose of this research, the open coding was conducted through the lenses of the four central psychological and phenomenological themes, with codes being generated for each of the theories and how they impacted the users in their interactions. These tagged elements were then combined and refined to build the results section as it stands currently.

The usability tests were analysed a little differently, leveraging the analysis method described by Tomer Sharon (2006), the “rainbow spreadsheet”. The spreadsheet offers users an organized method to collect and organize data, starting with observations of individual usability tests divided by tasks, and gathering observations together to find overarching pain points and themes between all usability tests. This method provides structure and an easily digestible visual expression of usability test results. The division of observations by task was useful for reporting the results of the usability tests to company stakeholders but needed to be ignored when exploring the results for the purpose of this thesis. Divisions based on the theories were used instead to organize the results in the same groupings as the observations and the feedback session.

Unfortunately, due to sensitive patient health information being visible through much of the videos, in the transcripts of the recordings, and on the images, most of the results were not allowed to be used in this thesis. Direct quotations were not included either as no clerks had given their permission of their words to be used in the context of an academic paper, only in the context of user research within the company itself.

4.4 Participants

4.4.1 Methodological Guidance

Generally speaking, the people that designers and engineers need to talk to are the intended users of the systems that they are designing. In the case of a RIS, these users are the people who work at radiology clinics and use a RIS. In the case of this research, the design team was able to reach out and contact clients of the company that use the RIS that is currently on offer. The participants were then chosen from clerks who work at the clinics belonging to the various clients who were willing to participate in the research. As for the number of users, though Nielsen (1993) has been quoted as saying that five users will discover 85% of usability issues, this estimation has been proven incorrect by work done by Schmettow in 2013. Schmettow recommends samples sizes that are much larger than five where possible. For the purposes of this thesis, three rounds of usability testing were conducted, each round had around five participants, and each took place at a different stage in the design process. The testing was also augmented with several discussions with various users and stakeholders, as well as observations for comparison. In total, this research had contact with 60 users, 12 of which were managers or decision makers. A detailed breakdown of the participants can be found in Appendix 3.

4.4.2 Clients

Client A is a medium-sized client, with four clinics in one region. They are working with the most up-to-date version of the old RIS offered by the company. Client size here refers to the revenue we generate from the client and the number of studies generated and diagnosed in a year. Client B is a large client, with 12 clinics in one region. B is also running the most up-to-date version of our old RIS. Client C is similar in size to Client A, with four clinics in one region, and running the old RIS. Client D has fewer clinics than Client B (only five clinics, with four affiliates), but is generating the same amount of revenue as Client B. Client E is very similar to Client D, with similar revenue and number of clinics. Client F is the outlier of the clients; they are a large clinic, nearly a direct competitor for Client B, but they are currently not a RIS client. Client F has spent time developing an internal RIS, something they are exploring moving away from: which was one of the reasons they were in contact with the company. Client E has also spent some development time on their RIS, adding a module that hooks into the RIS from the company to capture specific information that they felt our RIS did not do a sufficient job in retaining and displaying.

4.4.3 Users

The current studies on the new RIS interface were in fact the third round of usability testing that was conducted by the company since the start of the project. The first two rounds of usability testing were conducted at a single client (C) with a total of 11 different users. Four of those users were present in both rounds of usability testing, three other users were in the first, and five were in the second. There were also three site visits by a co-worker for observations with several of the same users. The author visited that site again twice to sit with one additional user and meet with a few of the users from the prior encounters.

Client C has four clinics within a bilingual city in Canada, and therefore has specific bilingual requirements for both their users and their software. The users at Client C follow the general pattern of users as the other clients. 84% of the staff of Client C are female. The two male staff are both PACS administrators, while the booking, billing, and front desk clerks and their managers are all female. The average age of the staff is between the ages of 45 and 55, with generally more than seven years of experience working for this client.

The research conducted took place mostly at Clients A and B. Both of these clients are predominantly English speaking, though they do infrequently interact with patients who speak other languages. At Client A there was no time to conduct any usability testing and instead the focus was on observations. Through these observations, 19 front desk and booking clerks were observed. Although some of the clerks worked in what could be referred to as the 'switchboard', a patient-facing location where the clerks were able to book certain exams, submit appointment requests, and complete specific and varied tasks for the clinic. The clinic manager for Client A also participated in a long interview. Here there was also a high (95%) ratio female to male staff. There was, however, a greater variation in age and experience in the staff at this clinic. Most of the staff had between four and six years of experience with four of the staff members that reported having over seven years of experience and five having between one and three years of experience (Figure 1). The ages of the staff were also very diverse, with three of the staff falling between 55 and 65 years of age. Approximately half of the staff were between 45 and 55, and eight (40%) of the staff there were under the age of 45 (Figure 2).

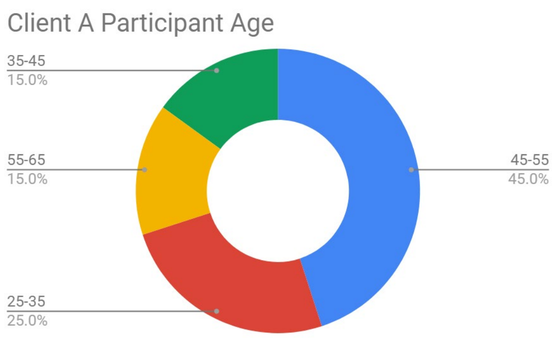


Figure 1. Client A Participant Age.

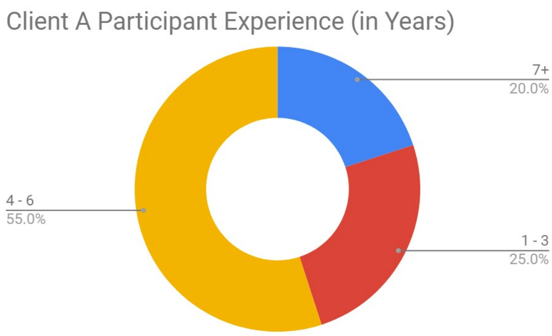


Figure 2. Client A participant experience at clinic (in years).

A limited time was spent in feedback sessions with representatives from clients D, E, and F. It was more difficult to gather demographic information from these clients as that is not something the company generally asks for, nor was it something that could be inferred from the discussions with them through email, voice chat, and screen sharing. Therefore, the information for these participants is less precise. For each of these sites, the IT managers or administrators are male, and the clerks and clerk managers are female.

Finally, the most time was spent with client B at three and a half of their sites. The 'half' refers to the MRI/CT section of one of their clinics which functions semi-autonomously while on the same physical premises as the rest of that clinic. Here 16 clerks and four managers were interviewed and observed. Usability tests were conducted with five of the clerks and one of the managers. Of the managers, 75% were female, and between the ages of 45-55. Of the clerks, 100% were female, ranging in age and experience from four days of experience and 25-35 years old, to 20 years of experience and 55-65 years of age (Figure 3). 68% of the clerks were under 35, and most of the clerks between the ages of 45-65 had over seven years of experience (37% of the clerks). The clerks who participated in the usability tests fell half above 45 with at least 10 years of experience and half below with less than 10 years of experience (Figure 4).

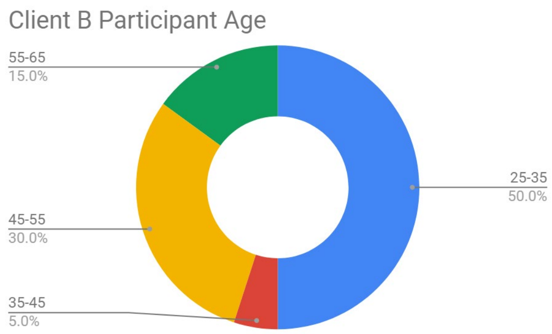


Figure 3. Client B participant age.

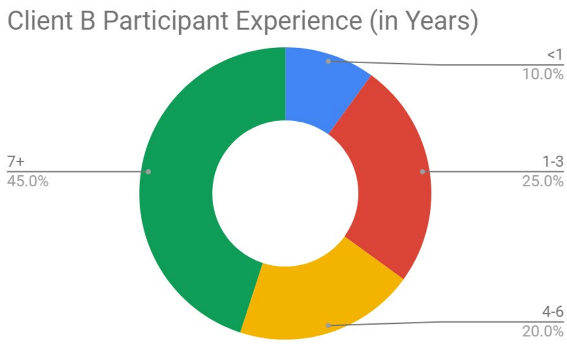


Figure 4. Client B participant experience at clinic (in years).

Table 1. Summary of Clients, their clinics, and their participation in the data collection.

Client	*Clinics*	*Data Collection*	*Roles*	*Participants*
A	3	Feedback Sessions	Front Desk	5
		Observations	Booking	14
		Usability Testing	Admin	1
B	12	Feedback Sessions	Front Desk	11
		Observations	Booking	3
		Usability Testing	Admin	4
			Billing	3
C	3	Feedback Sessions	Front Desk	3
		Observations	Booking	5
		Usability testing	Admin	3
			Billing	2
D	5	Feedback Sessions	Admin	2
E	5	Feedback Sessions	Admin	2
*F**	12	Feedback Sessions	Admin	2

5 Results

As described in the methods section, two rounds of usability testing and a few hours of observations had been completed prior to the author's beginning work at the company. These first two rounds of observations and usability studies were conducted with a prototype and a demo environment. All of the research conducted took place at one client, Client C. The research that was completed at this client had an oversized influence on the development of the interface of the new RIS. When prototypes of the RIS, updated from the findings from Clinic C, were displayed to administrators from Client A, B, D and E, it became very clear that clients of the RIS solution could have very different usage patterns. Client F, as a PACS client and not a RIS client, did not have specific usage patterns with the RIS to be disrupted, but had their own RIS workflows that the new interface would disrupt.

5.1 Feedback Sessions

As the informal feedback sessions and the semi-structured interviews with the representatives from Clients A, B, C, D, and E were conducted, a strong division emerged. This division will impact which interaction patterns users have trouble unsticking and which may or may not be disrupted when using the new RIS. Clients A and C both book all of their appointments through a calendar-style interface called a schedule grid, while clinics B, D, and E, all use a search interface to filter and display only available appointments. Clients A and C are very similar clients, both with four locations, a similar number of studies per year, and a similar amount of revenue generated. Clients B, D, and E are all much larger operations, not necessarily in the number of clinics they operate, but rather in the number of studies they complete in a year.

Another factor that seems to align the two groups is the amount of time the administrators of each client has spent investigating and engaged with the RIS. Clients A and C have expressed, on multiple occasions, that their last upgrade did not go well and that they haven't had time to spend on exploring more efficient workflows in the RIS than what they saw worked the first time they used it. This appears to be a case of satisficing (Simon, 1959), where the users have found something that works, and the cost of looking for something better is perceived as higher than the benefit of finding a more effective solution. On the other hand, Clients B, D, and E, though they expressed dissatisfaction with the role out of the last upgrade, had administrators who spent time working through the application to:

1. Find the most efficient methods to complete common actions, and
2. Asked for specific features and interaction to be made possible for them.

At the highest level, there are two types of clients, which lead to different types of workflows and interactions that users find difficult to break from. The first type of clients tend to be smaller clinics, they spend less time investigating the system, and use the calendar grid for all of their booking. The second type of clients tend to be larger clinics, spend more time investigating the system, and use appointment search to book their exams. It was fortuitous then, that the usability tests conducted by the author were with one of the second type of clients, those who use appointment searches rather than the calendar, as a major focus of the redesign is to encourage the use of an updated appointment search function.

5.1.1 Colour

The feedback sessions also exposed a few other interesting features. Both calendar-based clients (A and C) expressed that the colours they were seeing on their calendars were not sufficient for their purposes because they need to leverage a range of colours to a much greater extent than the others. They also reported that the colours visible on the calendar were too saturated. Two of the appointment search clients found the current colours overwhelming as well. The remaining clients didn’t comment specifically on the colours used. These comments referred specifically to the use of colours in the calendar and were separate to the few users who found the light theme of the new RIS to be too bright after having gotten used to the dark theme of the old RIS.

In the old RIS, colours are used to differentiate between the rooms visible on the calendar. However, in the new RIS, colours are generally representing modalities (essentially the machines that can be used to image a person- ultrasound, MRI, X-Ray, and so on), instead of the rooms in which procedures could take place. Physically, a clinic can only have a certain number of rooms and within these rooms they usually only have one imaging machine (modality). After further discussion, it became apparent that the room itself is not the important element, rather it is the procedures that are available in that room which may be dictated by the machine, the technologist working in that room that day, or by an administrator for other reasons. In fact, it later became clear during the observations, that the colour differences per room were more of a distraction than a help when booking procedures.

Colour and Availabilities

Colour is also used om the old RIS to indicate availabilities for different procedures within a modality, a far more useful application of colour. For instance, an ultrasound room may be available only for abdomen procedures in the morning and only chest procedures in the afternoon. These divisions are used for a few reasons. One reason is to ensure that no procedures that need to be completed in the morning (those that require fasting) are booked in the afternoon. A second reason is that technologists who take the images and interact with the patients often have preferred procedures, so when they are assigned to a room, they might have a specific set of procedures that aren't allowed. For example, there are often also clinic level policies indicating that male technologists aren't allowed to complete certain procedures with female patients, and female technologists aren't allowed to complete certain procedures with male patients. A third reason is to balance out the more and less physically demanding or complex procedures throughout the day. Clinics may prefer to structure their procedure availabilities such that their technologists are completing only one or two very complex or demanding procedures in a day or an afternoon. These kinds of rules, divisions, and visual indicators were brought up by every client in the feedback sessions, as conducting procedures and subsequently interpreting the resulting images are the central revenue generating actions of a radiology clinic.

5.1.2 Status

Colour was also an issue for the clients in the feedback sessions as it relates to the status of exams. Colours are used on the calendar to differentiate booked exams from exams for which patients have arrived at the clinic (Figure 5). The new RIS was not using the same colours or terms that the participants were used to, so they did not notice the status indicators at all (Figure 6). As expected, based on negative transfer and satisficing, they knew their way of doing things and couldn't perceive another option. Though some research has suggested that terminology can be a relatively simple way to match cognitive mappings, the terminology used in the old RIS is not terminology that was intended to be re-created. There are many statuses available in the old RIS, however they are arranged strangely. Half of the statuses refer to the current state of the exam while the other half indicate that the patient is ready for the next step in the status. For example, an appointment will go through the following statuses: booked, waiting for exam, waiting for report, and complete (among others). This is problematic for two reasons: the verb tense of statuses shifts across the statuses; and users can't easily differentiate between the "waiting" statuses at first glance, so they are forced to read through much more text.

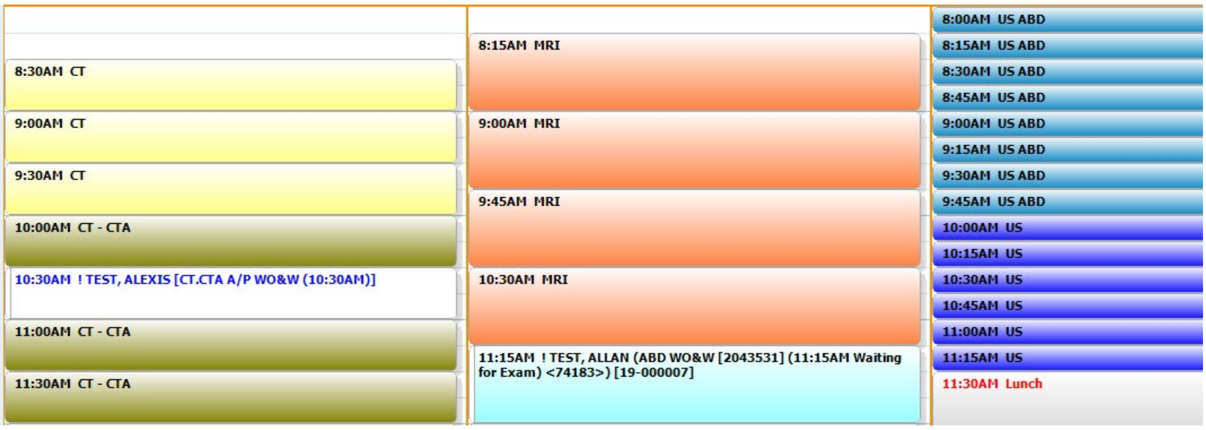


Figure 5. Old RIS procedure availability-based colour scheme. Colours indicate types of procedures available.

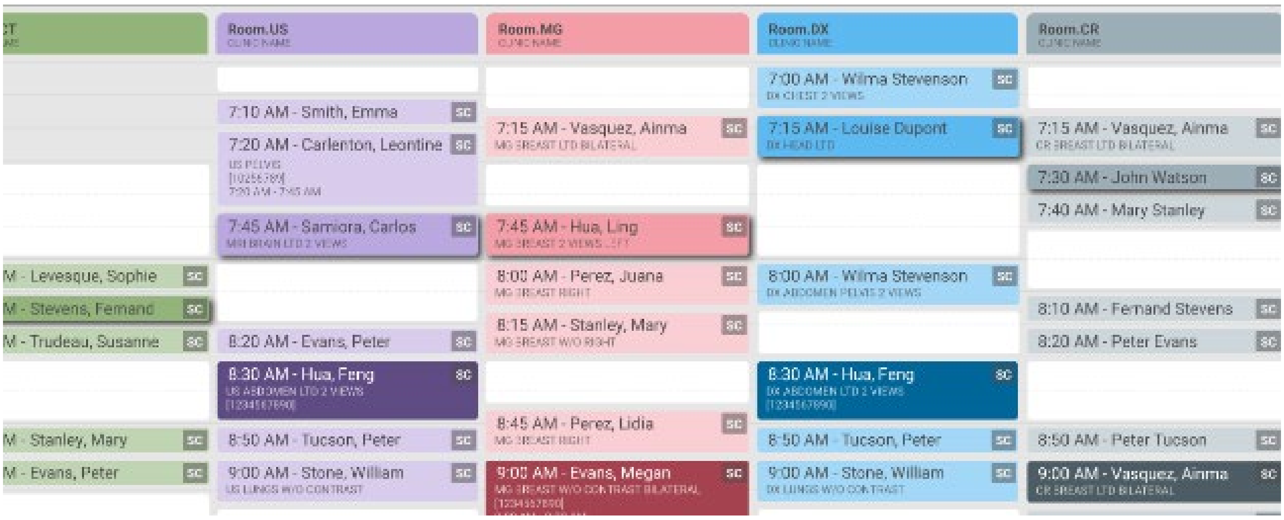


Figure 6. New RIS modality-based colour scheme. White slots indicate availabilities, varying saturations indicate selection and hover states.

5.1.3 Worklists

While inspecting the new RIS, the participants expressed very little interest in the worklists, with most of them admitting that their staff seldom, if ever, use the worklists that are available in the old RIS. Though the participants in the feedback sessions didn't go into detail on why the worklists weren't used much, the observations exposed some of the issues with the old worklists that must not be recreated. Only one client expressed a desire to continue to have worklists as they must deal with some very specific administrative procedures that are hard to keep track of without a series of worklists (Figure 7,8).

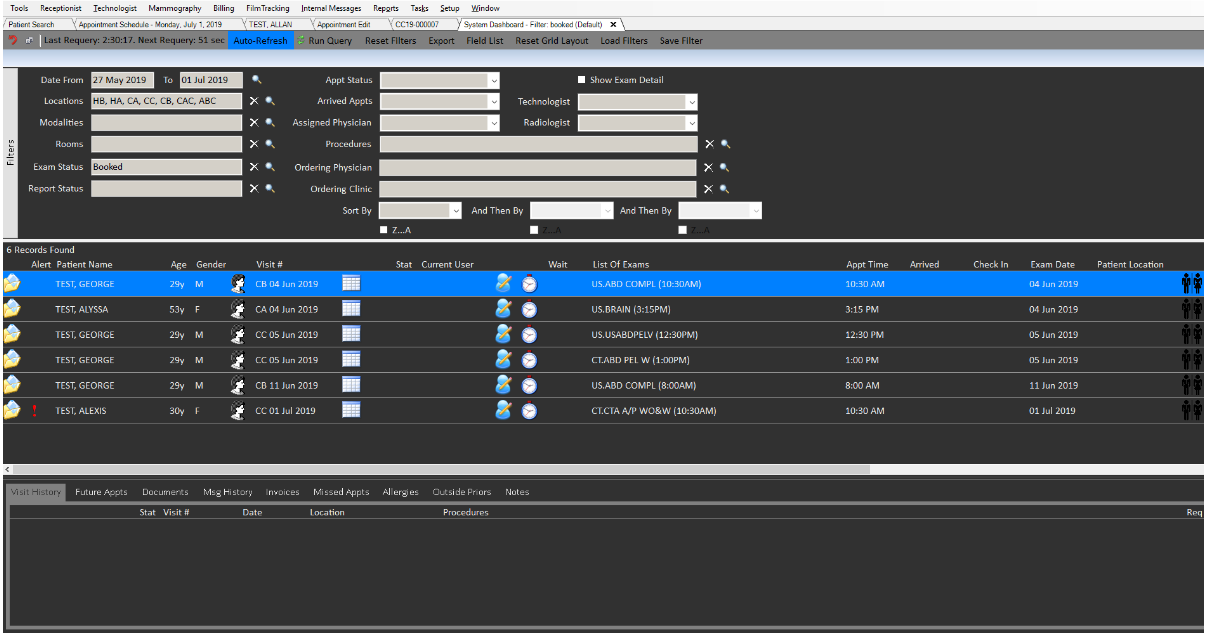


Figure 7. Old RIS worklist display.

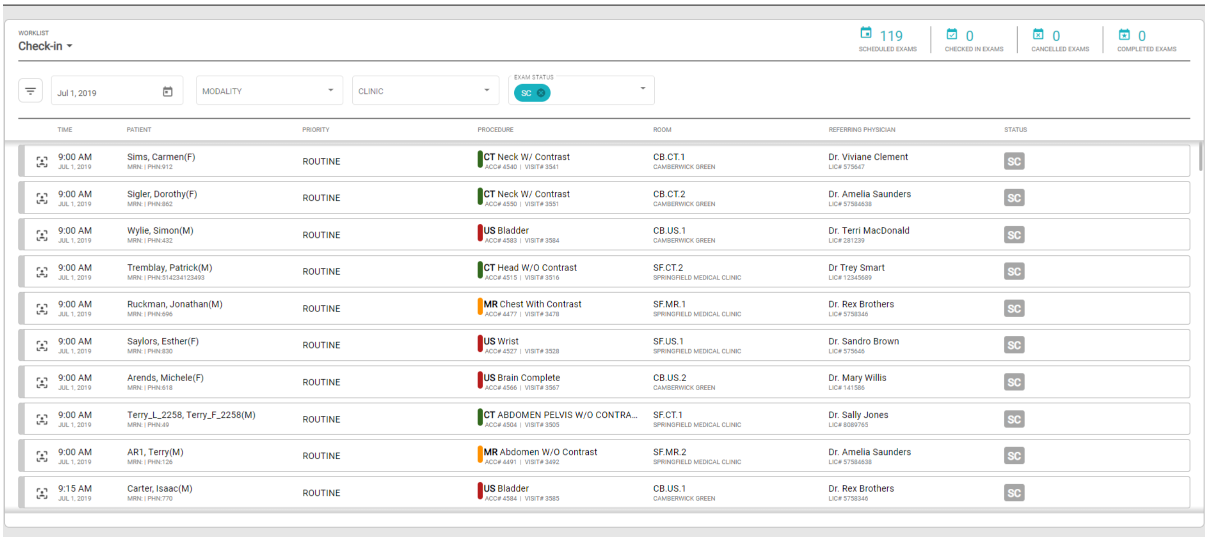


Figure 8. New RIS worklist display.

5.1.4 Calendar (Schedule Grid) Booking

Finally, when looking through the appointment search functionality of the new RIS, the clients who use the calendar all the time wanted more from the calendar while those who usually use the existing appointment search wanted less of the calendar. The clients who use the calendar all the time (A and C) wanted to continue to select elements on the calendar and view all the rooms for a single modality, rather than the room that has the available time slot for the procedure that the user is looking for. Those clients who use appointment search instead thought that the calendar display was taking up too much space on the screen, yet in both Clients B and D (both

appointment search clients), they still need to use the calendar to book certain appointments. These appointments usually have dependencies with other appointments and must be completed within a certain time of each other, something the administrators decided was easier to view and control on the calendar display.
Though it only emerged after some of the observations and some secondary rounds of discussion, the preference for or annoyance with using the calendar for appointment booking has to do with how much the booking clerks are responsible for helping to balance the days of technicians. At Clients A and C, there are instructions throughout the calendar written on top of false appointments that indicate only two of the slots may have one kind of procedure, or none of these procedures may be booked-- even if technically the slots in that part of the day do allow for that type of procedure. Similar cases exist for both clients B and D. For these clients, the majority of appointments are scheduled through the search except for certain groups of procedures. B and D require these procedures and the clerks responsible for booking them to use the visual calendar to manage the timing of patients and manage the spread of procedures throughout the day for technicians. While some of the appointments are complex, it is the technologists schedule that is the driving factor of this balancing act.

5.1.5 Overall

There was a lot to learn from the feedback sessions, with each client and their participants having strong opinions about what they believed would and wouldn't work in the new RIS as well as what they like and don't like about the old RIS. Where the feedback sessions fell short was the lack of context and real interaction. The participants in the feedback sessions, predominantly administrators and managers, were able to give general feedback about the way things are supposed to happen in their clinics based on the processes that they, as administrators and managers, have implemented, but they are not working in the clerk positions daily. The feedback sessions also did not allow for the participants to interact with the test environment directly due to some technical limitations. These two drawbacks were expected and planned for by leveraging the other data collection methods.

5.2 Usability Test Results

5.2.1 Calendar Users (Prior Research)

The usability tests conducted at Client C were conducted before the author of this thesis joined the company, and so are used here for comparison purposes. These usability tests were conducted in two rounds with two prototypes of the new RIS, and all tests were conducted with staff at Client C. The mix of users from this client were less optimal as a large portion of the users that were tested with were administrators or coordinators instead of front-line clerks who would be using the system. Of the nine people with whom the prototypes were tested, three were administrators, four were booking clerks and two were front desk clerks. The heavy focus on administrators, while good for getting buy-in from those who decide to purchase the software, did not provide an accurate reflection of how expected users would interact with the system. The status indicators are a good example of this: while all three of the administrators understood the meanings of the status indicators, none of the clerks did (Figure 9). Table 2 illustrates the difference between the old RIS and the Health Level 7 (HL7) standard codes that the new RIS was using in all of the prototypes tested.

Table 2. Comparison of status terminology in old and new RIS interfaces.

HL7/ New RIS	**Old RIS**
SC - scheduled	booked
IP - in progress	waiting for exam
CM - complete	waiting for report
ZZ - report complete	report complete

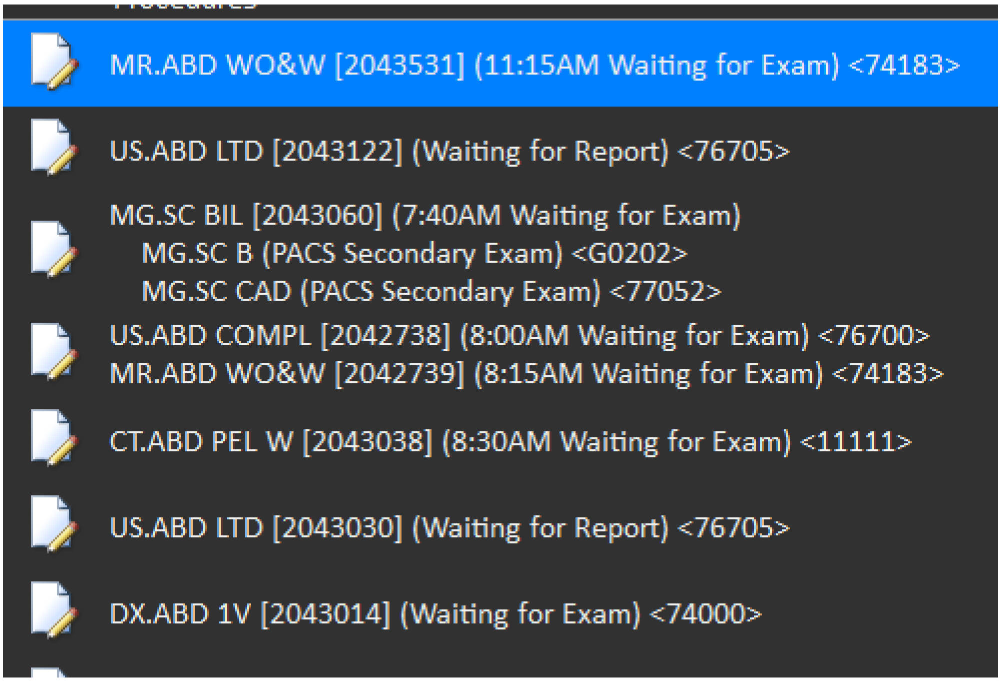


Figure 9. Old RIS Exam history list with exam statuses indicated in text.

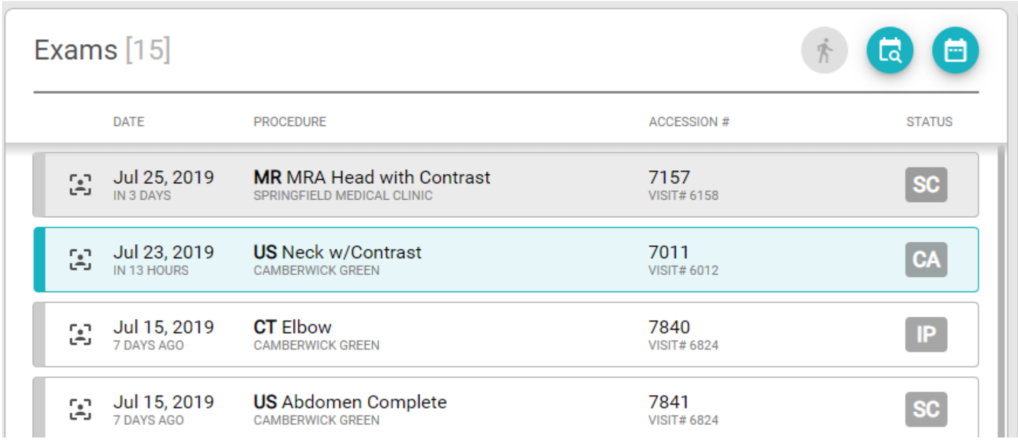


Figure 10. New RIS Exam history list with exams indicated by icons.

HL7 (HL7, 2019), the standard on which the new RIS had originally based its status indicators is an international standard for healthcare-related softwares to ensure proper interoperability between developers and companies. Though this kind of standard is important for the interoperability of software, the acronyms used in it are not very user friendly and have never, in the past, been exposed to users as they work through the RIS (Figure 10).

Status

In addition to the users not understanding the terminology that the new RIS is using, users weren't in fact noticing what the status of any of the exams were. Users, as demonstrated in the feedback sessions, were used to very clear colour-coded visual indicators of status for exams when displayed on the calendar (Figure 11). The use of a small icon at the top of the appointment blocks in the calendar did not stand out enough against the colour of the appointments for users to notice them (Figure 12). These statuses were slightly more visually distinct on the worklists and exam history lists in the new RIS. The dark grey icons stood out better against the predominantly light background of those screens (though users still didn't recognize them often, the administrators being the only users who noticed that status was indicated on the list). The rest of the users (booking and front desk clerks) didn't notice the icons and when they were pointed out, ran into the issue of not knowing their meanings.

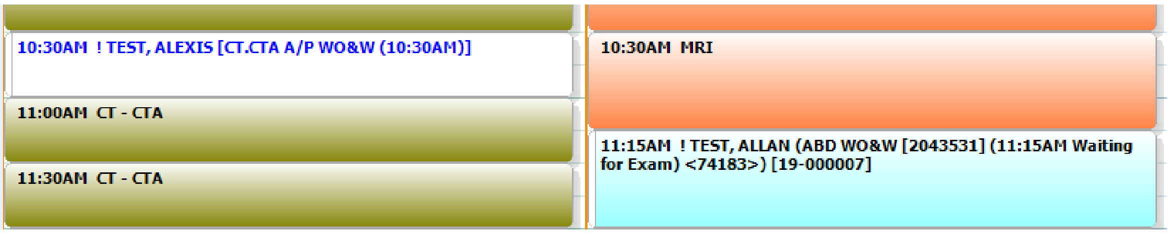


Figure 11. Old RIS Coloured Status indicators- White indicates booked, Blue arrived, and all other colours the type of procedure which can be booked.

Figure 12. New RIS Icon based status indicators. Located in the top right corner of each appointment.

Visibility on the list was only part of the issue; the icons do stand out from the pale background. However, Client C doesn't use any of the worklists in the old RIS. Even reminding patients of their appointments isn't something they keep track of with the (existing and dedicated) worklist in RIS. During observations at Client C on two separate occasions, once with a front desk clerk and once with the booking clerk, they explained that they always print out a list of appointments for the next day or two and complete all the reminder calls from that list. Other worklists are also not used, so the participants in the usability tests were unsure of the purpose or the use of the worklists. The calendar also proved to be a point of frustration with the users. On the one hand, they wanted to be able to open the calendar and select appointments straight from the calendar, but on the other hand they liked the idea of an appointment search function. From their discussions, not a single one of the participants was aware that there was an appointment search already in the old RIS (Figure 13). Due to their regular usage of the calendar for booking, the staff of Client C wanted and expected to interact directly with the calendar rather than the list of search results. Each of the users attempted, on multiple occasions to select space in the calendar that they thought was an available slot (Figure 14). Three of the users initially thought that the booked appointments in the calendar were open slots. Another four users wanted to select the open space around booked appointments directly to create appointments. The other two users, both administrators, did not go straight to selecting directly on the calendar, but they are not regular users of the system or of booking workflows specifically. All users needed to be prompted to look at the list of suggested appointments as they weren't recognizing that the list beside the calendar contained those suggestions (Figures 15, 16).

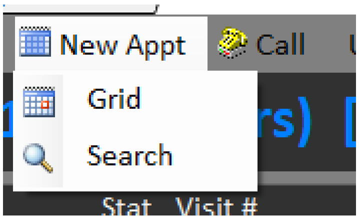


Figure 13. Old RIS Appointment Search Access.

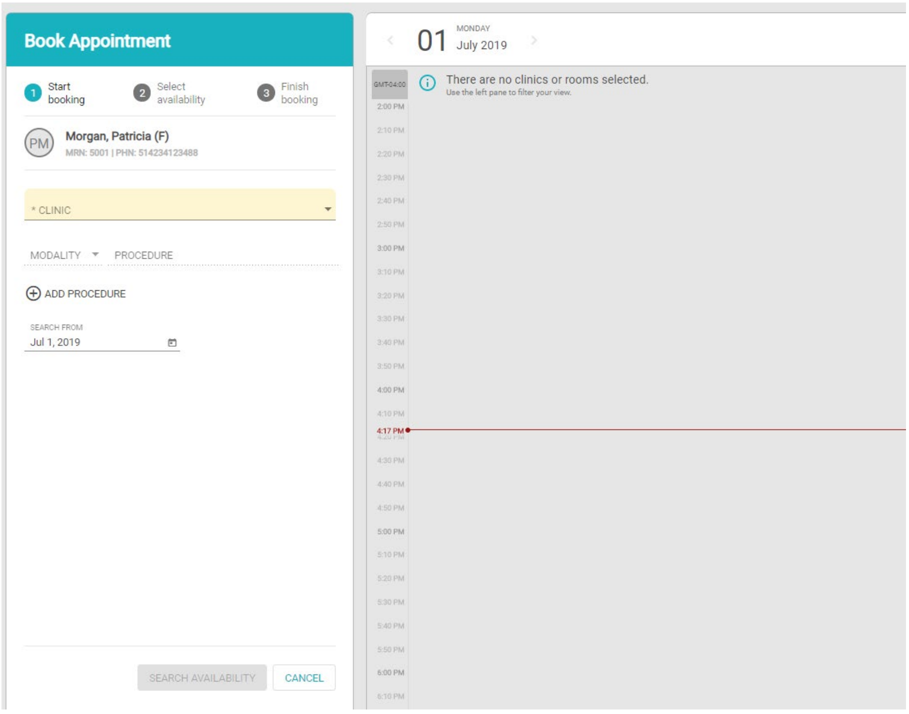


Figure 14. New RIS Appointment search "wizard" step 1.

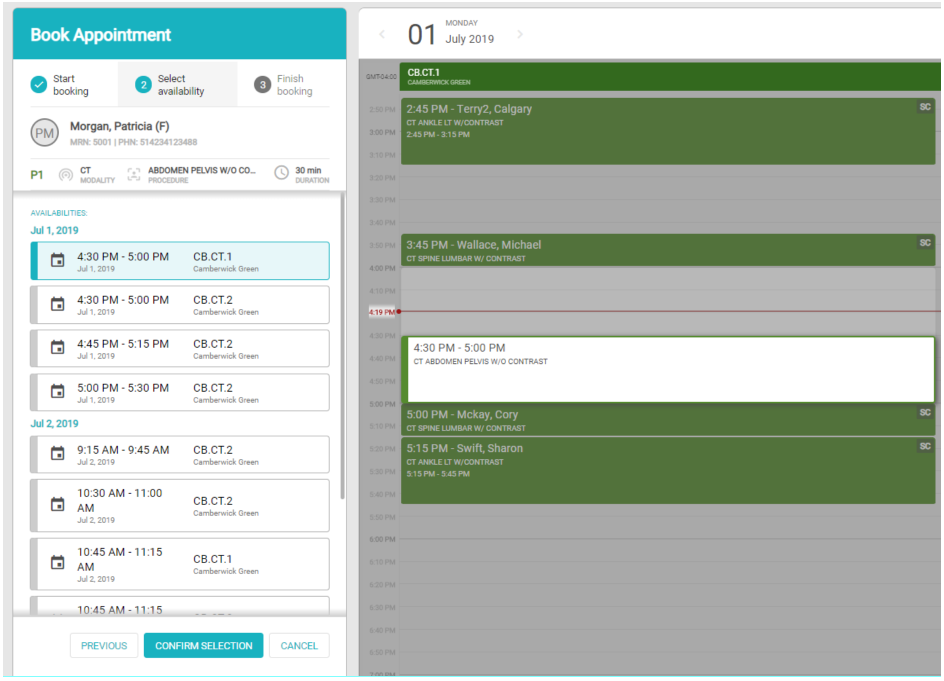


Figure 15. New RIS Appointment search "wizard" step 2.

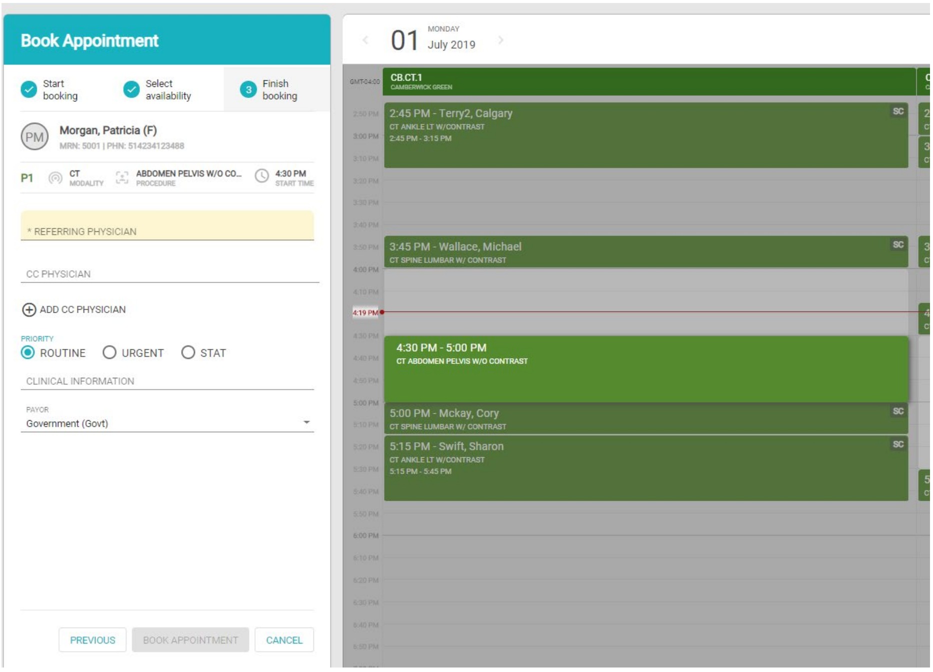


Figure 16. New RIS Appointment search "wizard" step 3.

Old Interactions

In the second round of usability testing conducted at this site, which was conducted with a live test site rather than a semi-functional prototype, a few more sticky behaviours emerged. Users wanted to doubleclick on any element that did not look like a button. So row items were usually double clicked rather than single clicked as was expected by the design. Double clicking resulted in what two of the users referred to as ‘flickering’, which was actually a detailed view sliding on and off the page in response to the clicking. They were so used to double clicking in the old system they automatically assumed that they needed to do the same here. In addition to the double clicking, users were constantly searching the top of the screen for actions. The five users who took part in the second round of testing had more issues with this than the first round as more functionality was available, so more actions were expected to be present. The users were looking in the toolbar of the browser-based navigation for action items rather than staying within the application. Four of the users wanted to use the browser’s ‘back’ button when going through the appointment search wizard. This was problematic for users as using the browser back button from within the appointment search wizard would take the users completely out of the wizard. This intention matches the locations of these functions on the old RIS (Figures 17, 18, 19, 20). In fact, all action items on the old RIS are found in the top bars of the application, making it no great surprise that users are looking in the same location for their actions in the new RIS (Figure 22). A few of the actions remain on the top bar, but others in the appointment booking wizard now sit at the bottom of the page.

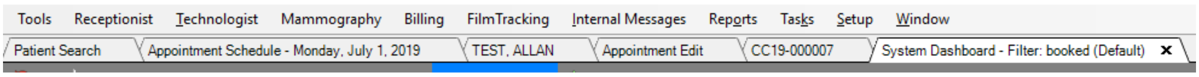


Figure 17. Old RIS Top Bar Navigation.

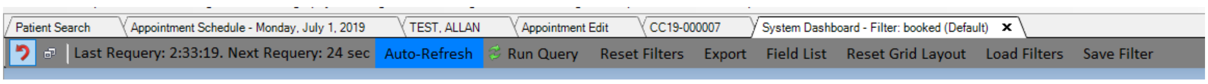


Figure 18. Old RIS System Dashboard Task Bar.

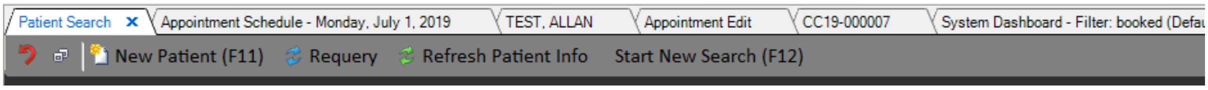


Figure 19. Old RIS Patient Search Task Bar.

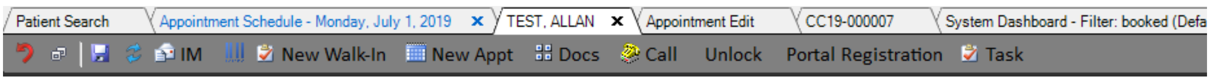


Figure 20. Old RIS Patient Record Task Bar.

Figure 21. New RIS Top Bar Navigation.

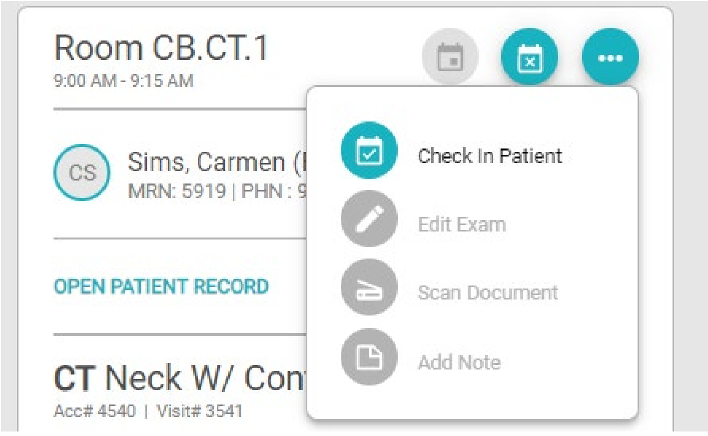


Figure 22. New RIS Contextual Task Access.

5.2.2 Appointment Search Users

While conducting usability tests at Client B, it became clear that it is one of the appointment search clients, where clerks prefer to book exams through the appointment search function wherever possible. The usability tests were conducted with three front desk clerks, two booking clerks, and one administrator who began working at the clinic as a front desk clerk 15 years ago. The front desk clerks consisted of one clerk who had started working for the client one month before the test, one clerk who had been there between three and five years, and one clerk who had been working for the clinic for over 20 years. The booking clerks also had one clerk with less than three years of experience and one with over 15 years. There were clear differences in their interaction styles. Firstly, there was a difference between front desk clerks and booking clerks, with front desk clerks relying more heavily on the calendar view in the appointment search function of the new RIS. They were looking at, hovering their cursor over, and reading from the calendar side more often than the list side. The older clerks had significantly more difficulty navigating through the interface than the younger clerks, though the administrator had the same amount of difficulty as the user who had between three to five years of experience.

Context

The usability tests followed the front desk clerk and booking clerk task scripts with a few variations as circumstances dictated. The front desk clerk tests were conducted at the front desks of the various clerks. This resulted in some very segmented interactions as the clerks would regularly get called away to attend to a different task or patient. There were also two users who were unable to complete the full test due to time constraints. Their feedback was taken into account for those tasks that they completed, and they were discounted for those tasks that they did not complete, explaining why a few tasks have results from six users while others have only four. Though not ideal, constraints applied when accessing personnel at the clinics. One last methodological note to keep in mind is that all of the usability tests were conducted in the company of the administrator. She does not have training in usability testing, and often offered more information, hints, and comments than is generally recommended in usability testing. However, her comments often exposed new or different usability problems when users didn't have to contend with the problem one of the colleagues had already experienced. These comments make it difficult to directly compare the likelihood of certain issues, but coupled with the observations at this site, some of the interaction issues appear to be sticky patterns based in the old interface, making their re-appearance highly likely. The interface used in the tests was an updated version based on the feedback from the research done at Client C.

Old Interactions

Some of the actions users wanted to take were similar to those exhibited at Client C, but others were quite different. All of the users at Client B also tended to click twice to access any action or feature in the interface. The clicking habits of the older users resembled those exhibited by the clerks at Client C. The younger clerks and the more tech savvy administrator did not follow the same pattern of double clicking everywhere. The older clerks also spent much more time reading tooltips and text before taking any actions and were more easily confused by the new interface than the younger clerks. Through our discussions after the testing, one of the older clerks indicated that she doesn't like to use the computer at home, while the other explained that she doesn't even possess a computer. These users were in direct contrast with the younger users who had their own laptops and smartphones. The older users, however, did not make as many typing errors as the younger users did. The younger users, while more comfortable moving the cursor throughout the screen quickly and going back and forth between views, tended to need to retype some of the text they were asked to enter at least twice, though sometimes more. The younger users were also more likely to be comfortable using a laptop trackpad than the older users, affecting their ability to move the cursor across the screen.

Like the users from Client C, users from Client B also showed certain behaviour patterns and preferences. All of the users upon starting their interactions tried to doubleclick to select various elements. Furthermore, they usually looked first to the top of any page for action items. Looking to the top of the screen for actions often led them to want to use the browser's buttons to move between pages, mostly to go back to the last screen. This happened at least once for each user, though usually this was between the patient’s record and the search results. Both of the older users also used the back button to try to update one of their search criteria in the appointment search. This matched the actions of users from Client C who also tried to do this a few times. The younger booking clerk didn’t go so far up the screen as to use the browser back button, but she did use the step navigation at the top of the wizard to move between screens over the ‘previous’ button located on the bottom of the wizard window. In the new RIS, the appointment search wizard contains two methods of navigation. The first method of navigation involved using the progressively revealed buttons at the bottom of the screen. Users would be presented with changing text contextualized to the step they were on; on the first step, they would have no “previous” button, and the “search availability: would only become active when users had entered sufficient information (Figure 23). The second method of navigation involved a series of tabs at the top of the wizard (Figure 24). These tabs were labelled with the steps of the wizard and became active after the user had completed a step and moved to the next. Neither of these navigation methods existed in the old RIS, all navigation there was done on the navigation bars at the top of the screen, like the task bar of Microsoft office applications. The closest visual equivalent of this navigation bar was the toolbar navigation of the browser used to display the new RIS interface.

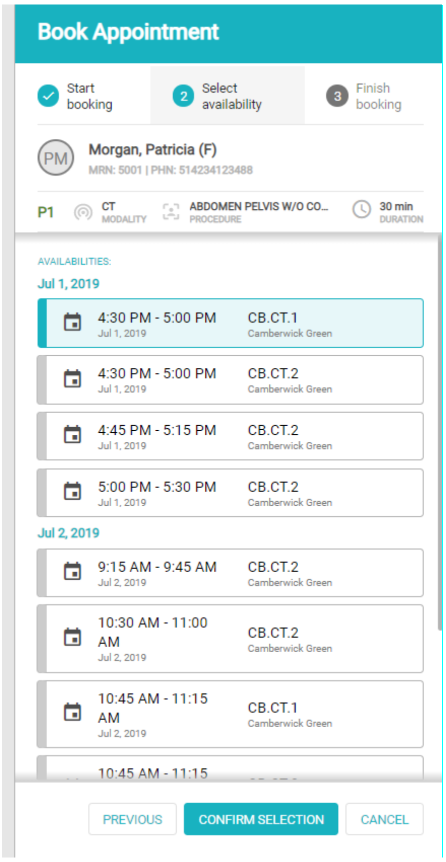


Figure 23. New RIS Appointment Search with 'previous' and 'confirm' actions at the bottom of the 'wizard'.

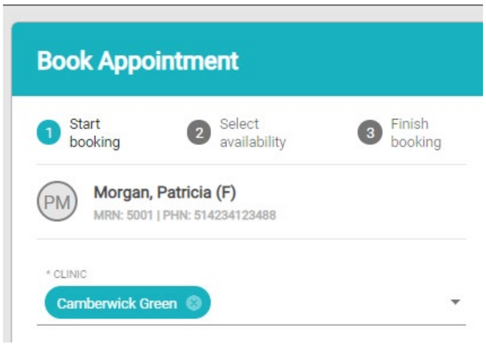


Figure 24. New RIS Appointment Search with navigable 'steps' at the top of the 'wizard'.

Visual Changes

A common request among users was to have bigger and more obvious visual changes in the interface to indicate when something was updated or changed status. This was an issue for every user when they encountered status changes. Like the users from Client C, these users were not familiar with the HL7 statuses used in the interface, and so did not immediately associate those icons with statuses. Furthermore, the users did not notice when a status icon was changed after they updated the status. Indeed they generally needed to have the status icon pointed out to them and explained before they made any connection with it. As in the first round of usability testing at Client C, the administrator was the only user who was able to identify the meaning of the status icons easily, the other users needed to refer to the tooltips associated with each of the icons to recognize the meanings (Figure 25). One of the tasks in this round of testing also had users cancel exams. This cancellation could only be done from within an exam record and caused a rather large grey box to appear on the exam record displaying that the exam had been cancelled and the stated reason for the cancellation. Even this change was not perceived as significant or visible to users as they completed the task (Figure 26). When asked to locate the cancelled exam in the list of exams, they found it difficult, despite the cancelled icon and the difference in appearance of the cancelled exam record when compared to a regular exam record.

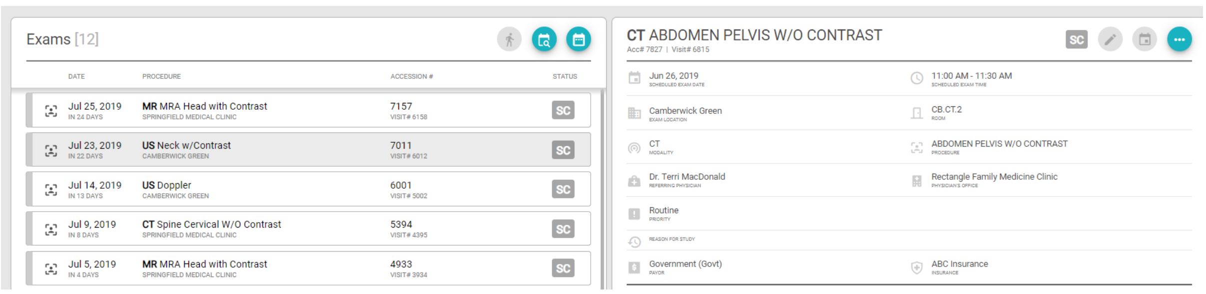


Figure 23. New RIS Booked Exam Record.

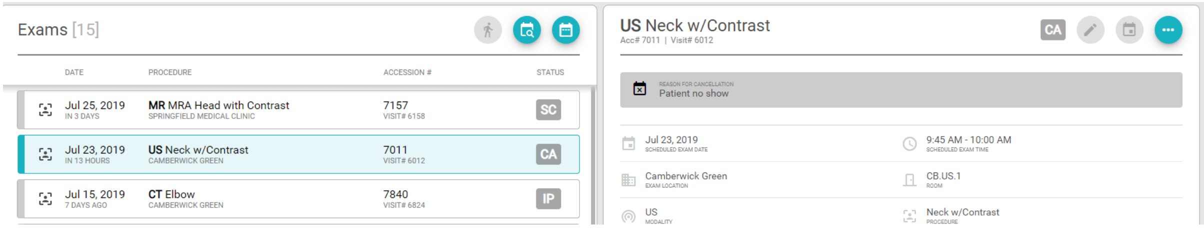


Figure 24. New RIS Cancelled Exam Record.

Changes were also not very evident through the booking process. Three different users commented that the changes between steps of booking both on the wizard and on the calendar display were not very obvious to them, and they needed to check more than once to make sure that they were on the correct step. At each step, there is a different type of information being displayed. The only consistency between all three of the steps is the name of the patient for whom the appointment is being booked. In steps two and three, the procedure names are also displayed. It was between steps two and three that one of the users was completely turned around. She indicated that she had turned away to mention something after selecting the appointment that she wanted. Upon turning back, she found that the display seemed identical to before she had turned away, despite her having selected the appointment. She had to reorient herself and found that, upon going back and forth between the second and third step, the calendar was not changing significantly (Figures 27, 28). With the calendar changes between steps not being that visually distinct, and having the calendar displayed as the majority of the screen during booking, this user could not easily distinguish differences in the wizard side of the display.

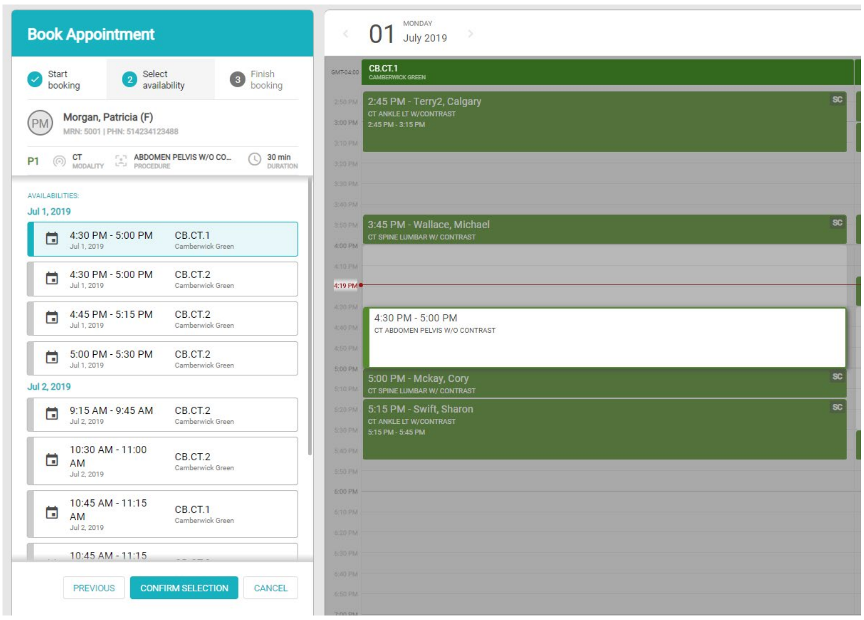


Figure 25. New RIS Appointment Search Booking Wizard Step 2.

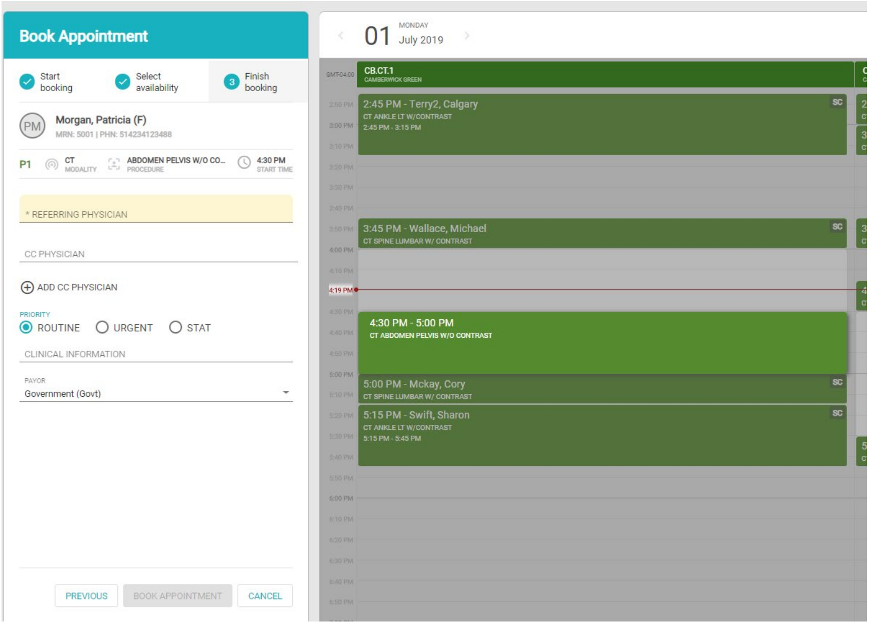


Figure 26. New RIS Appointment Search Booking Wizard Step 3.

Calendar

Displaying the calendar at all was a point of contention for the booking clerks and the administrator as they completed the test. Client B, as expressed above, is a client that relies mostly on the appointment search functionality for their bookings. The only cases where users are opening the schedule grid were when the user was a front desk clerk who happened to be booking a follow-up exam for a patient, something rarely done except by the clerk working at the CT/MRI mini-clinic within the main clinic. The front desk clerks did not think that seeing the calendar was strange or distracting, they did not comment about seeing it; their comments ranged more towards liking the visual of the schedule. The booking clerks, the administrator, and the booking manager (who wanted to see the tests), all expressed a strong dislike for having that level of transparency for what is on the schedule (Figure 29).

As they explained through the tests, having the calendar visible with all of the names and procedures already booked would lead to technologists asking the booking clerks for more precise management of the procedures they were booking. Currently, the appointment search function displays only the open appointments as a list (Figure 30). This list does not give the booking clerk any indication of what else is on the schedule for that day. At the CT/MRI clinic clerks book directly from the schedule as they are expressly trying to manage the time of the technologists and the scanners so that they are always working through appointments and not sitting idle. Were the regular booking clerks to have the same level of visibility as the CT/MRI clerks, the other technologists would be asking for the same kind of treatment, with booking clerks being asked to manage the types of appointments they would get throughout the day. This kind of micromanagement would slow down the booking clerks as they would need to balance not only the availabilities of the patient, but also the schedule of each technologist. From the perspective of the administration and the booking manager, honouring the preferences of technologists would not only make the booking process slower, but also result in certain procedures that are more complex or physically demanding being done seldomly, as they are not the technologists' preference.

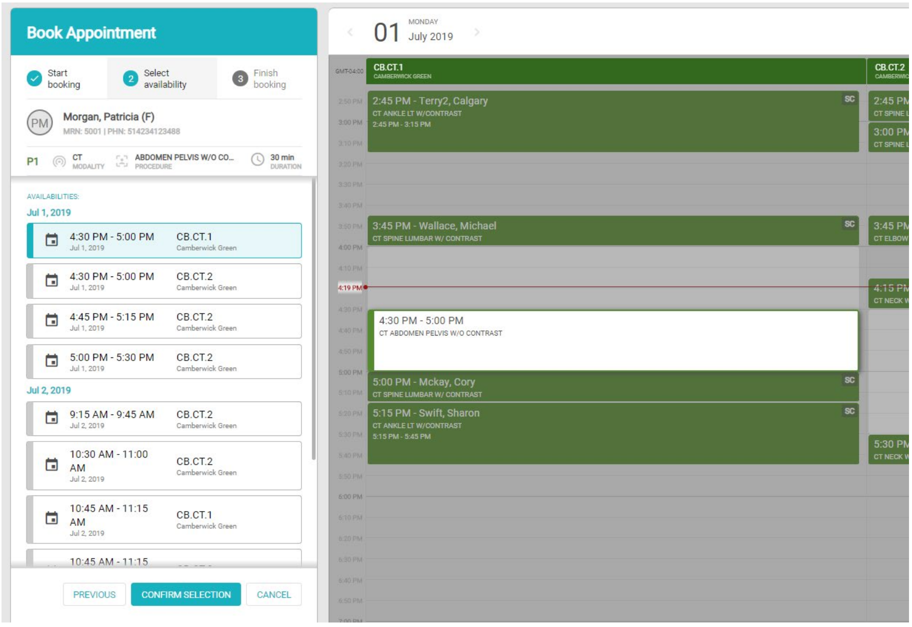


Figure 27. New RIS Appointment Search Results List.

First 500 Matching Appointments Found

Location	Room	Appointment Date	Time	Mins	Appointment Type
CLINIC B	US 1	Monday 01 Jul 2019	3:30PM - 4:15PM	45	US
CLINIC B	US 2	Monday 01 Jul 2019	3:30PM - 4:15PM	45	US
CLINIC B	US 1	Tuesday 02 Jul 2019	8:00AM - 8:45AM	45	US
CLINIC B	US 2	Tuesday 02 Jul 2019	8:00AM - 8:45AM	45	US
CLINIC B	US 1	Tuesday 02 Jul 2019	8:15AM - 9:00AM	45	US
CLINIC B	US 2	Tuesday 02 Jul 2019	8:15AM - 9:00AM	45	US
CLINIC B	US 1	Tuesday 02 Jul 2019	8:30AM - 9:15AM	45	US
CLINIC B	US 2	Tuesday 02 Jul 2019	8:30AM - 9:15AM	45	US
CLINIC B	US 1	Tuesday 02 Jul 2019	8:45AM - 9:30AM	45	US
CLINIC B	US 2	Tuesday 02 Jul 2019	8:45AM - 9:30AM	45	US
CLINIC B	US 1	Tuesday 02 Jul 2019	9:00AM - 9:45AM	45	US
CLINIC B	US 2	Tuesday 02 Jul 2019	9:00AM - 9:45AM	45	US

Figure 28. Old RIS Appointment Search Results list.

One element that was consistently enjoyed by all of the users was the calendar overview (Figure 31). The calendar overview displays a whole month with circles over those days which have appointment availabilities that match the search criteria the clerk entered in step one of the booking process. All of the users in the tests expressed their preference for this display; they indicated that it offers the information they need about availability in a way that is easier to digest, faster to respond to, and at a time that they would want to ask patients about it. The current solutions require users to either read one column of text very carefully or to click through days one at a time and find an availability. Importantly, this display also did not expose information about the technologist schedules. It simply indicated that there was at least one available slot for each selected procedure on the highlighted days. This display can cut out a significant number of clicks and reduce the time it takes users to read through their options. The biggest issue that the users faced with the display was how to move from the month view to the list view of the availabilities per day. It also matched a visual that users were used to: the mini month view of the calendar available on the schedule grid and the selection method for dates throughout the current application. The tabbed structure of the display, however, did not match any of their existing displays, and they didn't understand the terminology used to indicate the content of the second tab.

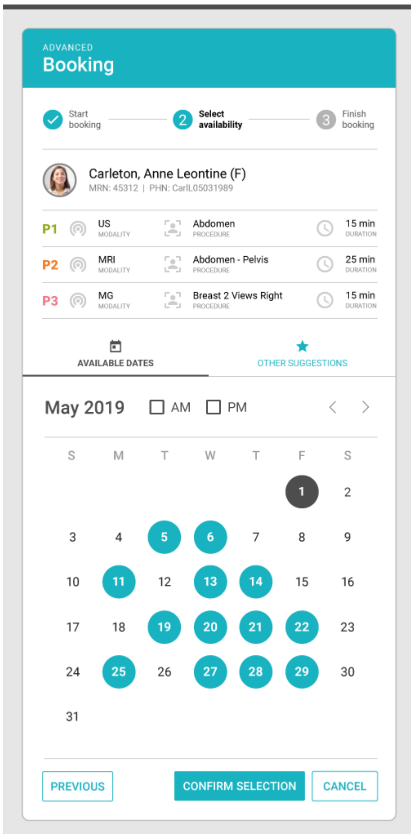


Figure 29. New RIS Mockup of Appointment Search Calendar 'Heat map'.

Patient Validation

Before clerks can book anything for any of the patients they interact with, they must first validate who the patient is. Knowing this, the new system was designed to allow clerks to validate patient identities with the patient record summary that the clerk sees when they select a patient from the search results. This includes the name, healthcare number, date of birth, address, and phone number of the patient. All of these pieces of information are visible with one click from the search results, yet every single one of the clerks in the usability tests at Client B insisted on stepping into the patient record to validate there. When asked about this, they indicated that they didn't even realize that the information was all visible from that first view (Figure 32). According to the administrator this is a clinic policy, they don't find that the old RIS reveals sufficient information for the clerks to validate the patient from the search results, so they insist that clerks always open the patient record. The clerks weren't even looking to find the information on the search results, not noticing the information and having a process they usually followed. What is interesting is that clerks at Client C didn't seem to have this same issue, they seemed content to use the information visible on the patient record to validate the patients.

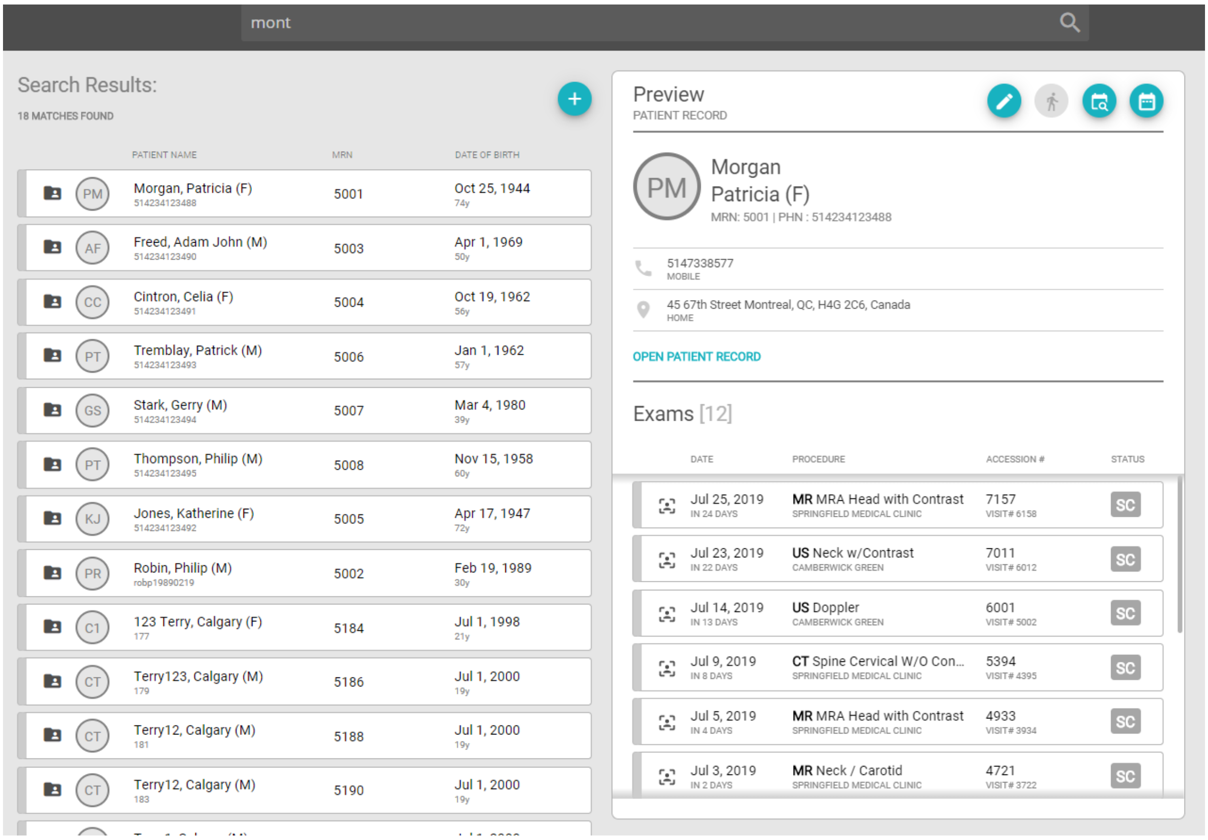


Figure 30. New RIS Patient search results.

Exam History List

Upon opening the patient search result and their record overview page, users are presented with an exam history list. This was also an issue for most of the users. Users in the first round of usability testing also found that it was difficult to understand the list and the order in which it was placed. Three users specifically in the first round complained about the display. In total, of the 15 people who participated in usability tests, nine had direct issues with the display of the exam history list. Beyond determining statuses, which we had already established were difficult to understand, users had difficulty understanding the order of exams. In the old RIS, past exams, future exams, missed exams, and appointment requests all have separate lists, so users can decide what kind of exam they are looking for and pinpoint the exams on a shorter list (Figure 33). The current iteration of the new RIS has placed all of these together on the same list, with the exception of the appointment requests, as those are not yet implemented (Figure 34). This single list is reverse ordered by date, with the exams oldest at the bottom of the list and those furthest in the future at the top of the list. Despite the reverse ordering of the dates of exams, the times of exams on a specific date are ordered in the normal direction, those earliest in the day at the top of the list, contradicting the ordering of dates. For most patient exams, this order probably won’t be too much of an issue for clerks to use. For example, the patient has a history of four exams, each happened in the past. They have one exam scheduled for three days in the future. They would have a total of five exams on their list with the exams that are the most pertinent for most of their enquiries at the top of the list. However, for patients that have many exams pre-booked, such as pregnant people who have pre-booked all of their checkups, they might have five exams booked into the future, and a history seven exams. These patients might have a question about any of the 12 exams on their file, but determining which exams are in the past and which are in the future is difficult in the interface. It was also difficult for clerks to quickly determine which of the exams was the closest to today, the small text under the date that told them how far in the past or in the future the exam would be was ignored and found to be less important than having the time of the exam written on the list.

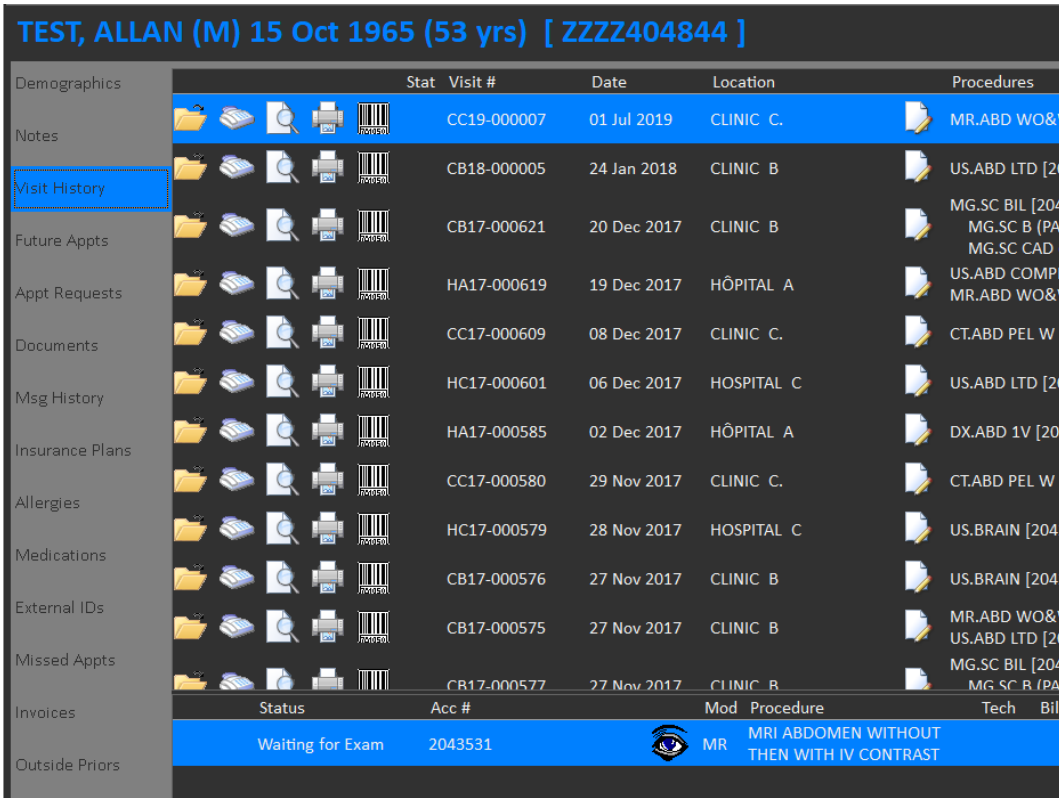


Figure 31. Old RIS Exam History List, lists are split so only historical exams are displayed.

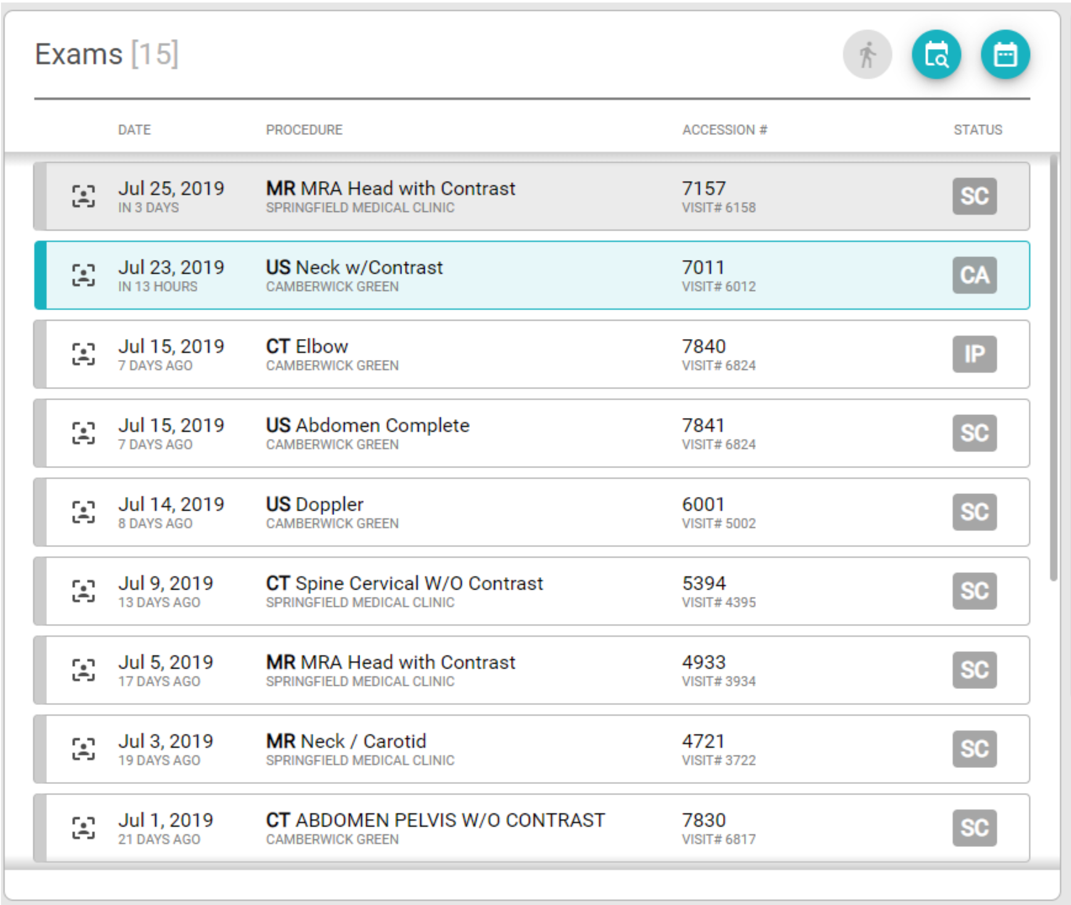


Figure 32. New RIS Exam history list, all exams are populated to the same list, regardless of past or future status.

Terminology

The terminology used throughout the interface, apart from the appointment status, was also problematic for about half of the users. In some cases, the terminology was indicating actions that were not yet possible in the testing version, and at other times, users were completely unsure of the meaning. In the case of the booking actions possible, there are two buttons that users could select, one to open the appointment search and one that opens the calendar through which, in the future, users will be able to book appointments. The labels applied to these buttons were ‘advanced booking’ and ‘manual booking’ respectively. Three of the six users in these usability tests were unsure which of the buttons to select and selected manual booking as they considered the task to be a simple one, one that they should complete manually. When asked why they decided to select manual, they indicated that advanced sounded like it should refer to booking very specific and difficult to book appointments that required more knowledge. They also found it disconcerting to be brought to the calendar for ‘manual booking’ when the calendar does not afford that kind of interaction at the moment. The old RIS, in contrast, uses menus to trigger these actions, with both booking through the schedule and through a search falling under “book appointment” and labelled as different options: “schedule grid” and “appointment search” (Figure 35).

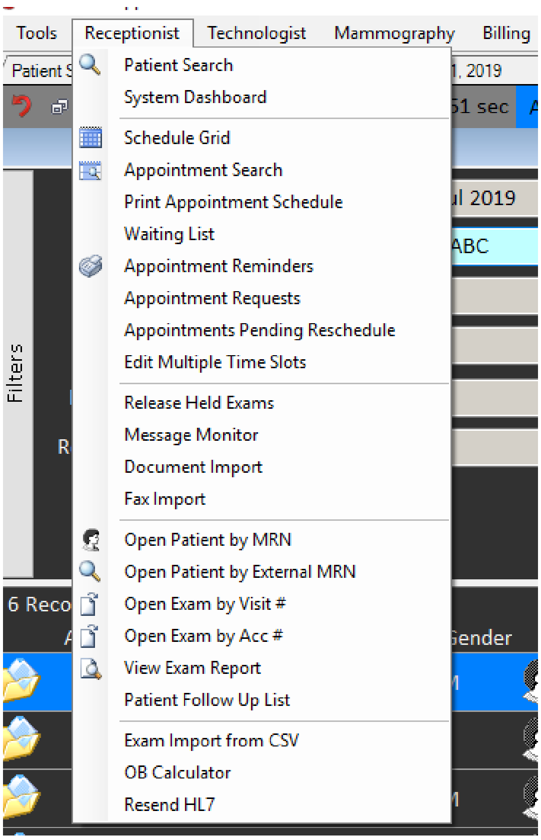


Figure 33. Old RIS Booking terminology.

Three of the clerks (two booking and one front desk) commented that they were very satisfied that the new interface honoured more genders and sexes than the old. Both the booking clerks were concerned with the lack of open text entry for special information about contacting patients. They wanted to be able to note down, in the demographic information if the contact person for the patient was their parent or caretaker. They also wanted to be able to add notes on the cancellation modal to give more details as to why patients had chosen to cancel their exams, as the options in the dropdown were not specific enough for them (Figures 36, 37).

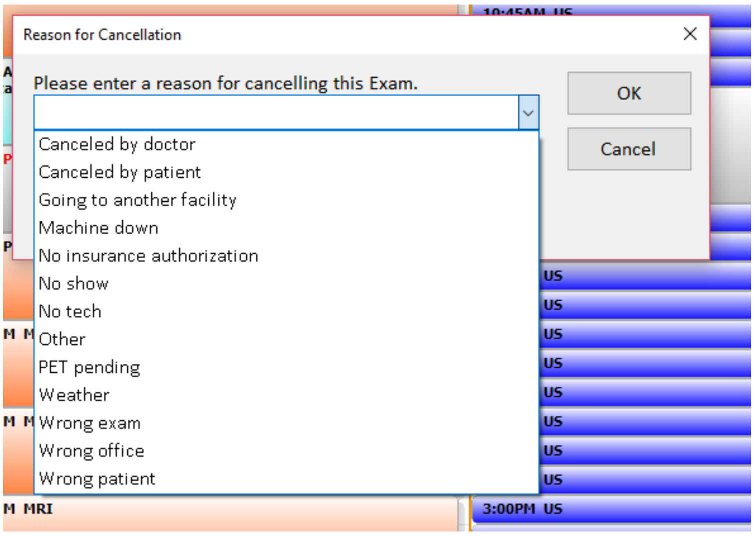


Figure 34. Old RIS Reason for cancellation dialogue.

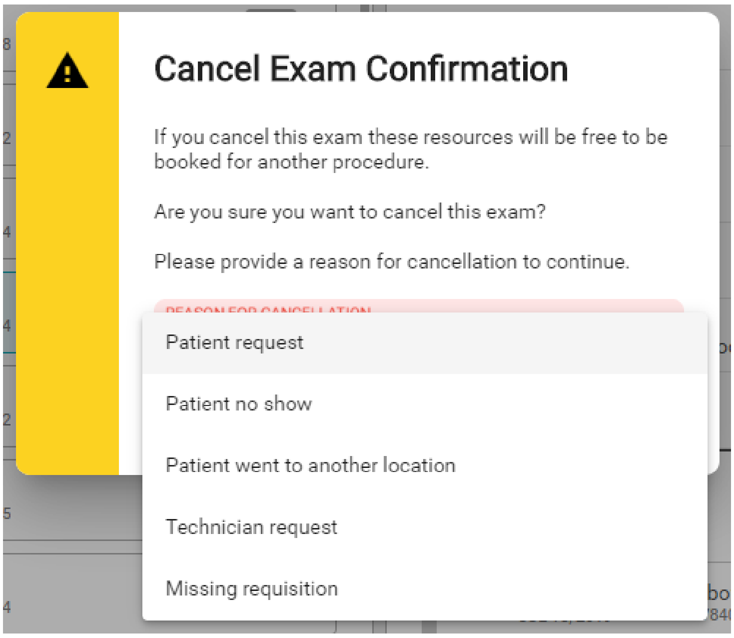


Figure 35. New RIS Reason for cancellation dialogue.

Worklists

As with Client C, the users from Client B did not use the worklists for anything (Figure 38). Only one clerk, who was asked to set herself up for completing reminder calls, actually opened the worklist section intentionally. Both of the booking clerks were asked to set themselves up for reminding patients of their exams, but the younger booking clerk had no experience doing that task, as the clinic generally uses an automated system for this. The administrator also looked at the worklist for the check-in task, but she, like the rest of the clerks always opened patient records to validate their information, forcing her to constantly leave the worklist and come back. Additionally, the administrator found that it took her longer to read through the names on the worklist than it would have to type the name in and find the patient directly. This perception was mirrored throughout the observations of clerks at clients A, B, and C with the old system. This was compounded by the fact that the worklist was well populated and the exam they were asked to check in was not the first or close to the top of the list (Figure 39).

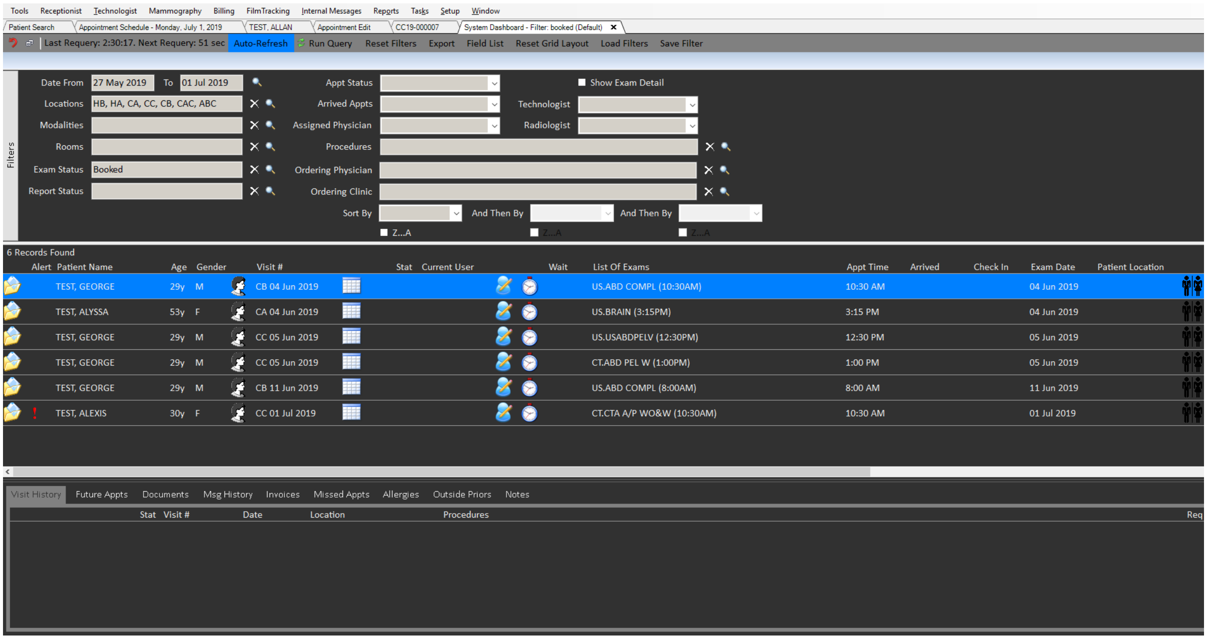


Figure 36. Old RIS Worklist display.

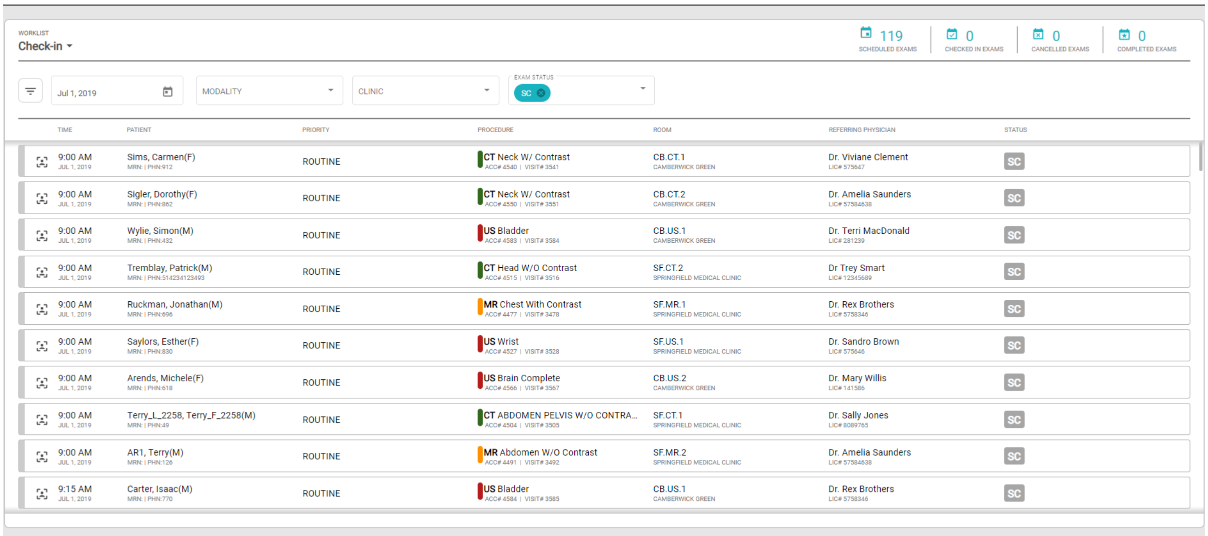


Figure 37. New RIS Worklist display.

Pain Points

Finally, during the booking process, there were two ways in which users found the new interface less useful than the previous. Firstly, when inputting search criteria, users had a few issues. While most of the drop down selections in the new interface are single select, the clinic dropdown is multi-select; where the single select menu disappears after the user makes a selection, the multi-select only disappears when the user clicks somewhere outside of the dropdown pane. This caused issues for two of the users in this round of usability testing issues and caused four of the users from Client C as well. The procedure selection was also a pain point. In the first round of usability testing at Client C, the three users who commented had questions about the suggestions drop down menu. They were unclear on the source of the suggestions that were being offered in the dropdown for procedures, and two of them didn't notice that the options displayed were even suggestions. This is a problem on two fronts. Firstly, the "suggestion engine" had not yet been implemented, meaning that the procedures listed are not, in fact, intelligent suggestions, rather they are an alphabetical listing of procedures. And secondly, it remains unclear to both the clerks and the developers what the suggestions could be based on: should it be procedures the patient had recently had, or procedures the clerk had recently booked?

Users from Client B did not ask about the types of suggestions that were on offer, instead selecting from the procedures on offer. What's more problematic was that none of the users realized that they could type to search for procedures in the procedure field. Users saw procedures pop up immediately upon their clicking into the field and instead of typing something in to the field to refine the dropdown items, they read through the options and scrolled to find the procedure they wanted. While not an issue in the test environment with only a few procedures are listed for each modality, as in the test environment, most clinics have hundreds of procedures for each modality, making this kind of visual scan inefficient.

5.3 Observations

5.3.1 Client A

Front Desk Clerks

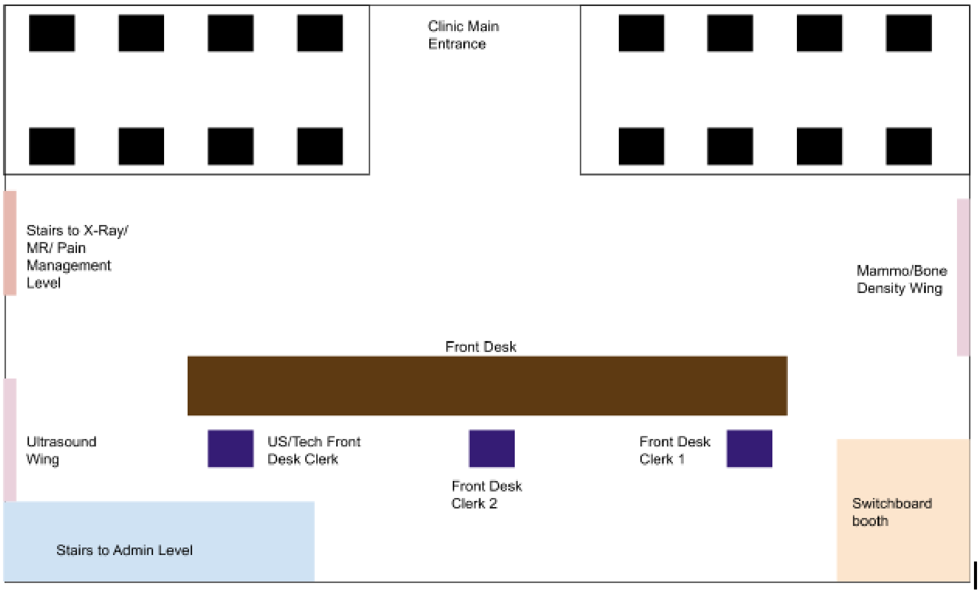


Figure 38. Client A Front desk.

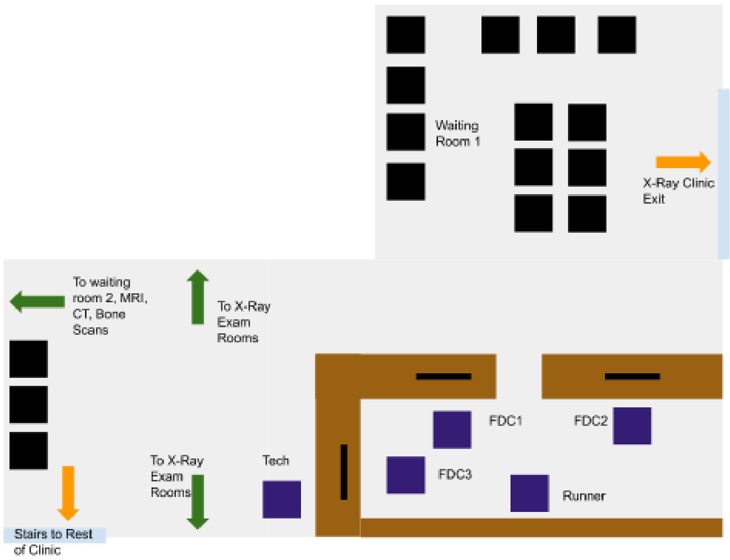
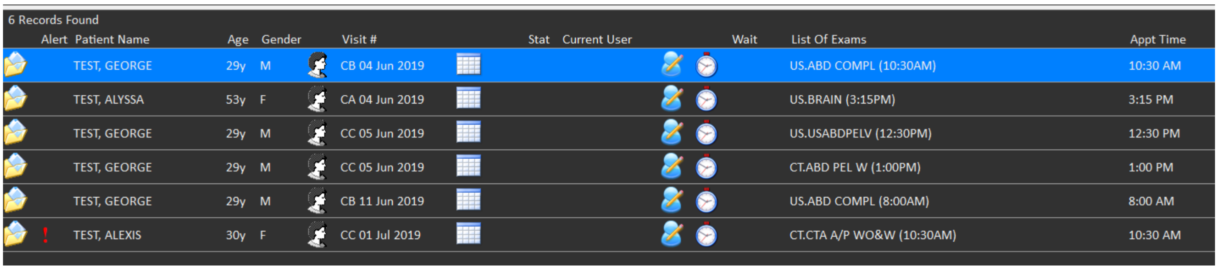


Figure 39. Client A X-ray front desk.

One day was spent at Client A conducting observations. A few hours were spent with two different front desks, each with a different set of modalities to focus on. The first front desk took care of most patients who came into the clinic for ultrasound and mammography exams (Figure 40). This desk was staffed by two designated front desk clerks and one clerk who managed the ultrasound patients once those patients had been checked in by those front desk clerks. The second front desk was focused on checking in patients who were at the clinic for X-ray procedures, MRI procedures, and pain management procedures (Figure 41). This second desk was staffed by three clerks and one "runner". In this case, however, one of the clerks was mostly responsible for entering completed exams into the system for technologists.

The five front desk clerks at Client A were observed using the worklist about half of the time. Four of the five liked to keep the worklists open on a tab that they could reference when they wanted to. One of the clerks was using a worklist to perform a task that is not usually assigned to front desk clerks in other locations. Technologists at this clinic use printed requisitions as worksheets but don't have scanners to input completed requisitions back into the system after appointments. Instead, the technologists would bring their completed requisitions to the front desk and pile them into a tray. The order of the requisitions in the tray approximately matched the order of the worklist, the clerk was able to use the worklist with confidence. Another clerk who kept the worklist open at all times worked at the front desk that did not deal with X-rays. She used the worklist to check patients in for booked exams. Interestingly, these two clerks were the only clerks who had rearranged the view of the worklist to maximize the height of the list and the number of results visible at any time (Figure 42, 43).



6 Records Found

Alert	Patient Name	Age	Gender	Visit #	Stat	Current User	Wait	List Of Exams	Appt Time
	TEST, GEORGE	29y	M	CB 04 Jun 2019				US.ABD COMPL (10:30AM)	10:30 AM
	TEST, ALYSSA	53y	F	CA 04 Jun 2019				US.BRAIN (3:15PM)	3:15 PM
	TEST, GEORGE	29y	M	CC 05 Jun 2019				US.USABDPELV (12:30PM)	12:30 PM
	TEST, GEORGE	29y	M	CC 05 Jun 2019				CT.ABD PEL W (1:00PM)	1:00 PM
	TEST, GEORGE	29y	M	CB 11 Jun 2019				US.ABD COMPL (8:00AM)	8:00 AM
!	TEST, ALEXIS	30y	F	CC 01 Jul 2019				CT.CTA A/P WO&W (10:30AM)	10:30 AM

Figure 40. Old RIS Default worklist column orders.

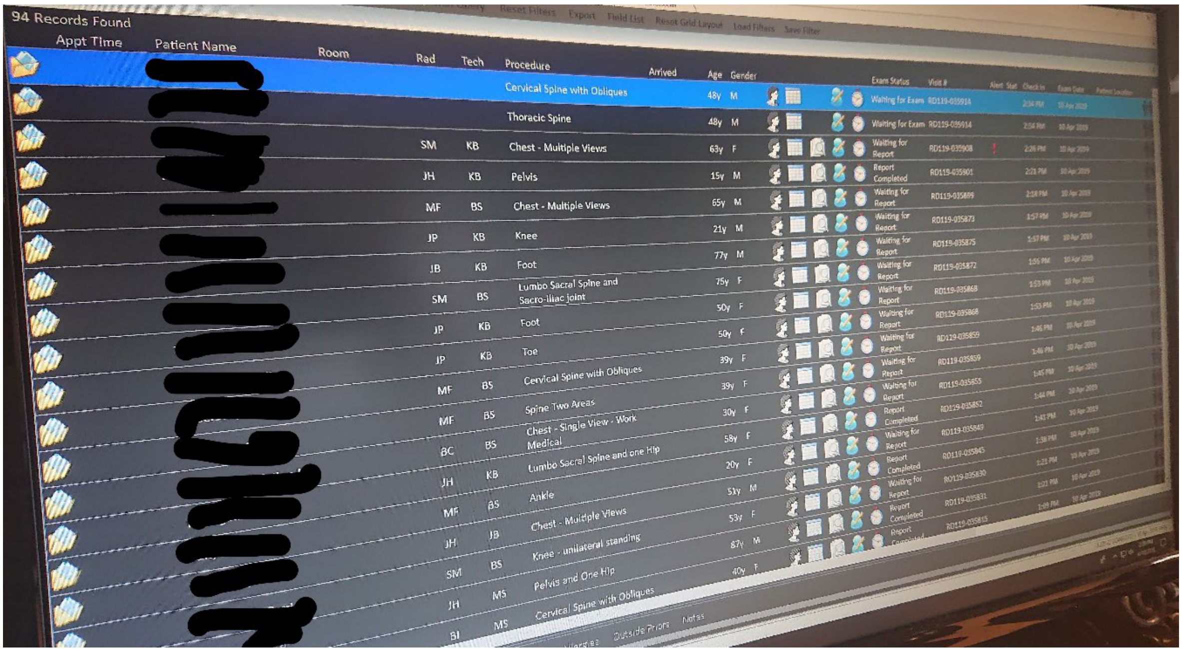
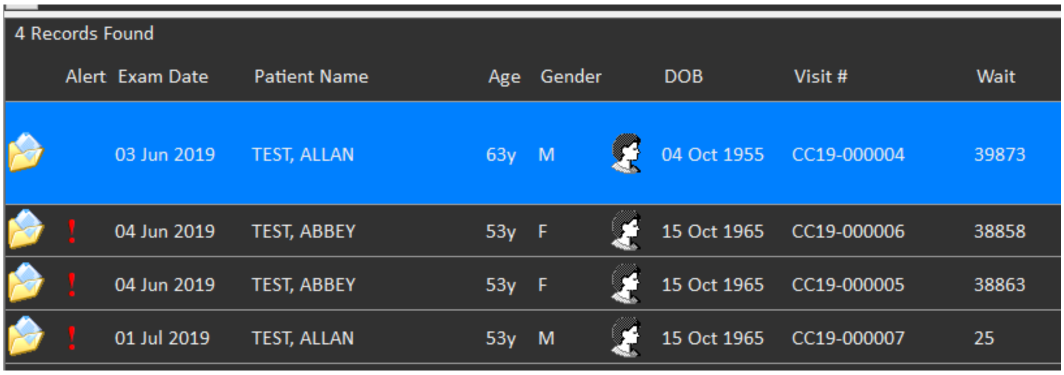


Figure 41. Old RIS Worklist, arranged to prioritize patient name.

Of the other three clerks, one did not have the worklist open at all, and two others used it sparingly. These clerks were at either check in desk. The clerk who did not have the worklist open at all was an older user who had experience as a booking clerk in the past and was dealing predominantly with walk in appointments. The few patients that came in with something already booked were quickly searched for and found by the clerk, reinforcing the idea that she didn’t need to use the worklist. The two clerks who had the worklist open in a separate tab from the main search tab used it for two different purposes. The first would start her search for booked appointments in the worklist, but she would only look at the worklist for three seconds and scroll up and down once on the mouse before switching to a patient search. The second clerk never looked for a patient’s appointment using the worklist, but rather kept the list open so that she could see the ‘waiting time’ to answer queries from the person accompanying the patient to the appointment about how long the patient might still take or where they were (Figure 44). The waiting time in this instance was not a reflection of how long it took for the patient to see a technician but, due to the technicians sending requisitions back to the clerk desk, how long the patient had been in the clinic.



4 Records Found

	Alert	Exam Date	Patient Name	Age	Gender		DOB	Visit #	Wait
		03 Jun 2019	TEST, ALLAN	63y	M		04 Oct 1955	CC19-000004	39873
	!	04 Jun 2019	TEST, ABBEY	53y	F		15 Oct 1965	CC19-000006	38858
	!	04 Jun 2019	TEST, ABBEY	53y	F		15 Oct 1965	CC19-000005	38863
	!	01 Jul 2019	TEST, ALLAN	53y	M		15 Oct 1965	CC19-000007	25

Figure 42. Old RIS Worklist with wait time column made visible at the end of the display.

Worklists were also not used much by the technologists. In this clinic, technologists worked by paper records for the most part. Though there are specific tools for technologists to use in the RIS program that the clinic is currently using, the technologists did not seem to be using any of them. The worklists that would automatically be generated by the RIS system for technologists were not used at all. Instead a system of papers were still used as proxies for the physical locations of patients within the clinic. The most complicated and confusing instance of this reliance on paper was set up by the third clerk at the first front desk. This clerk was more of an air traffic controller than a clerk. The task of this clerk was to make sure that patients were being taken to the changing rooms and assigned to the correct technician in the correct room from there. This involved her having a screen with a schedule view of the whole day for all of the ultrasound rooms at once. She would also have the schedules for each of the rooms printed out on paper arrayed below the screen. Both of these views were showing her essentially the same information, but she completed different actions with each. Using the screen display, she was able to see when patients were checked in to the clinic and were waiting in the front waiting room. This was also her last moment to verify that the procedures booked for each technologist and patient were procedures that they were confident doing and allowed to do. If a technologists was replaced at the last minute or the booking person didn't know about a specific preference, this clerk would switch different appointments around with the aim of keeping the appointment start times approximately the same. For this purpose she had a room blocked out as her 'switching room', to which she could send incorrect appointments, freeing up their space for the appointment she wanted to switch into that location. Or, more specifically, she would notice an appointment in the wrong position, find an appointment that she could switch the first with, then move the first appointment into an open slot, move the second appointment into the now free first appointment slot, and move the first appointment into the slot the second appointment had previously filled.

Once she had made sure that the appointments were scheduled with the correct technologists, she was able to concentrate on the patients. This took the form of some interesting paper shuffling. When patients are checked in to this front desk, a label is printed and stuck on a piece of paper, the patient is asked to wait in the first waiting room, and the clerk places this paper next to the coordinating clerk. The coordinating clerk checks that the patient is checked in to the system on the screen, marks the room on the patient’s paper, then calls the patient’s name. Once the patient gets up, she checks the patient off on the paper schedules she has, takes the patient’s paper and leads them from the waiting room to the changing room. At the changing room, she will mark on the patient’s paper the number on the waiting room and slip the paper into the tray of the room/technologist that will be conducting the appointment. All of these steps are meant to capture the location of the patient in the clinic and indicate to the technologists the difference between a patient who is simply in the clinic instead of a patient who is in the clinic ready for their exam. Technically, this patient tracking and sharing feature exists in the RIS that the clinic uses, but the clinic or the clerk had not set it up and used this physical paper and pencil system to keep track of patients instead (Figure 45).

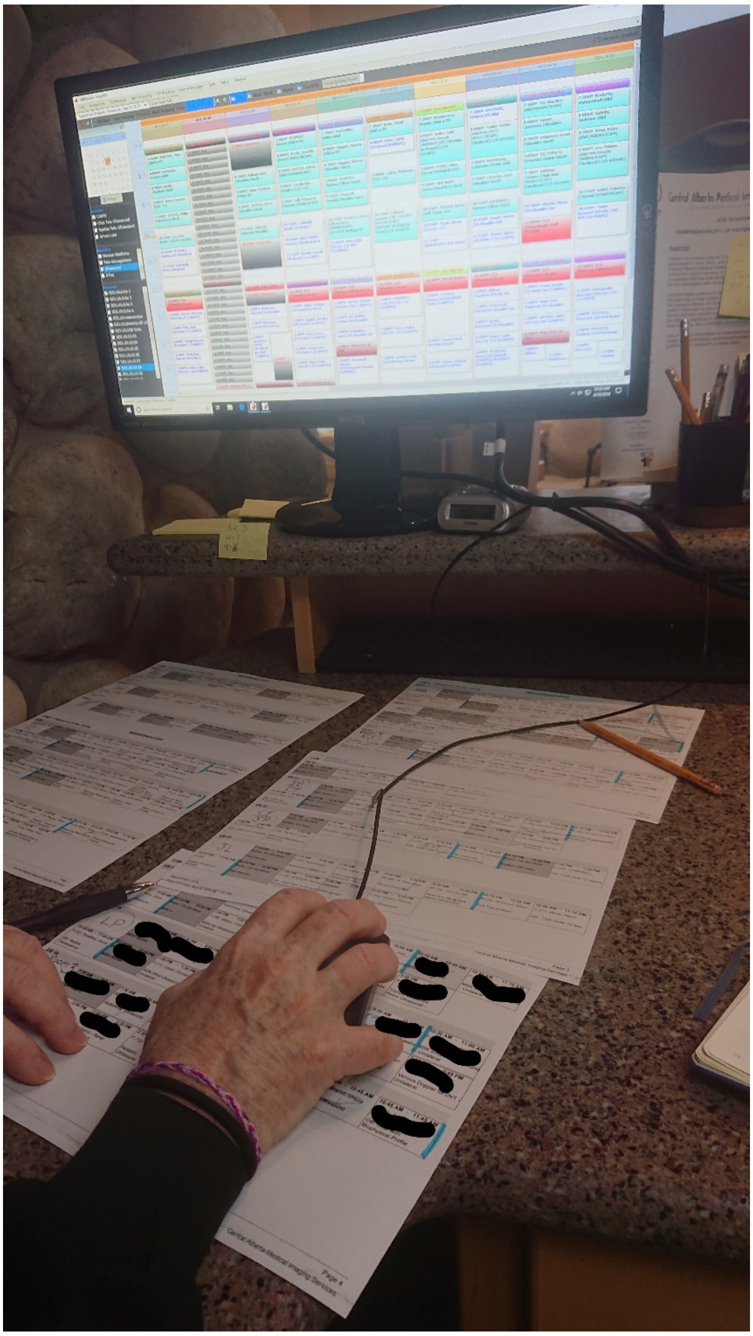


Figure 43. Ultrasound clerk physical/digital setup.

Booking Clerks

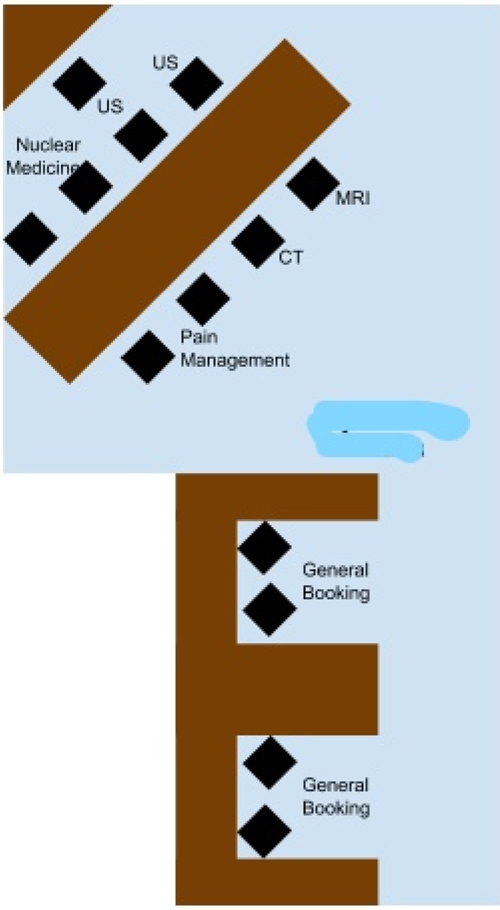


Figure 44. Client A general and specialized booking clerks.

The booking clerks at Client A fell into three categories: the “switchboard” clerks, the general booking clerks, and the specialized booking clerks (Figure 46). The “switchboard” clerks worked at the main clinic and were physically accessible to patients. These clerks handled a variety of functions including burning CDs, monitoring report statuses for patients and referring physicians, making reminder calls, performing some billing functions, inputting appointment requests, booking appointments for patients and physicians, adding new physicians, and coordinating protocolling for some procedures. These clerks mostly relied on patient search due to the variety of functions they worked on. When searching for a patient they’d search for date of birth then last name then finally confirming further details before moving forward with whichever action the caller or requestor was looking for. Often this meant booking appointments, which was always done through the calendar (referred to as “schedule grid in the old RIS), requiring the clerk to look through the days one at a time around the date that patient requested to find an opening. Due to the large number of rooms, this sometimes requires them to select a day and then scroll back and forth on the calendar to see all the rooms to search for availability. Perhaps not surprisingly, one of the clerks asked specifically about having a way to search for appointments rather than needing to constantly step through the schedule one day at a time. Both clerks referred to an older system that would allow them, through some kind of grid interface to search for specific appointments, this old system allowed them to search availabilities by type of appointment rather than the specific procedure. When shown the appointment search functionality of the old RIS, the clerk found it too complex, requiring more selection and specifications than strictly necessary. She was mostly interested in some kind of general search, where when looking for something in the schedule, she could select one of the templated availabilities and look for the next available. She and the other clerk who was working at the switchboard expressed a dislike for the huge variety of routes that users could take to achieve any action when one would be sufficient and most likely more efficient.

There were only two clerks who used worklists in the switchboard area. The first used a printed Excel file of the patients who were not reached through the automated reminder system set up by the clinic, requiring the clerk to call the patients themselves and determine the cause of the failed communication. Due to the information coming from a third party, the clerk was unable to use an internal worklist. The second clerk who used a worklist was the mammography clerk, who worked in the switchboard area rather than the booking area for the proximity to the mammography rooms and technologists. Like the air traffic controller clerk at the front desk, the mammography clerk had a hybrid approach to her worklist. This clerk was responsible for requesting prior films, digitizing films, and booking biopsies, call-backs, and follow-ups (Figure 47). The clerk demonstrated her process, in which she would book a patient for a mammography procedure, be asked about prior reports, and submit all the details. The system automatically asked about requesting priors for each new booking, and if the clerk affirmed her wish for priors, the system would always suggest certain defaults, despite those defaults never being used or being too vague or ambiguous, requiring the clerk to get rid of them each time. While initiating the booking process was done through a physical worklist which was a pile of requisitions, requesting priors and following up on them was usually done through a RIS worklist. The worklist, as with the other official worklists within the RIS did not allow for actions to be taken on the patient from the results list, but rather the clerk would need to select the patient, open their file, find the right tab of information and then enter the details from there. Though there were many search fields available to the clerk to refine her searches for film requests, she only used the status of the request to get herself a list of requests to work with. On occasion she did also search with a patient name, but the purpose of the lists was to move the requests from one status to another, from “requested” to “films obtained”, making status the most important filter.

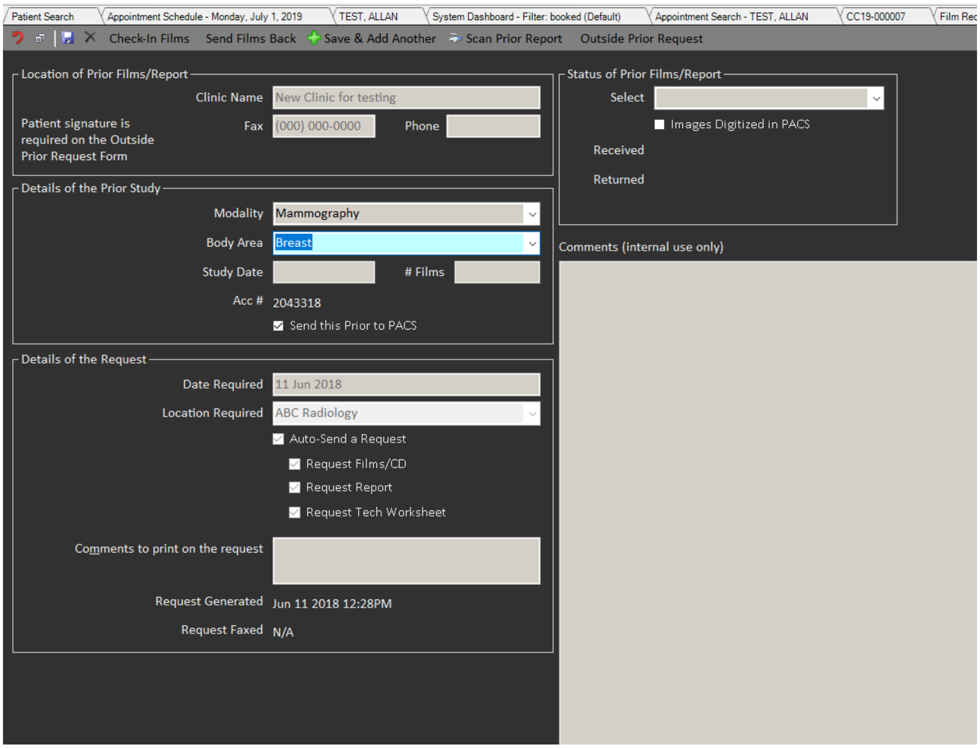


Figure 45. Old RIS Outside priors or 'film request' tab.

Finally, time was spent with the booking clerks located in the booking area for this client. The booking clerks, those dedicated solely to booking rather than the “switchboard” clerks who completed many other functions, were located at a separate location from the main clinic. Here again, there was a division in specialties for the different booking clerks. The first group of clerks booked general procedures, usually ultrasound procedures, but their unifying theme was that they did not require any protocolling or much special preparation by patients before the procedures themselves. The second group of booking clerks were more specialized with each type of specialization having between one and three clerks assigned to it depending on how common the procedures are and how much time the preparation for the procedures required. Between the two groups there were 13 clerks working of which nine were observed; four general booking clerks and five of the specialized booking clerks. Though the specializations varied, the actual interactions of the clerks with the RIS system remained the same for all but two of the clerks.

Protocolling was standard for all of the clerks. They would receive the requisition, load up any prior reports they could find through the online health records of the region, and input one file comprising of the requisition and the prior reports into an appointment request. The appointment request feature only allows one file to be uploaded at a time. The clerks found this difficult to work with because the prior reports needed to be printed off and scanned in with the requisition in one long set of pages. It was unclear if this was a case of the clinic not having found the correct tool for this process, or that there really wasn't a tool in the old RIS for this process at all. This appointment request with its single file was then set to the status of requiring protocolling and the technologist or radiologist in charge of that speciality would get a physical printout as well as a system update to protocol the appointment. Which protocoller it needed to go to, which documents were required for the protocolling, and how long the protocolling took all depend on the type of modality and procedure, but they all went through the same basic steps- with the same problem of only being able to upload one file at a time.

The general booking interaction patterns expressed by the clerks were pretty clear: when booking a procedure, each clerk would work from a physical requisition whether that requisition had been uploaded into the system as an appointment request or not. The requisitions from which clerks were booking were always already protocolled, having been faxed in and directed to the correct protocoller before the booking clerk could call the patient with an appointment time. Based on the information available in the requisition, clerks would open the schedule grid and click through individual days, scrolling across rooms where necessary, to find an appointment slot that fit for their patient. Specialized clerks would leave their search there as no one else would be booking for those appointment slots, but the general booking clerks would put a hold on the slot that they chose, check the requisition for a phone number, and call the patient (Figures 48, 49). Once they reached the patient, clerks would first verify the patient's details, their name, address, patient health number, and confirm what kind of phone number they were using. The verification process took place on the patient demographics page, allowing the clerks to tab through the fields and enter corrections all on the keyboard, which increased their speed and efficiency. The addresses however, were never entered into the main search or patient demographics fields. The general address fields were not used, as they did not format rural addresses correctly, so the clinic had adopted a practice where all clerks needed to enter the detail in the extra dialogue, requiring an extra set of clicks and movement between fields. Once the patient's identity was verified, the clerk would indicate to the patient that they had availability for the date and time they had already chosen. Most patients would take the appointment as suggested, though a few would have conflicts. Conflicts were resolved on the spot, with the clerk clicking through the days after the held appointment to find something else, though this was not always possible; either there were no other availabilities for weeks, or the procedure was time sensitive. The holds, however, can only be released by the same user who initiated the hold unless they have a timer on them, so if one of the clerks put the appointment availability on hold or forgets about it as they deal with something else, no one else would be able to book in that slot. This resulted in clerks often calling out to each other asking about the purpose and patient they had put the slot on hold for, trading priorities as they went.

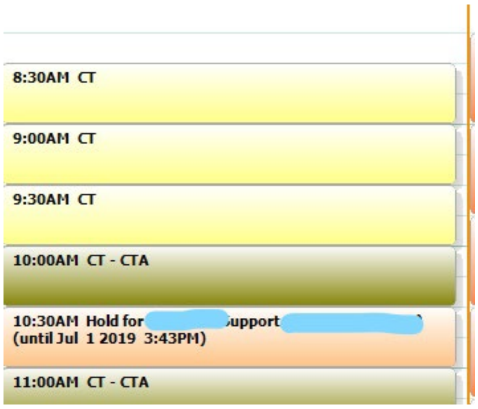


Figure 46. Old RIS Calendar slot 'on hold' display.

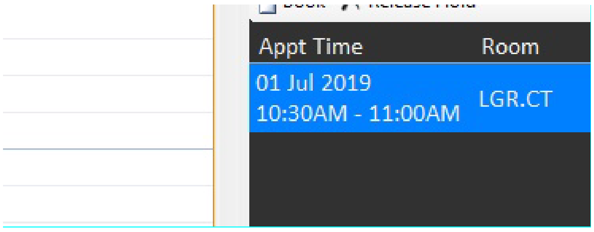


Figure 47. Old RIS Calendar right bar, contains information about holds and notes on the calendar.

There were only two clerks who deviated from this established booking pattern. The first of these two clerks specialized in nuclear medicine, and she deviated from the regular booking process in one specific way. This clerk still booked through the schedule grid, she had a set of procedures which could only happen once or twice in the day, even though the system allowed booking for many more. Therefore, she needed to look through consecutive days for appointment availabilities of the correct type then manually read through the appointments already booked on that day to look for the same type of procedure she was booking to avoid overbooking that particular type of each “available” day. To make it easier for her to view this information, this clerk repurposed the calendar grid. Though she was booking only for two rooms associated with nuclear medicine, she opened up two fake rooms, each next to one of the real rooms in the calendar. On these fake rooms, she would create an appointment-styled note for each of the procedures that was only allowed to be booked once or twice in the day and locate it next to the appointment that she had already booked in the real room. By putting this information into the topline of the appointment she had booked and having it separated from the rest of the appointments on the calendar, she was able to more quickly scan and assess the rooms for the conditions that would allow her to book her special procedures. This didn’t eliminate the need to step through the calendar day by day or scan the page visually each time, but it provided more clear visual triggers for her to target her search. She would also make notes about certain patient conditions which could affect the procedure in these calendar notes so that technologists would notice the information when they looked at their schedule for the day, making use of a feature for an unintended purpose, and not making use of notes or the spaces that technologists would otherwise look for (Figure 50).

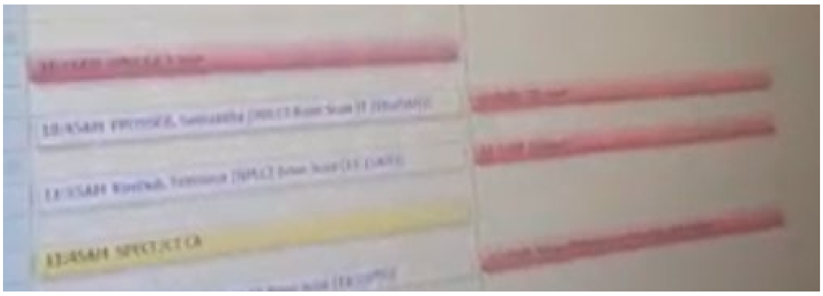


Figure 48. Old RIS Calendar display of two rooms, the first has appointments and the second contains only notes.

The second clerk who deviated from the rest of the clerk patterns specialized in MRI bookings and deviated by virtue of actually knowing about and using the appointment search function within the RIS rather than the calendar. She did indicate that she didn’t often use the appointment search, finding that she didn’t trust the results that much and that if there was any kind of special case or information she needed to keep in mind while booking she found it much easier to do that through the grid rather than the appointment search dialogue. She liked the fact that she could search for specific procedures; however, she found that not having the view of the calendar hindered her ability to book certain procedures as she didn’t have the visibility of the rooms, technologists, and the surrounding procedures it provided.

Generally, booking clerks found that there was a serious lack of visibility when it came to patients with other exams booked. If a patient called in or submitted a requisition for a procedure, the clerk would know only about that procedure unless they went searching for other booked appointments, resulting in the possibility of double booking a patient or booking them on the same day for procedures that are not allowed to be booked on the same day. These kinds of oversights are easy to make when the clerk is not immediately informed of these potential conflicts.

Beyond the address issues outline above, other patient demographic fields have required interesting interactions and workarounds to be adopted by the users of the system. These interactions were not pertinent or a problem for front desk clerks as they don’t use the demographics information in the same way. While front desk clerks will add addresses in the same extra dialogue box as the booking clerks, they do not need to interact with contact information the same way. They use whichever phone number is on the requisition as a method of verification of patient identity, but they don’t worry about how the reminder system will work with that phone number the same way a booking clerk does. The booking clerks need to verify not only the phone number itself, but also determine if that number is the primary number of contact and if the number belongs to a cell phone and can therefore be part of the text message reminder service. The problem that they faced regularly, however, was that only the first number listed is searchable in the old RIS, requiring them to keep whichever number is on the requisition there, even when it might not be a primary number. To get around this, they were adding in written notes about the fact that the second number might be the primary number. Additionally, patients who are underage often have legal guardians and elderly people often have contact numbers that are not their own. In the old RIS, there is no location for clerks to indicate if this is the case and who the contact information goes to, or else who if anyone is allowed to make decisions on the patient’s behalf. In the old RIS, the booking clerks write this information into the ‘special needs’ field for the patient (Figure 51). Clerks will also use this space to take note of individuals who can be spoken to when the patient cannot be reached. Though not an issue on its own, the special needs field automatically generates an alert for the patient when clerks open their record, contributing to the high number of alerts for patients which all clerks indicated were a block to their interaction flow. Alerts cannot be tailored to display for different roles, users, or actions, so front desk clerks will be seeing information the booking clerk needs to know, while the booking clerk may see information only pertinent to the front desk clerk. Often this means that the clerks are simply accepting all the notes without reading them as 90% of the time the notes don’t apply to them.

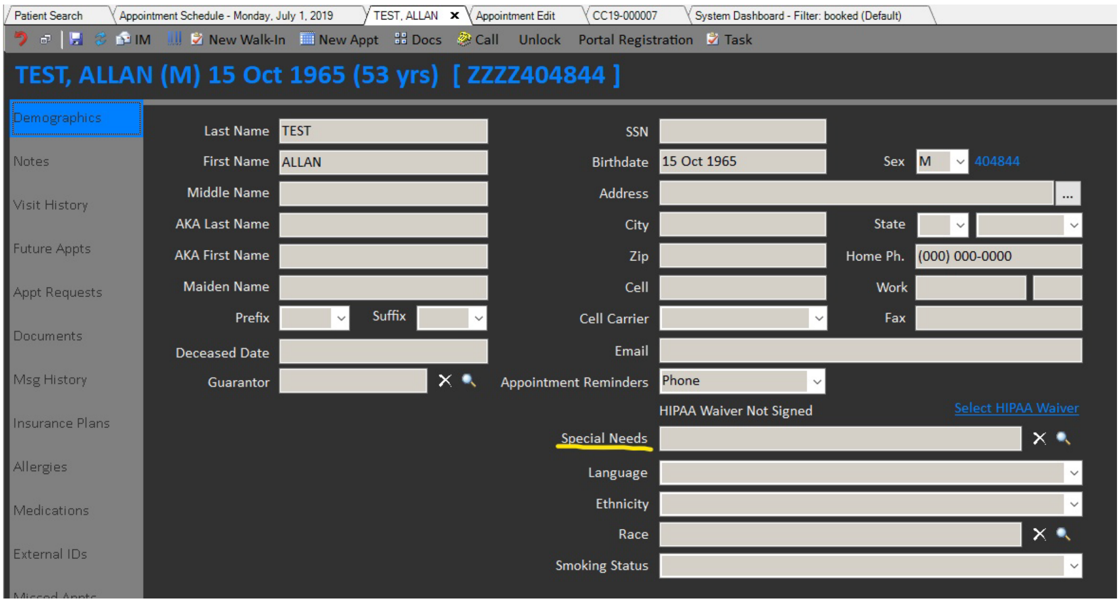


Figure 49. Old RIS Patient record demographics tab with special needs field.

General

Training new clerks at this site takes a long time, at least a few weeks per front desk clerk and longer for booking clerks. The main administrator explained that much of the training is spent having clerks learn various non-process information. For example, clerks need to learn what the colours of the various appointment slots on the calendar mean so they don't have to read the text every time. These colours may be re-used for different modalities and mean something very different. These colours also cannot change easily once they have been assigned, meaning adapting colours to a new type of procedure that doesn't fit into one of the predefined appointment types, it is nearly impossible. Beyond the rules about procedures that are defined by regulatory agencies, the clinic itself had rules about which procedures could be done on which days, sometimes indicated by the colours of the appointment types, but others are guidelines the clerk needed to know themselves, as with the nuclear medicine clerk needing to have a certain procedure no more than once a day. Furthermore, certain radiologists and technologists would or wouldn't do certain procedures even if the appointment type would allow for that, requiring the clerk to know this and apply this rule to their interactions themselves. All of these rules were handled differently depending on the clerks: some would have physical notes about certain requirements, others would ask each other about the rules if they thought they remembered some kind of rule but weren't sure what exactly it was. These kinds of rules not only take time to learn, but they also take time to implement for clerks, slowing down their booking process as they remember, find, reference, and apply the rules to their bookings.

5.3.2 Client B

More time was spent with Client B with two full days there, which included three different front desk locations, their central booking office, and their central billing department. Usability testing was conducted with these users, targeting the booking and front desk clerks. One of the administrators was present throughout these observations.

Front Desk

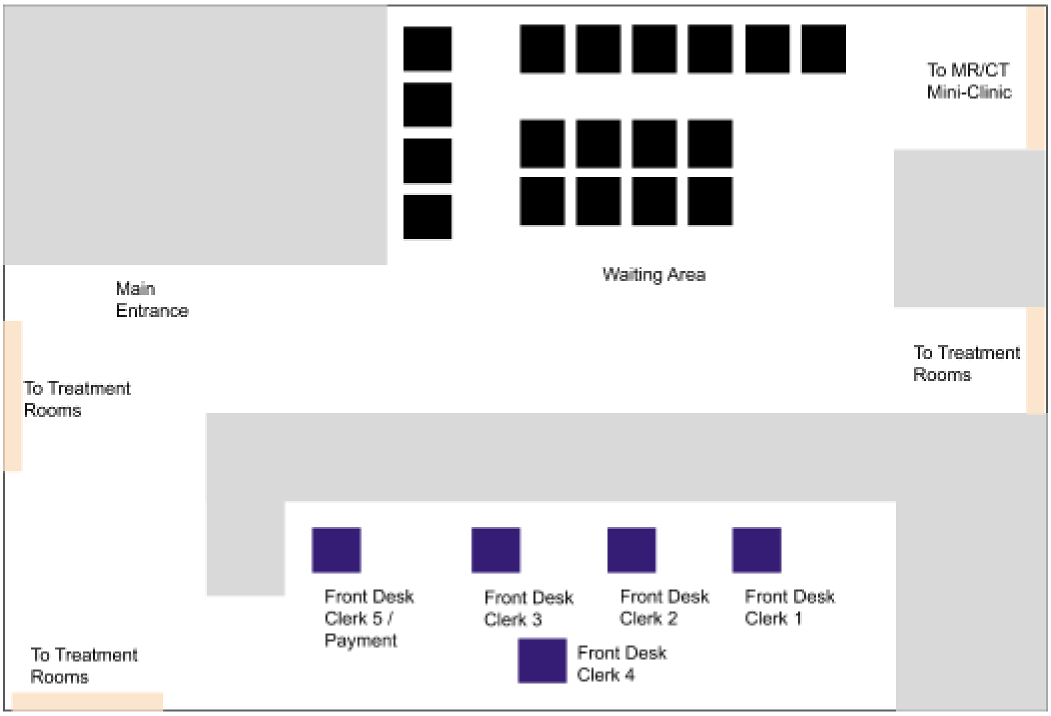


Figure 50. Client B Front desk setup at main clinic.

There were three different front desks that were observed during the time at this client. The first front desk was at one of the central and most busy clinics of the client (Figure 52). There were five clerks assigned to this front desk. The second front desk was for the clinic-within-a-clinic. Physically, this front desk was in the same location as the main clinic, however these clerks dealt only with MRI and CT appointments. The MRI/CT front desk had one front desk clerk with two other clerks in the same area that focused on different tasks. The last front desk was located at a clinic on the outskirts of town, catering to a more rural population, and was staffed by four clerks during the day though that number decreased to one clerk for the evening when only a few rooms remained open for X-ray walk-in exams.

The front desk clerks at Client B offered a broader range of how they would check patients in. For the most part they would, like some of the clerks in Client A, have a worklist open with the booked appointments for the day listed, and they would search for the patient there (Figure 53). If, however, they needed to scroll on the worklist display, they would switch over to the patient search function and find the patient through a targeted search instead. This was the process used by two of the five clerks at the large clinic front desk as well as two of the four at the smaller clinic outside of town. However, this method was slightly different for each clerk who was checking patients in. As one clerk explained it, some days she wanted to have the list expanded to show many results at once (Figure 54), but at other times she would purposefully reduce the number of results she could see so that she could more easily and more quickly identify individuals from the list. To identify patients from the list, the booking clerks would use the name of the patient or their date of birth, then if they had a requisition, they would compare the procedure on the requisition to the procedure booked in the system in the preview pane before opening the patient up to the demographics page and reviewing the demographics completely. Depending on how popular the modality was (how many appointments were booked for it for a specific day), clerks would adjust the filters to reflect all booked exams at a specific location or only those exams for a specific modality. Each of the four clerks who worked from the worklist regularly had their own specific method for using the worklist and their own threshold of time spent searching for a patient on the worklist before they would switch to a patient search.

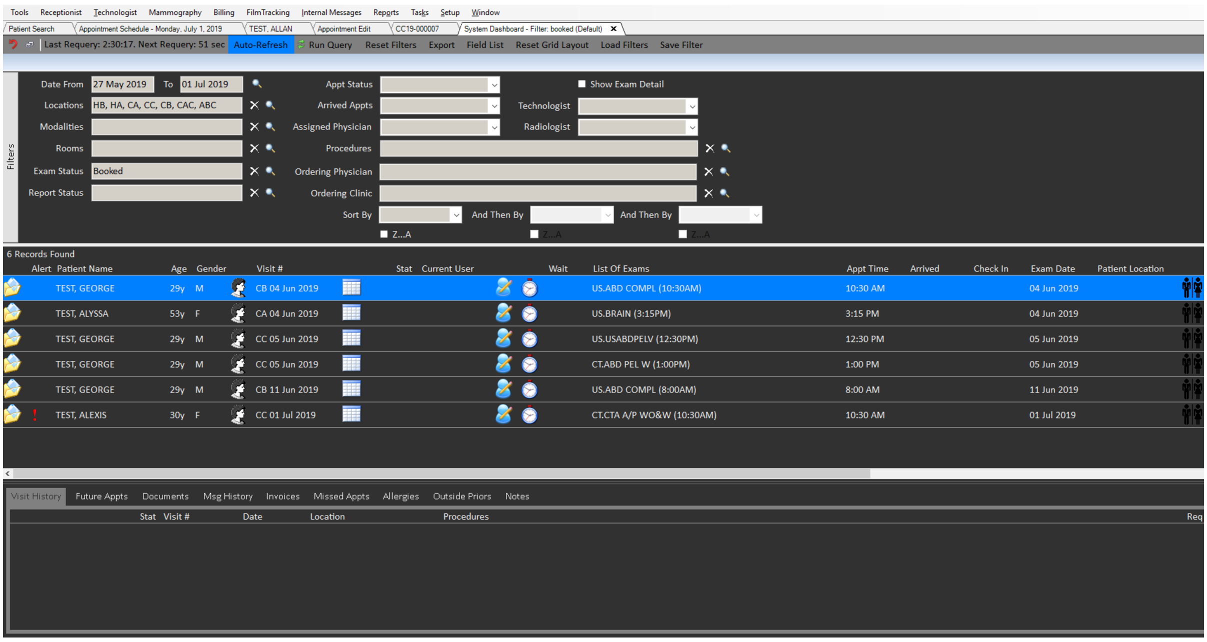


Figure 51. Old RIS Worklist with filters and patient history visible.

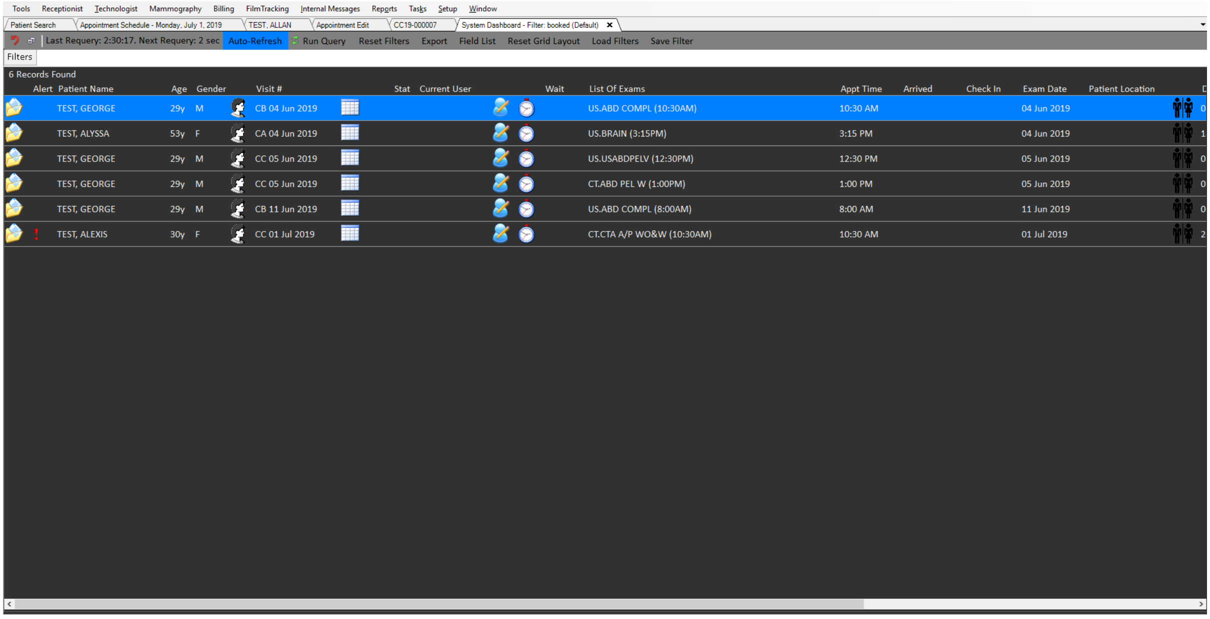


Figure 52. Old RIS Worklist with no filters or history visible.

The clerks who have the worklist open but don't check patients in from it found that there was too much information being displayed and what was being displayed was not helpful in their attempt to find the correct patient. Patients were often unable to remember the exact time of their appointment; often they would remember what time they were instructed to be there, but that could be 15 to 30 minutes before the start of the exam depending on the procedure they were going to have completed. Patients also were often unsure of the exact name of the procedure they were having completed or even which modality was going to be used. They might remember that it was something with their abdomen, but that could be a large range of options from the clerk's perspective. Finally, scanning for the name of the patient on the worklist was also not a simple endeavour when the name of the patient could be difficult for the clerk to understand, spell, or be or be ordered in a way the clerk wasn't familiar with. The program also does not allow for easy searching within the worklist (Figure 55). While the clerk could filter the worklist down to locations, modalities, and statuses, searching for a specific patient through the worklist was more difficult-- there was no simple "ctrl + f" to let them search for parts of the name or date of birth. The five clerks who predominantly used the patient search found that the healthcare number of the patient was the most reliable search criteria for their patients (Figure 56).

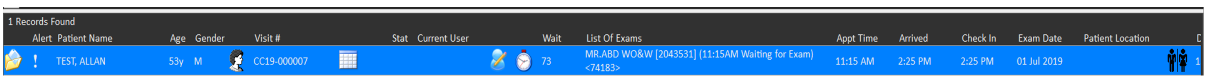


Figure 53. Old RIS Worklist column headings reading: Alert, Patient Name, Age, Gender, Visit#, Stat (priority), Current User, Wait (time), List of Exams, Appointment Time, Arrived (time), Check in (Time), Exam Date, Patient Location.

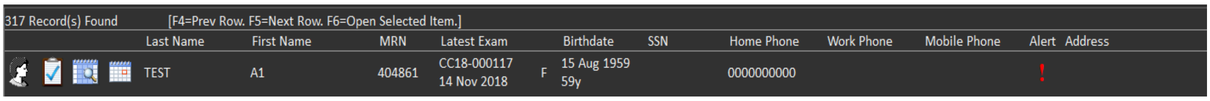


Figure 54. Old RIS Patient search result column headings reading: Last name, First name, MRN (reference number of the patient), Latest Exam, Birthdate, SSN, Home Phone, Work Phone, Mobile Phone, Alert, Address.

What was very different in Client B compared to the other clients was that certain front desk clerks, like those at the MRI/CT clinic as well as some at a different clinic that one of the front desk clerks often worked out of, would use the schedule grid to book patients in. Though this is not the intention of the schedule grid, and not a check-in method used by any of the other clinics observed, both of the Client B locations employ this method regularly. The uniting factor between these two locations is the size. Both the MRI/CT clinic and their other clinic that uses this method have two or three modalities in a few rooms, allowing their calendar view to display all the rooms of the clinic at once, making this method of check-in viable for these locations. The other clinics of this client have too many rooms to comfortably fit them all on the screen when displaying the schedule grid. Furthermore, the clerks who do not use the calendar grid regularly for checking-in patients find it difficult to read, as names and procedure titles are often cut off making it difficult to read through the appointments. Additionally, while every other part of the RIS has a dark theme, with a black background and white text, the schedule grid has a light background and the text is displayed in bright blue, making it difficult to read visually as well (Figure 57).

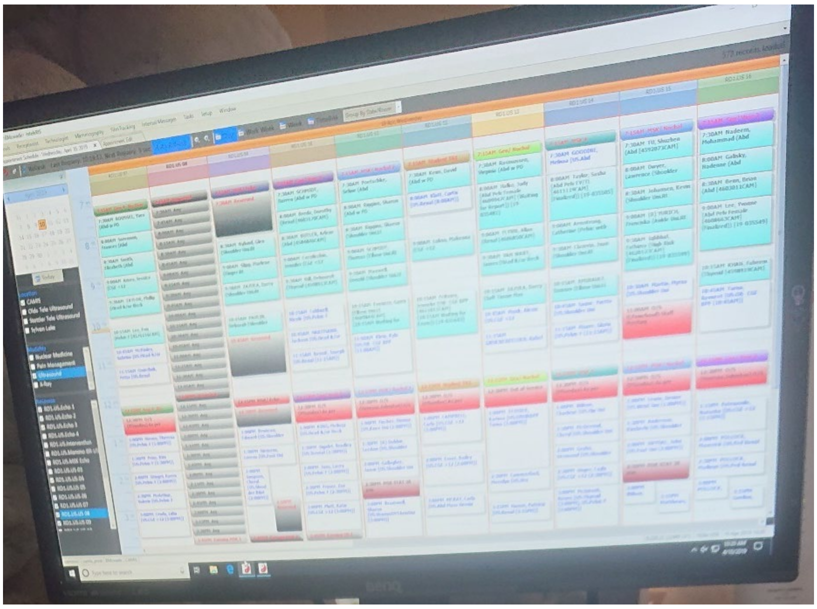


Figure 55. Old RIS Calendar display of status, with blue indicating checked-in patients, and white indicating booked appointments.

Once a clerk had located the patient and the procedure they were going to check in they, like the clerks at all the other clients, would open up the patient demographics to validate the patient was who they said they were. This, like at Client A, would be done by tabbing through the fields and asking the patient to confirm their information; corrections could then be made quickly and efficiently as the clerks hands were already on the keyboard. However, Clients B and A were located in a region where the healthcare cards of patients were not scannable, requiring clerks to manually type in the cards' information and making the entry of these numbers subject to human error. With the exception of Client B's MRI/CT clinic, all modalities were checked in and all walk-in exams were created by the same group of clerks at the front desk (Figure 58). Due to the spontaneous nature of walk-in exams, clerks often needed to work directly from the patient search screen to find patients and book them in for new procedures. Unlike looking for patients with booked procedures, generally the first search criteria used to identify walk-in patients was their healthcare number, allowing clerks to more efficiently target their search. From there, if the patient existed in the system, the clerks would verify the patient's demographic details on the demographics page, tabbing through the fields as they went. If the patient did not yet exist in the system, the clerk would continue to enter details into the search fields of the patient search dialogue, until all were entered and then they would select "create new patient". Upon creating the new patient, they would then be able to book the walk-in exam. Clerks liked this process as they would be able to see whether the patient record would be duplicating another record throughout the time that they were entering the details of the patient, and creating the new patient record would automatically pull the search criteria they had entered into the record to create the patient from there.

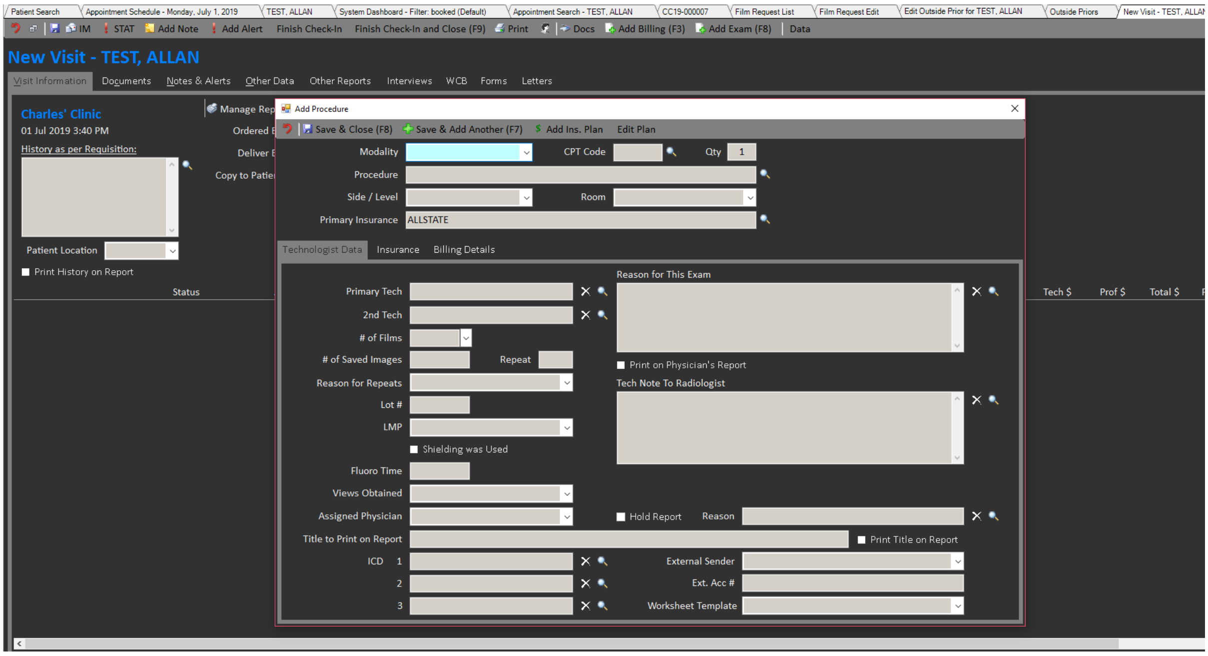


Figure 56. Old RIS New walk-in exam creation.

Although the intention of Client B was to have a clear distinction between booking clerks and front desk clerks, their commitment to patient satisfaction often left the clerks with no option but to help patients book appointments. Here clerks followed one of three interaction patterns. Firstly, the clerks at the MRI/CT clinic were all specialized clerks, taking turns at each of the desks in the clinic to book, check in, and facilitate protocolling the exams that were conducted in that part of the clinic. As such, patients who asked to book MRI/CT procedures could be directed to any of the clerks there. However, all MRI/CT procedures required protocolling first, so any attempt to book an appointment right there would be met with the friendly reminder that the clerk would take the requisition and someone from the office would get back to the patient with availabilities as soon as possible.

The second interaction pattern of front desk clerks took a different route. These clerks, which represented half of the nine clerks at the two other front desks, did not want to book anything themselves. Either they did not feel comfortable booking anything yet (both of the newest clerks did not book anything themselves), or they did not like to book appointments as they were not officially trained to do so. If a patient came up to these clerks asking for an appointment to be booked for them, these clerks would call the central booking office and act as a go between, having the booking clerk open the patient record and search for the procedure the clerk read from the requisition then relaying the conversation between patient and booking clerk as they worked out which location, date, and time the patient would be comfortable with. This method generally took more time than a clerk doing the booking themselves, but they felt most secure using this method as they did not like the appointment search function or the calendar booking process.

The final interaction pattern of front desk clerks was to book appointments themselves. These clerks had generally been working for the client for upwards of three years. Of these clerks, the majority would book appointments through the schedule grid and would only book appointments for the clinic in which they were located at the time of their search. Only one of the observed front desk clerks booked through the appointment search dialogue. This clerk was one of the oldest clerks and one of the clerks with the greatest experience at the client, and had spent some time working as a booking clerk- or rather, at the time she learned to use the appointment search function there was not as strong a division between front desk and booking clerks. She also expressed the preference for control over the results. She found it was faster and easier to control her interaction with the patient if she was the one controlling the search. She would then share the results with the patient, interacting directly, getting a better sense of what the patient would be most likely to accept.

Worklists are used in the process of checking-in patients for their exams as well as many other actions in the clinic. The basic worklist, when filtered by the status of booked exams, can facilitate front desk clerks checking patients in, but these clerks also use worklists with other statuses to keep track of patients in the clinic. All of the clerks observed kept a worklist open somewhere on their screen that was set to show any number of statuses which they used as a way to answer questions from the people accompanying the patients to the clinic. Questions might include where the patients might be or how long they might take before they were ready to leave. The clerks at the front desk would also keep these worklists to give walk-in patients an idea of how long they would need to wait before they could have their exam and whether the clinic was on time, falling behind, or ahead of schedule. Knowing these statuses are helpful for patients, but also for booking clerks who may have patients asking to be fit in right away; they can then call the front desk clerks and figure out if they can direct a patient to the clinic or not. These worklists are also used by technologists to know which patient is checked in and ready for the procedures. This would help the radiologists prepare for whatever procedure would be coming up next. All of these worklists however, often fail at their intended uses as clerks found that the worklists often had too much information on them to easily find the information they were looking for. Often they would rather have one big worklist that contained all modalities and to get a global sense of how the clinic was doing, but they constantly needed to reduce their scope because they could not differentiate status or modality in the old RIS worklist display. There is nothing to indicate modality but a few letters buried among many, and nothing at all to indicate the status of the exam if not directly filtered for. Each of these failings meant that the clerks, while they like the information the worklists could provide, avoided using them until asked a specific question that would allow them to tailor their view.

Booking Clerks

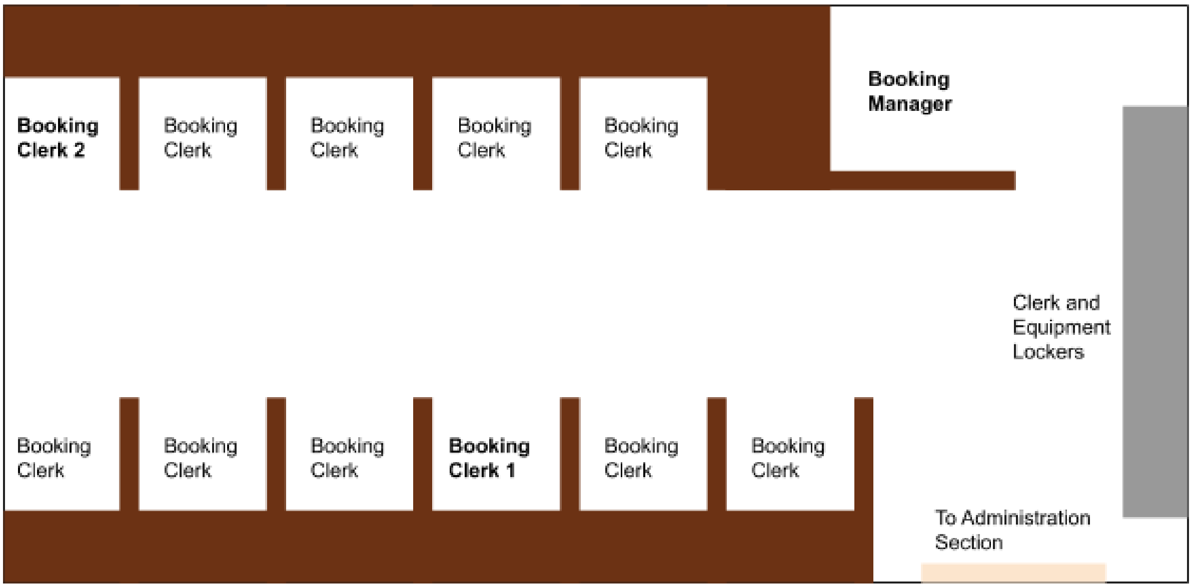


Figure 57. Client B Booking clerks (bold text indicates observed clerks).

Booking clerks at Client B are also divided like Client A in some ways. They have their general booking clerks and some more specialized clerks. Only the general booking clerks were observed as they worked (Figure 59). The specialized booking clerks were located at a different location. They were notified of new appointments in their purview through the appointment request functionality and the task list depending on what kind of action they were asked to complete. The task list was also used to alert authorized users when a new clinic or referring physician would appear (Figure 60). The task list was not well liked due to its complicated search method. Although many fields were available, clerks needed to be highly specific in the criteria using more than one to get to a list of tasks assigned to them, something that made it nearly impossible to see any overview of what tasks were on the list in general. The only other list used by the booking clerks with any regularity was a recent items list. This list provided the clerk with an overview of what they had done and which patients they had opened, within the last 24 hours and offered them a good reference point for fielding questions about patients or opening up previously seen exams to give examples of something to someone else.

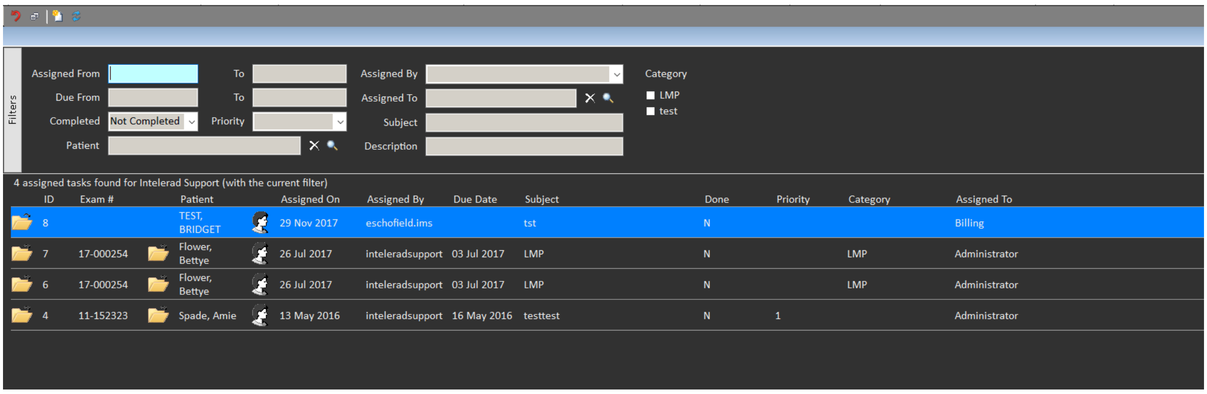


Figure 58. Old RIS Task list display.

Although patients were required to bring requisitions with them when they arrived at the clinic, they were not necessarily required at the booking stage because clerks relied on the patient relaying the information on their requisition to them. Reading procedures off the requisition itself was simple enough, but patients and clerks often had problems with entering information about the referring physician – Doctors' name were often abbreviated on the requisition (Figure 61). The patient might also refer to a doctor by their first name rather than their last name, meaning there would be no match in the display of referring physician names in the system. The name of the doctor might also have many possible spellings and be difficult to pinpoint by name alone. Even if the name was easy to find, the doctor might practice from multiple locations, making it difficult for the clerk to pinpoint the correct location to which to send the report for the patient. To circumvent the naming issue and find the correct location, clerks would often search for a clinic, an address, or a phone number and select the doctor based on that. Interestingly, when a doctor called to book for a patient, the clerks would indicate that the doctor was the one booking the appointment. This designation meant that even if the doctors office forgot to send the requisition right away for a clerk to attach to the appointment by the time the patient checked-in, they would still be able to begin the procedure as the clinic trusted that the doctor asked for the correct procedure and that the requisition would soon appear.

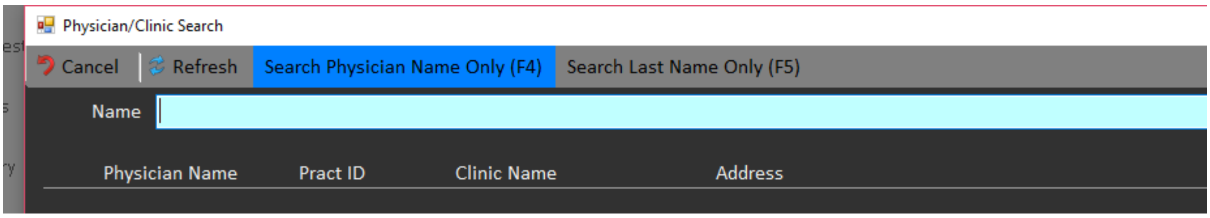


Figure 59. Old RIS Referring physician search.

When actually booking appointments, once they had validated the patient, every single one of the booking clerks at Client B used the appointment search function of the

system. None of them opened the schedule grid. Unlike the clerks who focused specifically on the MRI and CT procedures at one clinic, these general booking clerks booked for all of the other modalities of the client at all 12 of their locations. With such a large group of options, were they to use the calendar grid containing so much information they would either need to have a separate tab for each clinic and each modality within the clinic to be able to view all the rooms day by day, or they would need to constantly be changing the filters of what they were seeing by checking and unchecking boxes on the left side of the screen to check day by day what the availabilities were. Neither of these options were viable for the pace at which these booking clerks were supposed to be working. They usually booked as they were called, so they would not have the time to look day by day for openings and then call the patient whose requisition they had in front of them. Instead, these clerks would receive a call, find the patient who had called them (or create a new patient), take note of the procedures they would be booking, and then search for availability. By using the appointment search function, they were able to provide options within moments. The appointment search dialogue also allowed for refining searches as they talked to the patients, so they could simply enter a different clinic or a different day and have the results populate quickly. They did try to keep their list of results under 500 as they had experienced an ordering issue otherwise. The results were always displayed in order of clinic, then by time within that clinic. So the last clinics on the list would get cut off from the display if too many options were available at all the other locations.
To refine the results, clerks could filter based on the location, the date range, the days of the week, or adjust the time between procedures in the case of multiple procedures being booked at once. None of the filters were direct text entry- every one required the clerk to open a dialog box and enter the details into there. This allowed for each dialogue box to be quite specific and support things like a click and drag multi select, but made each filter more complicated to access than if they could have started to enter details and search from the fields that they could immediately see (Figures 62, 63, 64, 65, 66). What was more confusing was that they could select the field, which highlighted it, giving a signal that they could type in it, but inputting text was not actually possible. None of the clerks were observed to take those actions as they had all learned that they needed to select specifically the search icon to be able to open the filter and search anything. Once the results were listed, they could start offering them to clients, however they were often presented with 5-10 availabilities at a single clinic on a single day, so they needed to determine how best to present those options to the patient. The two clerks spoken to usually presented three or four of the options based on the clinic the patients prefered. The options were usually taken from the list as follows: the earliest appointment, the appointment closest to noon, and one appointment toward the end of the day. Usually these options were sufficient for the

patient to choose an appointment, but sometimes they needed to reset the filters for a different day or time.

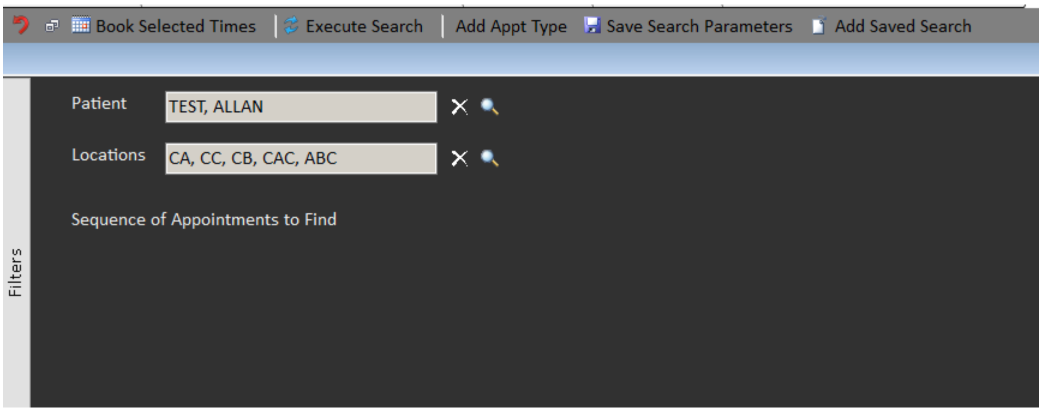


Figure 60. Old RIS Appointment search patient and location filters, selectable only through the looking glass icon.

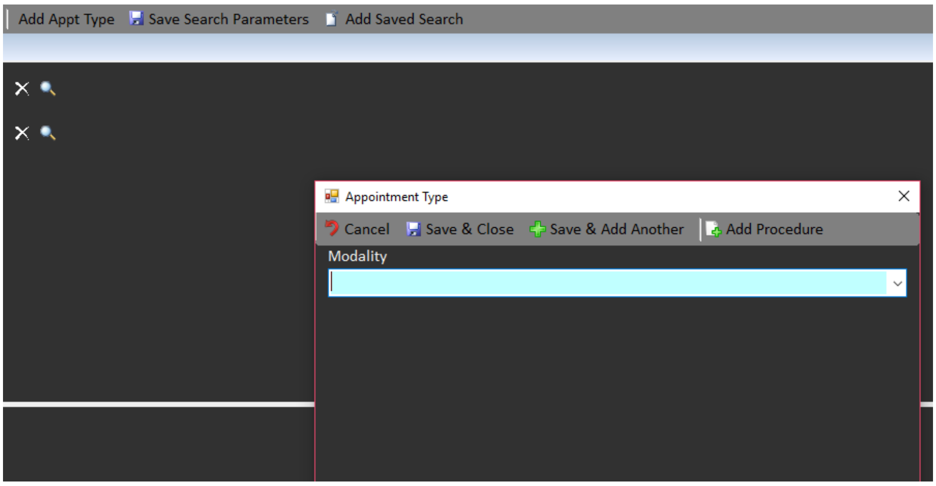


Figure 61. Old RIS Appointment search; add modality dialogue, accessible through the 'add appointment type' action on the task bar.

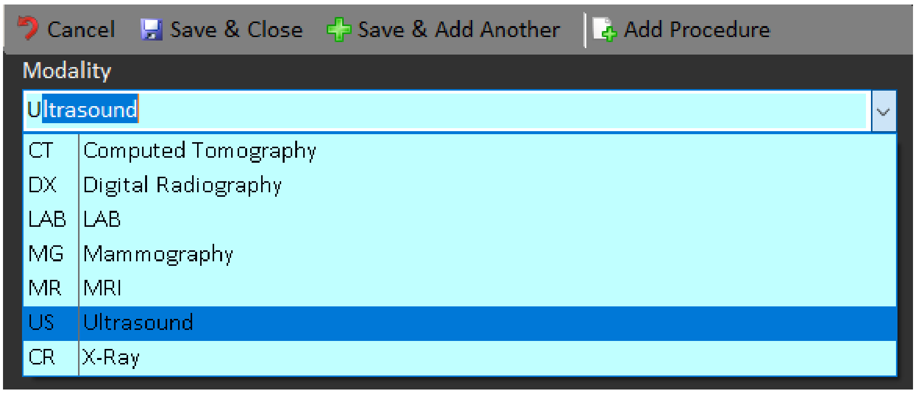


Figure 62. Old RIS Modality selection dialogue allows typing in the text field unlike the location filter.

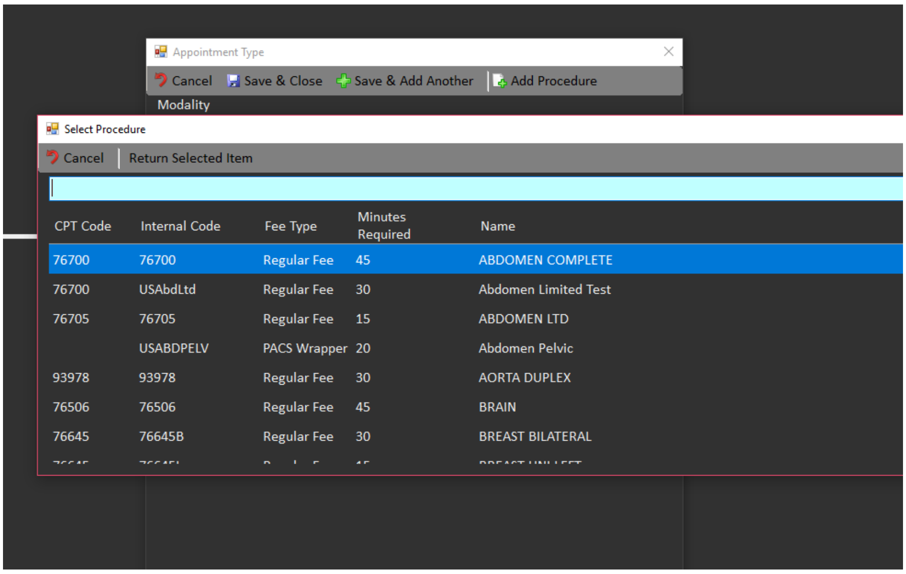


Figure 63. Old RIS Appointment search procedure selection, appears automatically after modality selection.

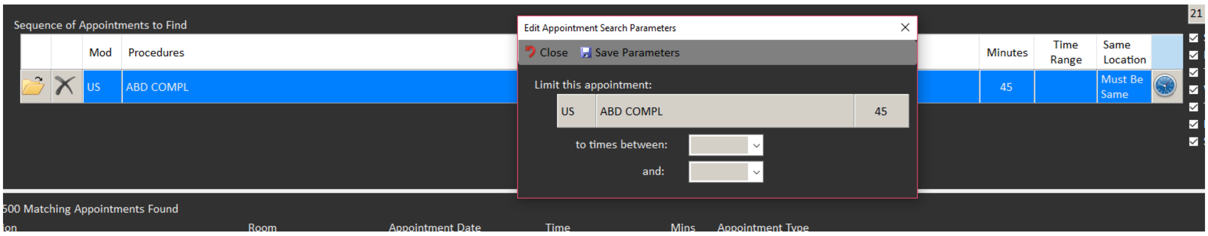


Figure 64. Old RIS Appointment search time selection only available when selecting the clock icon on a procedure.

Client B's booking clerks often needed to keep tabs on information about the patient, things like their English language skills, if they have a guardian, or if someone other than them was allowed to make decisions about their appointments for them (like parents), much like at Client A. However, unlike Client A, the booking clerks here did everything that they could to avoid creating alerts. For example, one of the clerks had a case of a relative of a patient call for the patient. Not having had this number on record before, the clerk clarified who the person was, confirmed that the patient had given them leave to make decisions for them (ensuring they knew patient details), and then added their name, number, and status into the work phone field of the patient file. By using this field, they were able to take plain text notes but not generate a popup that would get in the way of a front desk clerk. As a result, far fewer of the patient fields at this client had alerts pop up and disrupt the actions of any other clerks. These clerks would also take note of the methods the patients preferred for reminders. The clerks spoken with indicated that most patients between 18 and 80 would rather have an SMS reminder than any other option, with those patients under 18 having a parent or guardian choosing for them. Not all patients chose the SMS reminders, and so some still required the clerks to call and remind them. This was done through the reminders function of the system, and was usually only done by one or two of the clerks who knew the functionality well. One of the clerks who did this function demonstrated the interaction, first she needed to make sure she had selected the right thing as it didn't copy over correctly all the time. As she explained it, the reminders function was available at a global level where you can 'remind' individuals about whole appointments or you can select individual procedures. However, when reminding from the procedure level, the system fails to populate the reminder to the appointment level, so patients with multiple procedures in the same appointment might be seen again in the reminders function as their appointment was not reminded, only the procedure itself (Figure 67). The clerk doing this found that when that happened, the patients were likely to be called multiple times and disliked the disruption to their day.

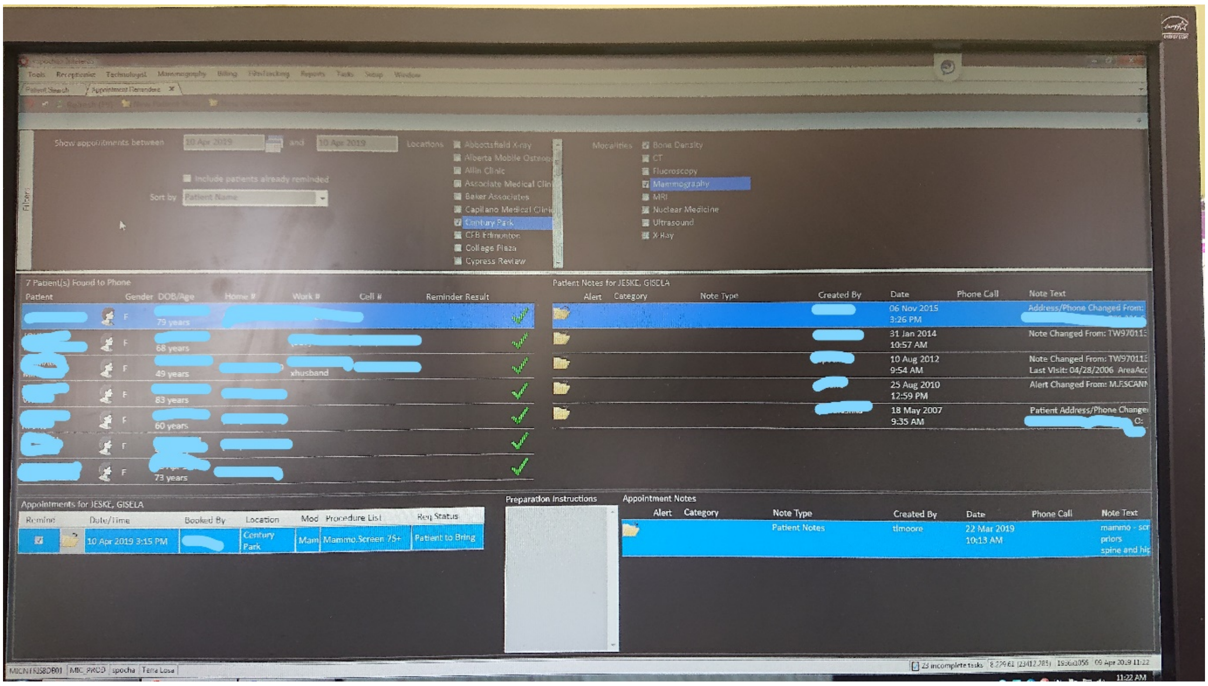


Figure 65. Old RIS Appointment Reminders Tab.

Though Client B did not cater to technologist and radiologist specific requests for procedure duration times, schedule balancing, or other personal preferences, clerks still needed to learn a great number of rules and requirements before they were able to book. One of the clerks spoken with estimated that she spent nearly a month in training, going from simply observing to being observed before being allowed to book on her own. She found that this amount of time was necessary as there were so many procedures available at the clinics that it might take three weeks of taking calls before she would encounter one of the specialized procedures. She also demonstrated the many ways that she reminded herself about the many rules around procedures. On her desk, she had a binder with over 100 pages of official rules decided at the administrative level of the client. Additionally, on the walls around her desk, she had pinned up further information, including a copy of the requisitions used by the client so she could guide patients to providing information she needed to know, regulatory guidelines that she needed to abide by when booking certain procedures, and some handwritten notes about new procedures and rules that she received in her email but had not yet had a chance to print out. During the observation with the clerk, she had two patient calls that required her first to open up the binder to review if the procedure was even completed at the clinic, and second to review the paper she had about regulations surrounding the procedure. All of the rules and changing regulations meant that she was also checking her email regularly to make sure she knew what changes were being made to the procedures she was booking.

Billing Clerks

Billing had two sides to it. On the one side, clerks at the front desk were responsible for ensuring that if the method of payment was not insurance, then they were issuing invoices to patients and collecting payment (Figure 68). On the other side, the billing clerks were responsible for sending claims to the various insurance providers to make sure that Client B was reimbursed for the work that they were doing.

In the past, the clinic had had patients pay for their procedures before they were conducted. However, they noticed over time that often patients would need to return to the front desk to pay for additional services when their procedure ended up requiring more than was originally expected. This was mostly an issue for interventional procedures where the patient was injected with something, but could also happen when more films or views were required than originally expected. The current practice at the clinic was to have patients pay after they had completed their exam and the technologist had had a chance to enter any updates to the procedures that were completed. To do this, clerks at the front desk would open the patient's appointment and open the billing tab for it to print an invoice and then charge it to the patient’s credit card or preferred payment method.

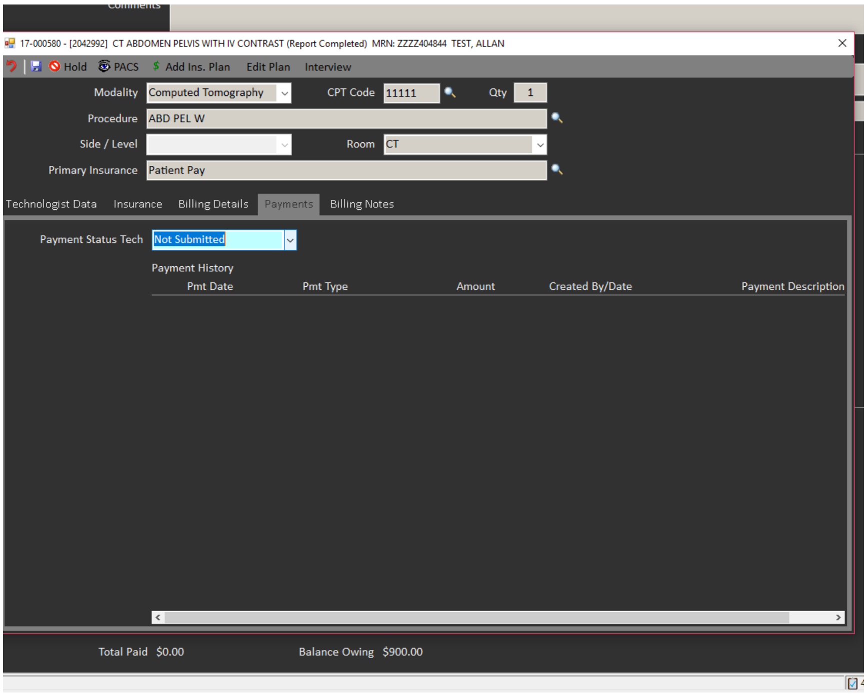


Figure 66. Old RIS Patient payment and invoicing dialogue.

The dedicated billing clerks handled billing on the claim submission side. These clerks would review the claims made by each of the clinics and submit them directly to the responsible insurance providers, including the government, workers compensation, and private insurance providers. They usually didn't work directly in the RIS system, preferring to export their files and work in Excel or directly in whichever submission software they needed to use. Only one of the clerks actually spent the majority of her time in the RIS. She was responsible for reviewing failed claims, finding the issues in the records and fixing them, and managing some of the billing information for procedures and payers. This clerk would update information in the procedures themselves to reflect if there was a change in how much an insurance plan would cover of different procedure costs or adjust how much of a reduction the client needed to make in the cost of certain procedures when they were performed with certain other procedures. She also managed the types of insurances and payers that were accepted, so if the clinic did a certain procedure as part of a research project for a university, the patients themselves would not pay, but rather the university. The client needed to keep track of those decisions for their records and needed to keep track of which research groups were still sending them patients and which were finished with their studies. All of this was managed through the RIS interface, but none of it was simple to find or easy to adjust. Often the clerk was faced with pages of check boxes and fields that they had never used. She would also encounter fields she did not know the meaning of and as no manual was available for her to review, she did not know if her use of the field was correct or not (Figure 69). Her frustration over the lack of transparency and the seemingly incoherent visuals of the billing piece of the system were reiterated by the chief financial officer of the client. This is one of the reasons that the new RIS system is actually not developing a billing module, rather the new system will partner with a third party to avoid this confusion.

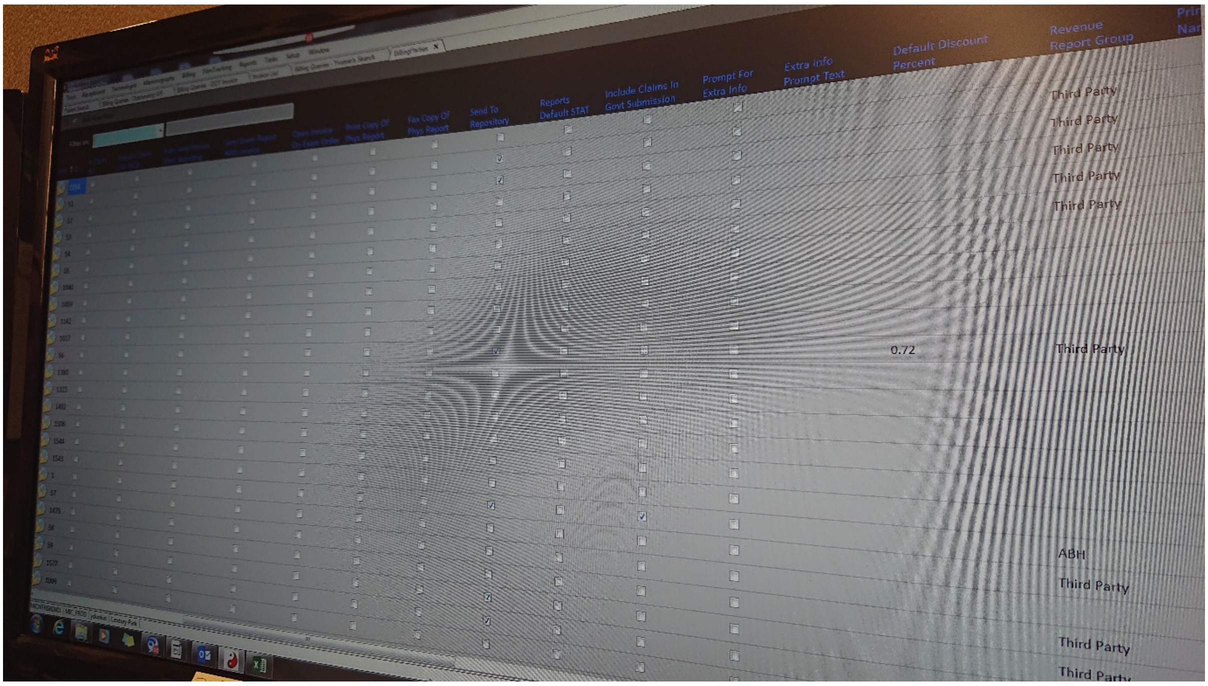


Figure 67. Old RIS Billing page with unclear purpose and unwieldly UI.

5.3.3 Client C

The observations at Client C were conducted by both the author and a co-worker on separate occasions, however the focus of these results will remain with the time the author spent with the client directly as well as two other observation sessions conducted by coworkers for which video recordings had been made. These observation sessions were conducted with two front desk clerks and two booking clerks, with the author and a co-worker observing one of each type of clerk directly. There were other observations session for which notes were available. Where applicable, these will also be referenced. Finally, there was also a recorded session with a billing clerk available from this client, however following the decision for the new RIS project not to explore a billing section, this video was not discussed in this research.

Front Desk Clerks

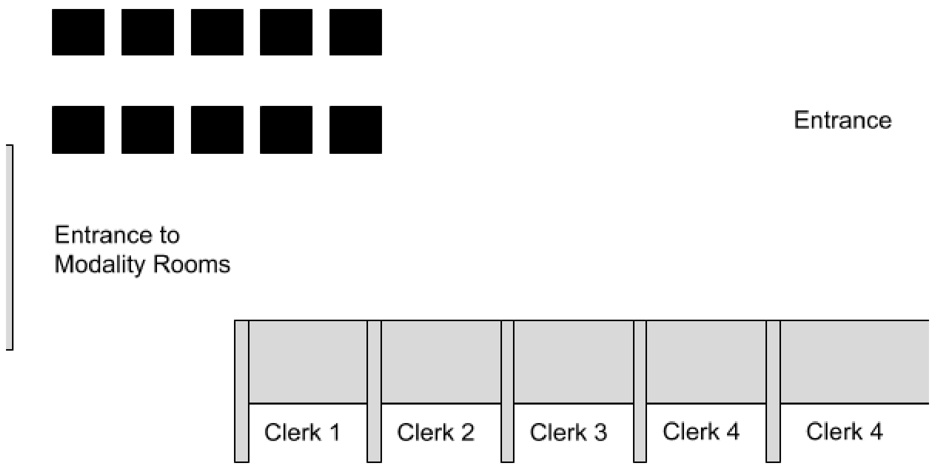


Figure 68. Client C Front desk.

Front desk clerks at this clinic didn't use worklists at all (Figure 70). When asked about worklists, the clerks interviewed didn't recognize the term. Thinking this might have been due to the naming of the worklists in RIS being a "system dashboard", questions were altered appropriately, but the clerks still did not know what it was or its purpose. All the front desk clerks talked to would begin each patient interaction from the blank search page and search for the patient by scanning in the insurance card of the patient. Upon choosing their search results, they would confirm all of the patient demographics, or else create a new patient if one did not exist. For patients with booked exams, the clerks, after validating the patient, would open the future exams panel to find the booked appointment and check the patient in for the appointment schedule for the current day. As far as was observed, there were no deviations from this pattern of checking patients in. The clerks sometimes had the schedule grid open, but they were not seen checking patients in from that view. When checking patients in, the clerks would print labels with the patient name clearly typed along with the procedure and the room in which the procedure would take place and the time of the scheduled procedure. Every label would then need to have the time of check in written on it.

The front desk clerks of this client did not show as much differentiation from the booking clerks. Rather, these clerks functioned as general booking clerks as well as front desk clerks. Very regularly, clerks would book appointments for patients. These were both follow-up appointments as well as general new appointments, in addition to the walk-in appointments they would handle throughout the day. Walk-in, much like the booked appointments, were started from the patient search. Once a patient was located they would validate the information. If the clerk found no results from the patient insurance card scan, they would continue to enter the patient details in the search fields and once all were full, they would create the patient, adding the information required for the procedure as they went. Booking new appointments were similar to walk-in appointments but involved the clerk opening the schedule grid to search for an available slot for the procedure the patient was asking for. Depending on the procedure, this could take a while, though with common procedures the clerk would often not look at it at all because they knew there was a waiting list for the procedure. If the procedure was waitlisted, the clerk would keep a copy of the requisition, taking note of the date the patient had requested the appointment and add it to the folder which contained the requisitions for the various modalities. Patients were then asked to bring their original requisition to their appointment. These waitlisted appointments were not scanned into the system, nor were they added to appointment requests. When asked about this, the clerks indicated they wanted a system that would allow them to track waitlists digitally but that this was not an option in the RIS as far as they knew.

Front desk clerks were also tasked with reminding patients of their appointments the following day. This was usually done by one of the clerks on a rotating schedule. The clerk designated to conduct the reminder calls would have a printed list of patients for each modality that she would then call using the numbers listed. The confirmation calls would cover the preparations and last-minute questions the patient might have. Once a call was complete, the clerk would indicate that she had reached the patient and that they were coming. If she couldn’t reach the patient, she would also note that down. In the case where a patient cancelled an appointment, she would also note that and inform the clerk responsible for booking that modality that there was an opening the day the reminders were being sent out for. Usually reminders were called 48 hours in advance.

These clerks all had to keep in mind both their front desk duties as well as their booking or additional task duties, keeping them up and running around all day. Because they were often booking appointments, they also needed to know a lot of the rules around booking. One of the clerks had a few A5 sized pieces of paper with handwritten notes tucked into her drawer that covered the rules that she usually needed to keep in mind. Others had more rules scrawled around their stations. Most of the clerks also kept a copy of both the French and English versions of the requisitions of the clinic on hand as the procedures were all listed in French on the system with no option for translation, so the clerks would need to reference their annotated copies to know what certain things were called in the other language.

Booking Clerks

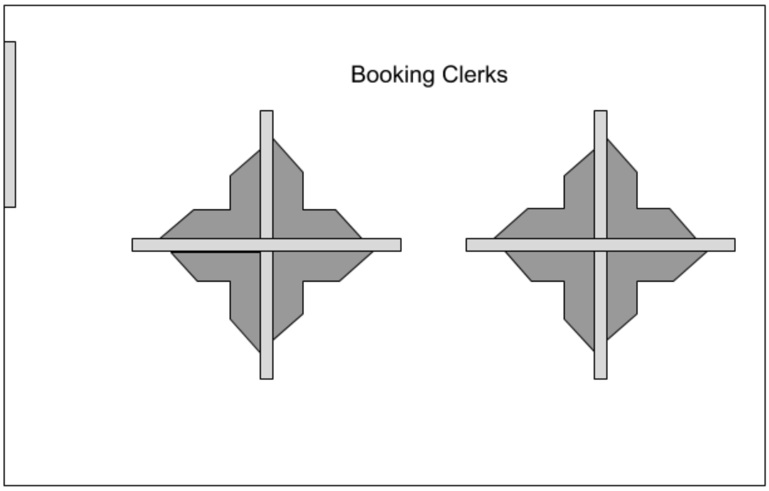


Figure 69. Client C Booking clerks.

The specialized booking clerks booked for one modality exclusively from requisitions in their waitlist folders (Figure 71). They had a few procedures that required protocolling before booking, but for the most part protocolling was not an issue, and patients just needed to wait until the clerks were able to call them. The schedules for technicians and radiologists were generally known about three months in advance, so clerks would book all the appointments until that time. Like Client A, all clerks at Client C were aware of and catered to the preferences of the technicians and radiologists at the clinic. Client C, however, was the only client observed that also allowed for technologists to take different amounts of time for their procedures. Clerks were constantly updating the procedures they booked with the times for the different technologists. This also affected the organization of the calendars for the schedule at this client. Where Client A had organized their calendar to have standardized availabilities for the various types of appointments-usually between 20 and 60 minutes in length-Client C had their days populated with 15 minute blocks that they would then collate into appointments based on the technologist and appointment type they were booking (Figure 72). This client also didn’t make use of colours to the same extent as Client A, with most of the available appointments displayed with the default dark blue.

Figure 70. Old RIS Calendar with 15 minute slots, clerks will then combine slots for various appointments.

To book a procedure, the clerks at Client C would usually pull out the requisition that they wanted to book, call the patient, and open their file. With the patient, they would confirm all of their demographic details, only clicking into the fields on the screen when they had to make an update. They would then go through the consent forms and/or checklists required from the patient, asking questions specific to the modality that they were booking. This was also done at all the other clients, though only for those modalities and procedures where these forms were required. After completing the checks to make sure the patients were able to move forward with the procedure, the clerk would open up their schedule and search for the next available slot. This would usually begin with the last location the clerk had found an availability and moved forward in the days from there. Upon finding a spot, they would offer this to the patient and most of the time the patient would take this option. When the patient agreed with the time, the clerk would book the spot and enter the additional information they had from the requisition and the patient about the referring physician and reasons for the procedure. The one exception to this process were the cancelled exam slots. When a cancelled exam would appear in the next few days, rather than going through the entire process of finding a slot, the clerk would instead open up their waitlist folder and start calling patients until they found someone who could take the slot in question.

Clerks would often get calls from patients who were getting impatient about how long it was taking for their appointments to be booked. These phone calls or appearances at the clinic were often followed by a flurry of activity as the clerks all tried to track down the requisition the patient was talking about. Often the requisition wasn't as old as the patient thought it was, or else it was for a different modality than they thought, causing the clerks to look everywhere whenever they got a request like this. There have also been a few cases where they really could not find the requisition. A common complaint among the clerks was that they would like to have a digitalized system for all of this rather than constantly using paper. When the administrators were asked about certain functions going unused they explained that when they switched to the old RIS system, they encountered so many issues and had such a short time frame that when they found something that worked, they stuck with it where possible. At this point, they found there would be little sense in training staff on new procedures when they expect to have an updated system in the near future.

6 Discussion

The results of the research provided an interesting mix of information. From the usability tests, it was clear that there were interactions that all users found similarly difficult to change. However, there were distinct differences in actions and expectations between the two types of users. Those clerks who were from a client that relied on the calendar for their booking tended to use their mice more for their interactions, and they tended to have less customization in the views that clerks regularly used - both in the absolute number of clerks who had made customizations, and in the nature of their customizations- and they tended to be more focused on visual cues with more clerks allowed to make more changes to appointments. Clerks from the clients that relied on the appointment search function tended to have more clerks who made more customizations to their views, used their keyboards more for interactions where possible, and tended to be more restrictive in the access they gave to clerks.

6.1 Workflow Analysis

Though the RIS supports a wide variety of functions, there are four central actions that are the most important for booking and front desk clerks. These actions- searching and validating, creating a new patient, booking appointments, and checking-in patients- cover the most important value generating actions of the system. Like with any system, the methods of use intended by the developer are not always followed. Sometimes as a direct result of client policy, but other times it was due to individual clerks finding methods that worked better for them. Of the four central actions here, only one did not have more than one route to access it, making it difficult to draw direct comparisons between clerks as they completed their tasks. To normalize for that, the individual keystrokes and steps of these actions were broken down using the Keystroke Level Modelling (KLM) of Card (1980) and Omanson (2010). To account for the time it took for clerks to read through options, a standard reading speed of 380 wpm was used as found in Rayner (2010), along with the assumption that to find the right patient the clerk would need to read specific details from each entry in the whole list of options. Though this does not necessarily model exactly how clerks would conduct their search, recording each clerk’s preferred visual search pattern was not possible in an active clinic. Instead, a standard amount of reading time was added to each action that passed through specific locations where reading and visual search were required. The relative time given for different searches were based on what recordings could be made.

To determine the time it would take an experienced user to complete the four tasks below, and following the calculations and constants laid out by Card (1980) and Omanson (2010), the calculations were as follows:

Location Recall (Hick-Hyman Law):

$$T_d = b_a \times log_2(\frac{1}{p_i}) + a_d$$

Where b_d and a_d were both empirical constants derived by Cockburn (2007) measuring as 0.08 and 0.24. Though Omanson was able to simplify the probability of the next action by virtue of a randomized set of tasks with no weighting to any of the options, the probabilities used in my calculations were qualitative, reflecting probabilities based on observations. In the case of search results lists, worklists, and calendar views, these probabilities reflect that any of the options could be the result. In the case of options being chosen from a menu or task bar, these probabilities reflect the commonality of those options being chosen in that workflow. Often the menus and taskbars had many options that were not used as participants used the RIS, so although these options are there, they were weighed at a 0.00 probability of being selected due to the fact that they were never used.

Mouse Movement (Fitts's Law):

$$T_m = k \ + I * log_2(\frac{D}{S} + 0.5)$$

In this simplified version of Fitts's law, as determined by Card (1983), k and I are both constants, measuring as 0.8 and 0.1 respectively. D represents the distance the user's mouse needs to travel, and S represents the size of their target. This function was easier to apply to the various actions taken by users in the system, though an assumption was made about users always taking the most direct path to the target item from the point of their last selection. By using the location of the last selection as the starting point for the movement to the next action, the assumption was made that users were not going to move the mouse as they read through options or as they considered their next move. This is not necessarily how all users interacted with their mouse, however as it was not possible to collect more specific and detailed recordings, a more accurate model of their mouse movements was not an option.

Further assumptions were also made with regard to the clerks always searching by a patient's last name or their Patient Health Number (PHN), therefore both consisted of four characters. When entering the patient's date of birth and gender, the clerk would use the format listed below. When entering the patient address, they would use the dropdown selections for province and country, requiring them to only enter one letter and hit enter. The sample information that was being used was kept the same:
Name: George Test
DOB: 03 Oct 1989
Gender: M
Patient Health Number: 3452
Phone number: 3453453456
Address: 432 Main Street, Montreal, QC, D4F3E2, Canada

It was assumed that only five results were returned from the patient search, and that the patient was one of 10 entries visible on the worklist. The calendar was set to display three rooms with 56 appointments visible, spread evenly across the three rooms, with the clerk looking specifically for the first and last name of the patient on those options. Finally, for validation, it was assumed that the clerk would be looking through 11 fields and reading approximately 20 words for each validation.

6.1.1 Searching for and Validating a Patient

There are three ways by which clerks were able to search for patients; through the patient search, the worklist, or the calendar. In the observations, it was determined that the most popular option was the patient search function, but the worklist was also used by many of the clerks. Apart from the clerks at Client C, nearly every other clerk at least kept a worklist open, even if they did not use it as regularly for finding patients as the patient search function. Finding patients through the calendar was not used by any of the observed clerks, though some of them mentioned that clerks at a different clinic that were part of Client B had used that option in the past. After breaking down how each search method would work, it was found that in holding the patient the same and using the same visual scan method, the calendar search would take the longest, approximately 30 seconds in the old RIS and 28 seconds in the new RIS. The worklist would take 13 and 11 seconds respectively under the optimal conditions, and using the patient search would take 12 and 8 seconds.
Most of the difference between the various methods can be explained by the number of options that the users need to wade through to find the correct option. This was also the deciding factor for users when observed using the system; those who could not find the patient they were looking for with the worklist would switch to the patient

search because it always offered them a shorter list to choose from and would speed up their search time. This was also why the clerks observed never used the calendar grid to search for a patient, even when they knew the patient was booked for an exam. The number of exams they would have to look through to find the correct one was so much higher that it slowed them down even more than just the worklist.

Another interesting piece to note is the time it took users to move from the search bar to where they could select the patient. On the old RIS, clerks needed to select a specific icon on the list result to open the patient record, a small icon of a person's head (Figure 73). This icon, measuring only 35 px across, was the sole method of getting into the patient record, taking about 1.2 seconds to reach. By contrast, in the New RIS the clerks could click anywhere on the search result of the patient in the new RIS to access the information they needed to validate the patient, requiring only 0.75 seconds to reach (Figure 74).

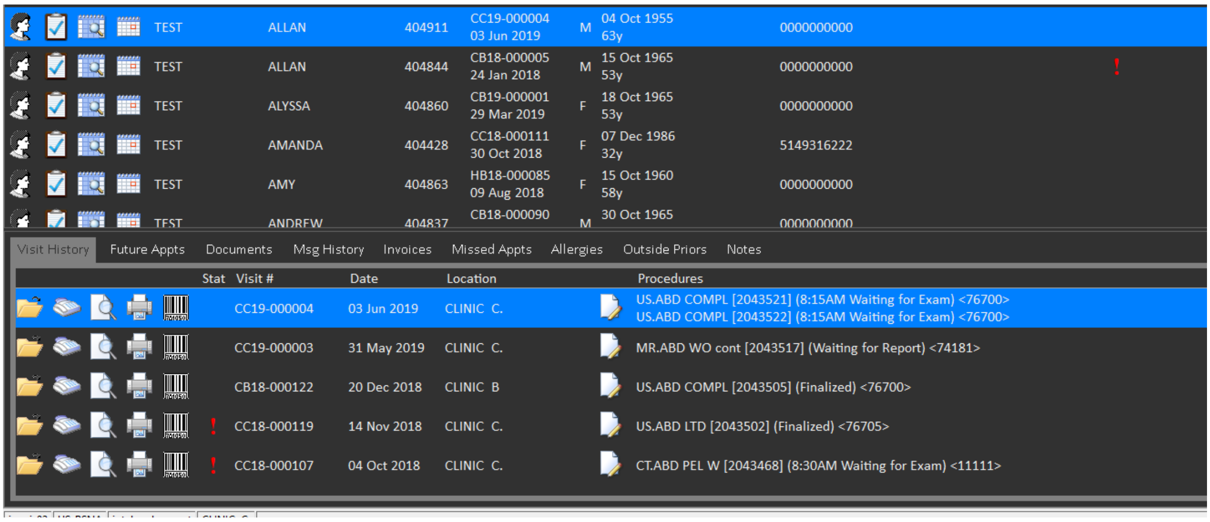


Figure 71. Old RIS Patient search results details display.

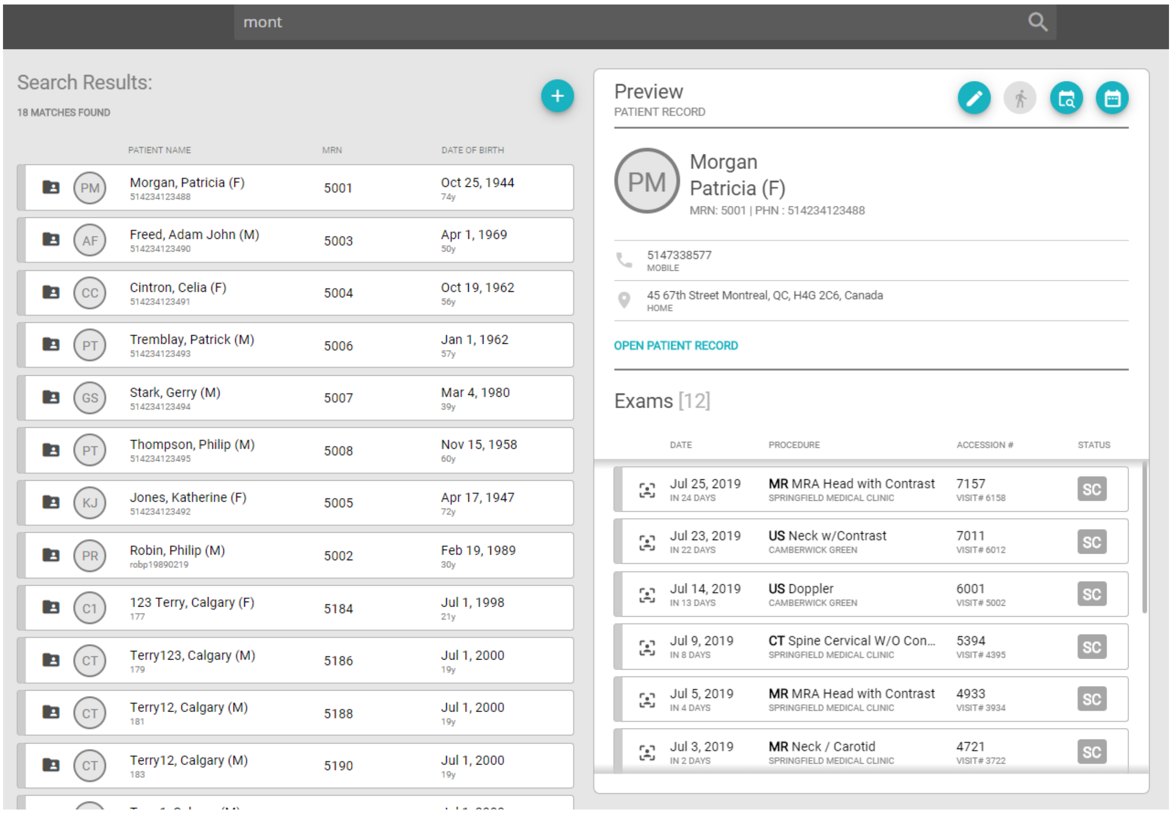


Figure 72. New RIS Patient search results details display.

6.1.2 Creating a New Patient

Clerks only have one way of creating a new patient in either of the RIS environments, however at the moment, this is the one location where holding the content equal, the new RIS is in fact the slower option. When the user has no mistakes in their text entry, creating new users in the old RIS can take as little as 20 seconds. Conversely, creating a new patient in the new RIS will take at least 3 seconds more. The greatest difference in time here comes from the way the new patient dialogue is initiated. Where clerks in the old RIS can enter the new patient details directly in the search fields and create a new patient from there, the new RIS requires clerks to start the new patient from scratch no matter what they had entered into the search field (Figures 75, 76). Depending on which and how many criteria the clerk used to find the patient and confirm that they were not in the system already, the clerk may need to retype full names, dates of birth, and/or patient health numbers. Each of these repeated criteria doubles the amount of time that the clerk is spending on that field. While unfortunate that this is the case, it may be difficult to adjust this as the search bar of the new RIS does not have field-specific entry points, making it easier to search for different values and switch criteria when one doesn't work, which can speed up the search process over the old RIS when considering the time it takes for users to clear and switch search fields in the old RIS.

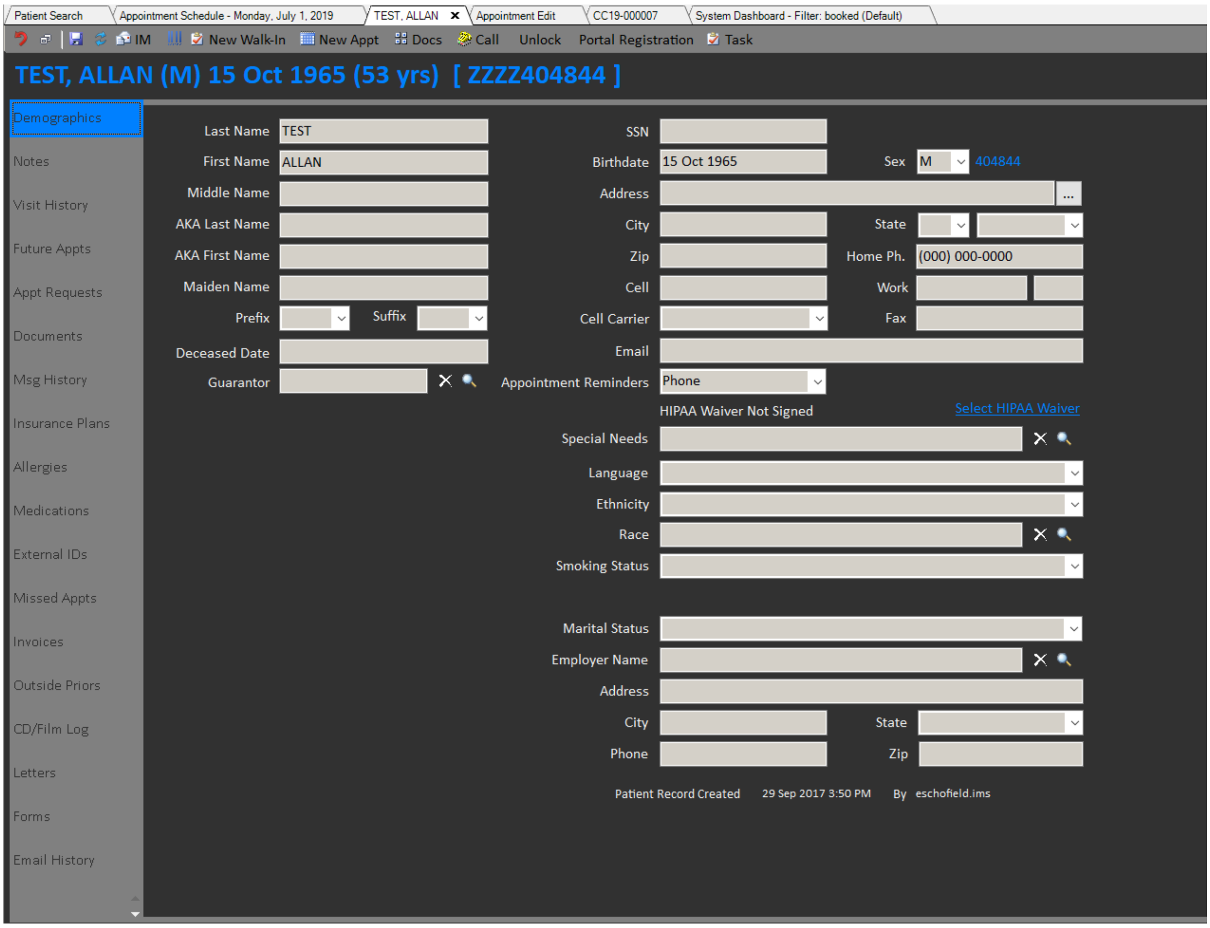


Figure 73. Old RIS New patient creation, fields with text were automatically populated from the search criteria.

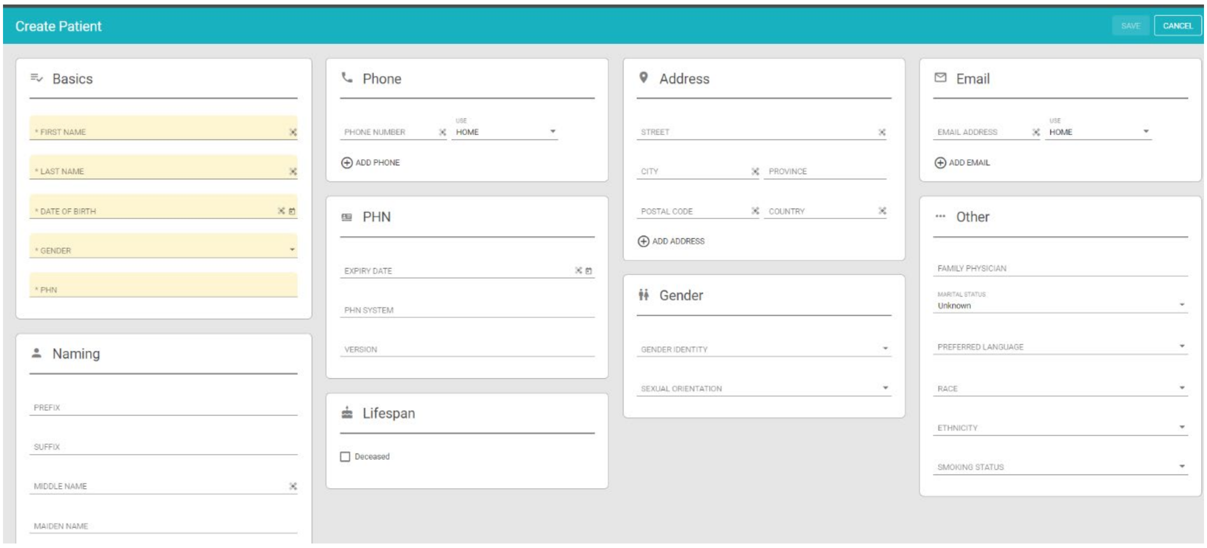


Figure 74. New RIS New patient creation, search bar precludes automatic population of patient details.

6.1.3 Booking an Appointment

To book an appointment, clerks were given two methods in the old RIS: to book through the schedule grid, or through an appointment search function. Both of these options required users to be taught the process of booking as neither contain any direct or clear indicators of all of the steps clerks need to take to book an exam. The walk-in exams of the old system were better, they could only be accessed through the patient record and always popped up a window with the fields that needed to be filled in (Figure 77). Searching for and booking procedures through the calendar or the search function, on the other hand, did not have clear indications of what steps to move through next, nor did they highlight what elements needed to be completed at all. The only indication that the user would get would be a notice about the need for a referring physician if they progressed too far through the process without one. Between the lack of direction, the dense information, and the multistep selection methods, in an optimal situation, booking through the appointment search would take users 37 seconds to complete. Compared with the 65 seconds it would usually take a clerk to book through the calendar, the appointment search offered a much more efficient method to reach a suggestion.

Further improvements in time came from the fact that once a search is set up with the appointment search, the clerk would receive up to 500 results at once, encompassing any clinic, date or time in the future. The incremental cost per suggestion was extremely low for clerks using the appointment search function, a fact that was reflected in the terms that clerks would use when addressing patients. Where clerks from appointment search based clinics asked patients about their availabilities and offered multiple options at a time, clerks from calendar booking based clinic would usually call to offer patients a preselected option from their schedule and not open up the conversation to more suggestions unless specifically asked by the patient.

Though the new RIS had only one option for booking appointments, this option, in optimal conditions could reduce the time it takes for a clerk to book an appointment to 16 seconds. This process took its inspiration from the efficiency of the appointment search function and returning multiple options from one search. In addition, two changes improved the speed by which the clerk could navigate the interface. Firstly, the interface guided the clerk through the booking process, all of the integral parts of booking a procedure were located on progressive screens to ensure that the clerk would both remember each step and move seamlessly through the process. Secondly, the interface did not rely on a modal popping up in the middle of the screen constantly, but instead by keeping all user actions in the wizard to the side of the page, so the clerk can reduce the space they need to cross to reach their actions (Figure 78).

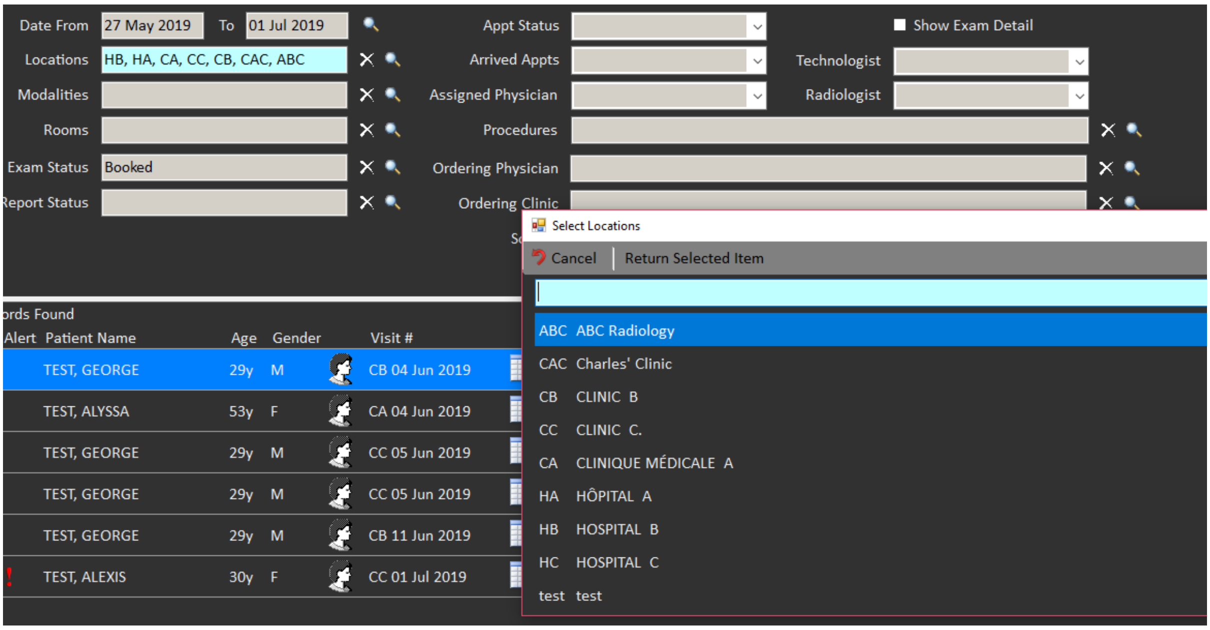


Figure 75. Old RIS Appointment search location selection modal appearing in the middle of the screen.

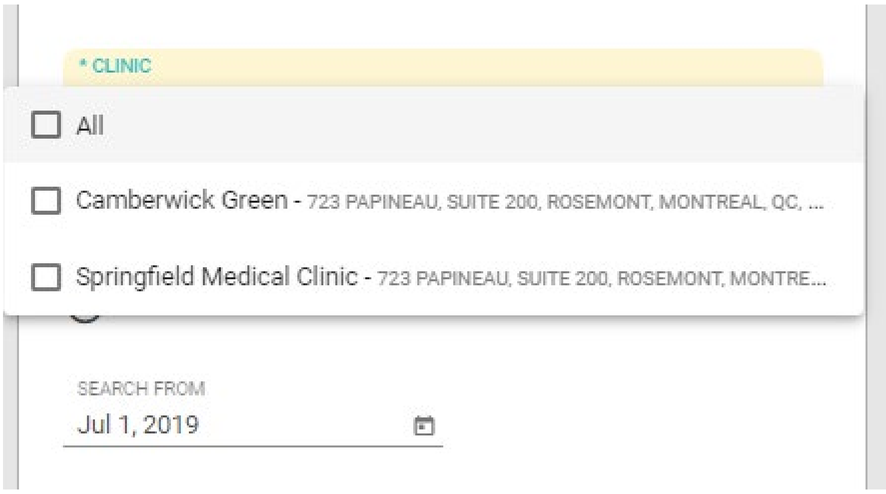


Figure 76. New RIS Appointment Search location selection dropdown appearing above the field.

6.1.4 Check-in Patients

Finally, clerks would also need to check-in patients for their exams (Figure 79). For this process, the old RIS gave the appearance of allowing clerks to complete this process from three different locations, however there was truly only one screen on which the actual check in action was possible. Therefore, the three methods were less about how to check in the patient, and more about the three methods a clerk could use to reach the page allowing them to check in the patient. To get to this screen, clerks could begin from a patient search, the worklist, or the calendar. If validating a patient only required that the clerk read the patient demographic details, they would be able to check-in a patient, in as few as 19 seconds through the patient search, even faster through the worklist at 12 seconds, and once more slowest through the calendar at 30 seconds. To truly validate the identity of a patient clerks needed to review all of their demographic information with the patient themselves, but from these baselines, clerks would have the quickest time reaching check in through the worklist and the patient search.

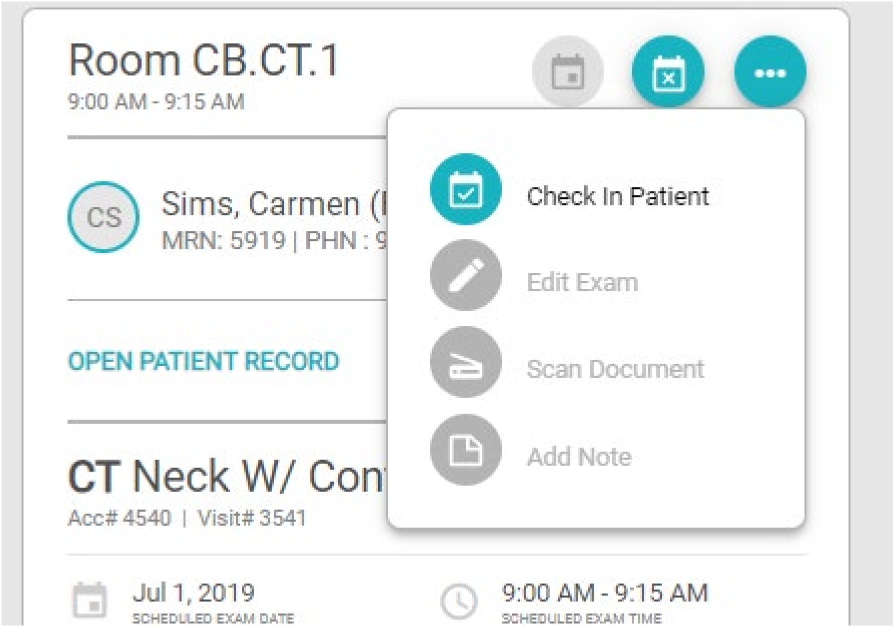


Figure 77. New RIS Check-in function on exam record.

In the new RIS, a similar pattern emerged with the worklist being by far the fastest option, taking only 10 seconds, while the patient search took 18 seconds. In the present stage of development, the new RIS does not support the calendar very well, making it a less optimal method for the action of checking-in patients, though even if it were working properly, it would face the same kinds of issues as the calendar in the old RIS. Both of the calendars suffer from the high number of exams that are visible at once, and the reduced legibility of the exam slots due to their reduced space. It was possible to filter the calendar view in the old RIS, and the present iteration of the new RIS copied the filters of the old directly. The problem with these filters was that they were checkbox based, so a clerk would need to both check and uncheck each room, modality, or clinic individually to adjust the filters. Each change that the clerk would want to make would require a lot of selection (Figure 80).

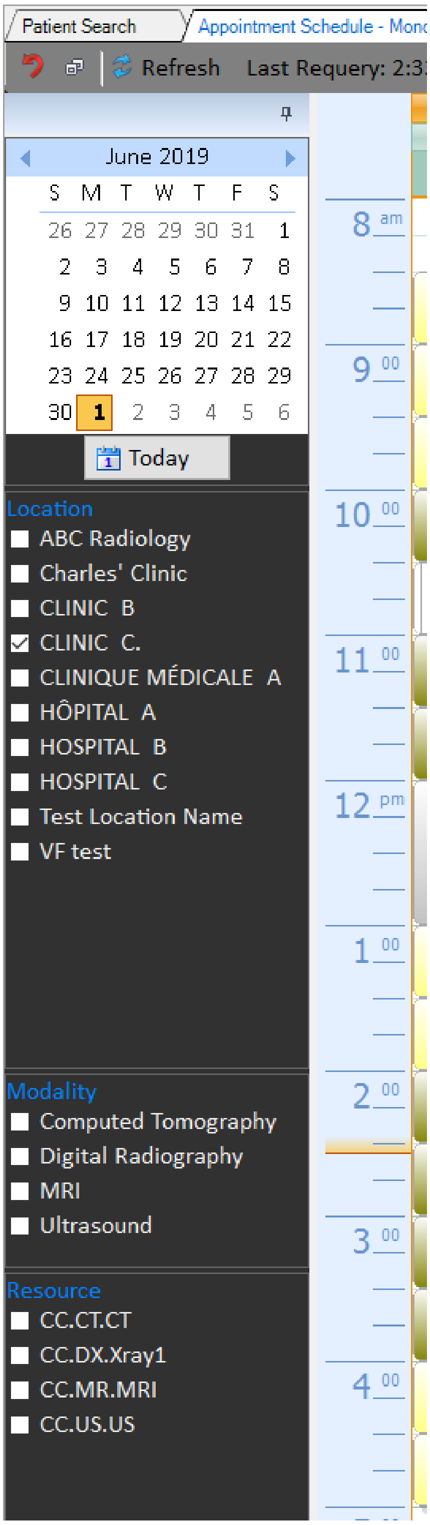


Figure 78. Old RIS Calendar filters.

6.2 Stickiest Interaction Patterns

6.2.1 Cognitive Mapping and Familiarity

Even a cursory comparison of the interfaces offered by the old RIS and the new RIS exposes significant structural differences between the two therefore negating all of the cognitive mapping built by clerks over their use of the old RIS. One of the clearest examples of this structural difference was the basic location of action items. In the old RIS, the action items for each screen were always located at the top in the task bar of that tab (Figure 81). Though the new RIS matched this location for the top-bar navigation items, and all the action items for individual elements were located at the top of their individual card. The change in design broke the prototypical and familiar look of the old RIS interface that clerks had gotten used to. The first impression (Tuch 2012) and the expected visual search pattern of users (Todi, 2018) were interrupted by the changes in the new RIS. All action buttons were moved to the top of the section they would affect, rather than keeping them at the very top bar of the entire application like the old RIS. In some cases this resulted in clerks selecting browser action buttons outside of the application; in others they did not notice search buttons at the bottom of the page: and still others preferred to use the navigation at the top of the booking wizard within the new RIS over the same navigation options at the bottom of the screen.

Similarly, the constant reinforcement of modals and criteria entry fields appearing in the middle of the screen in a separate window of the old RIS lead users to ignore or not notice smaller, more localized changes and data entry fields in the new RIS. The clerks were looking where they anticipated something to be, sometimes before anything had changed, as they were trained that that was the location for that specific element as shown in the work of Hornoff (2003). Furthermore, after spending years learning that only specific icons could be clicked to effectuate desired actions, clerks were still aiming for those locations, clicking specifically on the patient name or icons on the screen rather than the much larger row elements as the developers had intended (Figure 82). Tversky's (1993) findings were correct here, indicating that clerks were using their knowledge about needing to select specific locations in order to pre-move their cursors to reach the intended location before they were sure of their clicks to increase their speed.

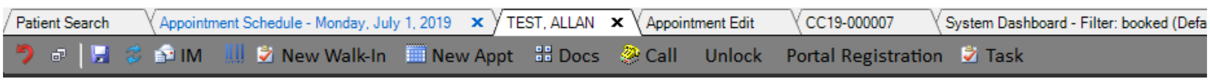


Figure 81. Old RIS Patient record task bar.

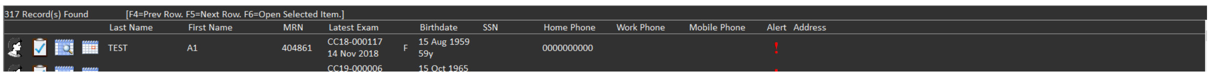


Figure 82. Old RIS Patient search result element.

How and where the information was being displayed to users also proved to be a problem when faced with the mappings users had built of that information in the old

RIS. The visual searches completed by users and aided by their familiarity with the system (Todi, 2018) were broken in the new RIS. Despite not having a very obvious or distinct display of exam status on the worklist or in the exam records of patients, clerks were unable to determine the location of that status indicator in the new RIS, either in the worklist or in the exam history list. They also expected to find the information they wanted hidden and divided across multiple screens, so when it was all displayed together, they felt overwhelmed and often didn't even notice that the information was there (Figures 83, 84). To top it off, the old RIS failed to make use of any kind of intelligent affordances or signalling; user cognitive maps were based on their own understanding of the interface with very little real guidance from the designers. The new RIS, by contrast aims to provide users with those affordances and signals that encourage the development of a comprehensive and intentional map.

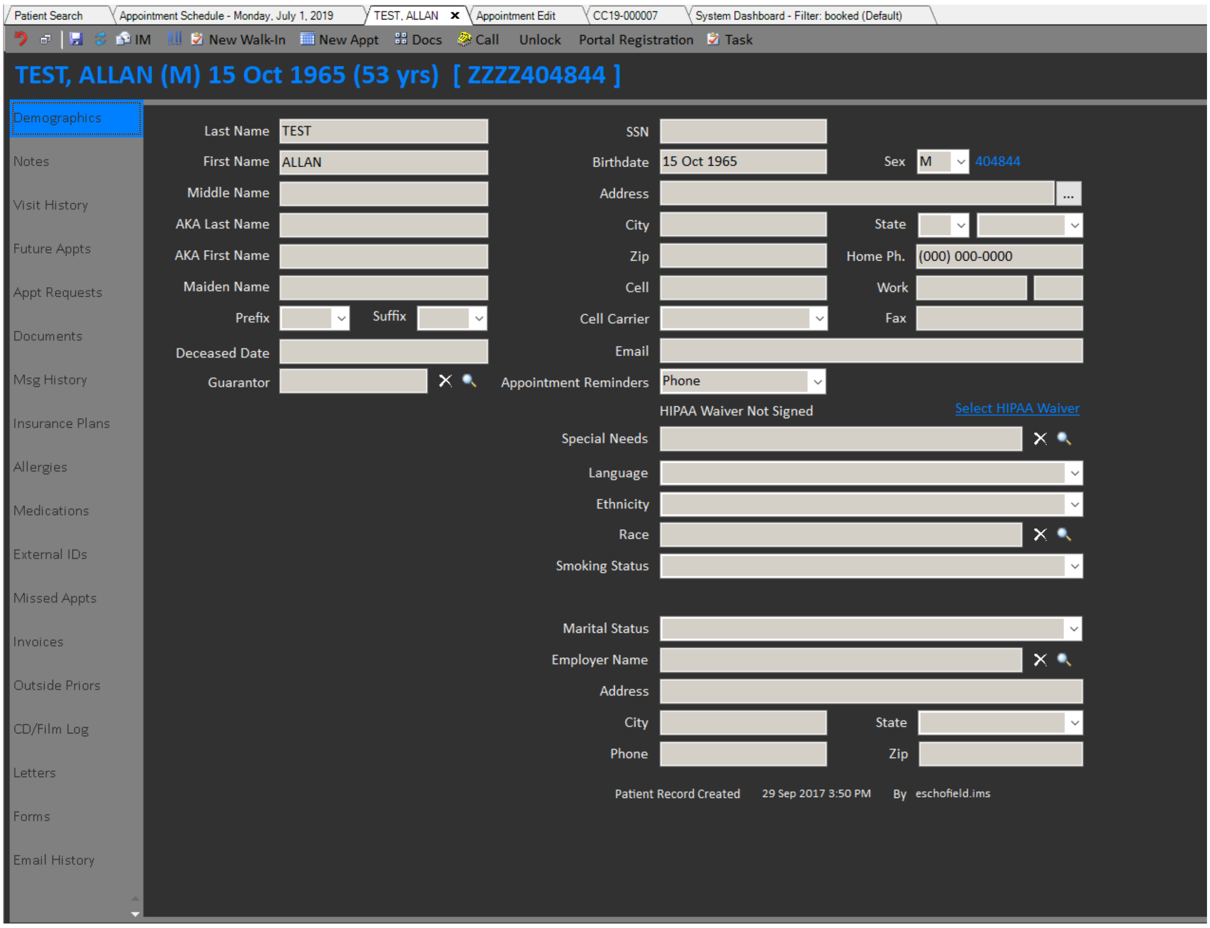


Figure 79. Old RIS Patient record page.

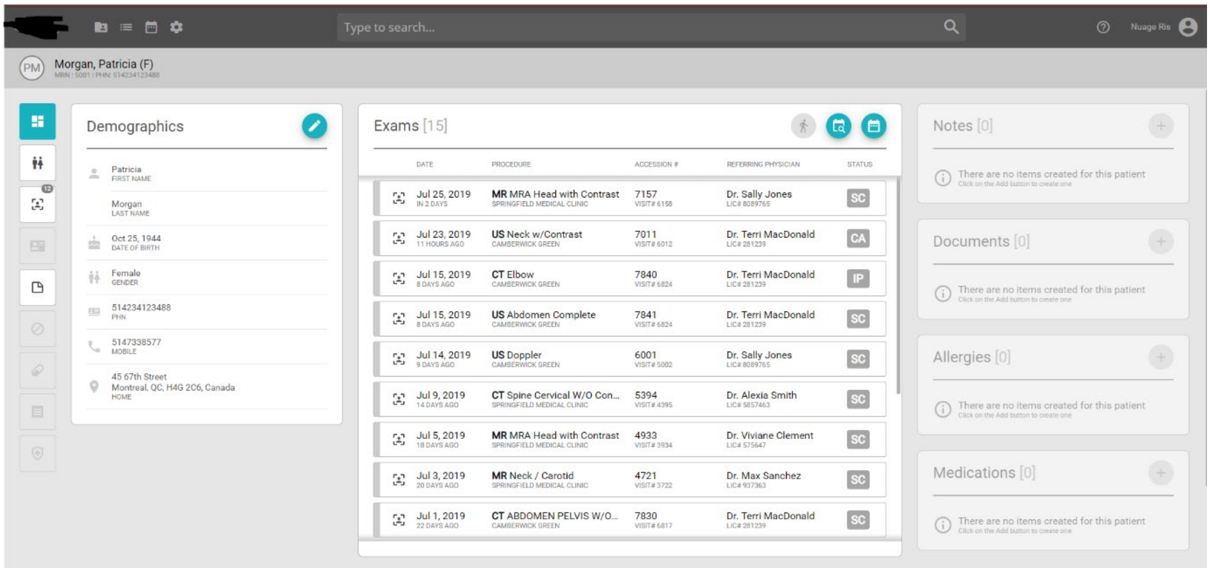


Figure 80. New RIS Patient record page.

6.2.2 Cognitive Automation and Procedural Memory

The automation and procedural memory displayed by users was strong and came from two different sources in most cases. Firstly, clerks were trained on the system to use it in a certain way, using the client-level procedures. Secondly, within the general procedures clerks were trained in, each developed their own personal automations and memories. At the clinic level, clerks developed automations around either the calendar or appointment search methods of booking appointments, though generally there was more cognitive automation possible in the appointment search than on the calendar (Altman, 2008; Mosnell, 2003; Raskin, 2000). Users were able to build up a process of entering data in a certain way with specific shortcuts and knowledge about where their next actions would be. These process expectations did generally match with the order of the processes in the new RIS, making that switch much easier, but in those places where the starting point or the next step was not what the user was expecting clerks would get muddled, searching for that step that they knew was next and not noticing that either it wasn't needed or that it would be found in a different location. For example, the clerks would have a more difficult time learning the new RIS, as the order of the actions taken was different. Client A is the strongest example of this: clerks there would first find an availability, then add patient details once they had confirmed the patient would take the spot they had picked out, a process that would be impossible in the appointment search function in the new RIS.

Adding patients always began from the search fields on the patient search page. The fields in the old RIS were specific, allowing clerks to run their search and verify there were no duplicate patients as they entered the information, and once all the information was entered, they were able to create a new patient populated with the entirety of their search criteria. The new RIS broke this workflow, forcing clerks to adopt new interactions for creating new patients. By combining the search fields, clerks were able to search for patients more fluidly, but they became unable to use the fields as entries into the new patient record. Clerks would need time to adjust to the choice to facilitate one workflow over the other and was a cause for confusion and dislike of the new system. Adjusting to the new system would rely on coping strategies (Heyer, 2018), but not all clerks were very strong in these strategies, many relying far more on their procedural memories (Carroll, 1986).

Procedural memory was also present in a lot of cases: any action that required them to click something would receive a double click. Selecting multiple elements in a dropdown list were expected to be a click and drag motion rather than clicking each element individually. These kinds of physical automations were also apparent also in the selection style of elements on the screen. Clerks would move their mice more slowly than expected of efficient users because they constantly needed to aim for 35px targets. Finally, where possible, clerks would default to keyboard based interactions, eschewing the mouse (Ryle, 2009; Gerrig, 2015). These physical preferences were not immediately available to clerks when testing with the new RIS, and from the results of the usability tests where they were unavailable, the preferences remained sticky. Although seemingly small, these interactions build the base of all other interaction with the application. By messing with these small building blocks, clerks focused on their frustration here instead of seeing the benefits from other changes in the process.

6.2.3 Negative Transfer

The effects of negative transfer could be felt in the cognitive automation, mapping and procedural memory users developed. These psychological elements build up the foundation upon which negative transfer rests. Once a map is built, a process automated or memorized, it becomes that much harder to unlearn and relearn actions in a new interface (Altman, 2008; Carroll, 1986). For instance, after learning that patient details would never be properly displayed in the search results of patients or on the worklist in the old RIS, their presence in the new RIS went unnoticed. The same can be said for statuses- while users grew used to reading the status from a verbose parenthetical on the exam record, a more visually distinct status went unnoticed by clerks until prompted that it was being displayed.

Though this effect was less present in younger users, several of the older users, including two from the usability test of Client B, froze when asked to complete some of the tasks. They had learned to use RIS systems over the years by relying on training- they were always told how to complete the tasks that they were meant to complete. Younger users had fewer if not no issues poking around the application until they found a reasonable option to complete the next step of the process. This was most pronounced in the first booking clerk at Client B who was the youngest clerk to participate in a usability test. Older clerks had learned to work within the parameters they were given, they found a method that satisfied them and was sufficient for their needs, and they left it at that (Simon, 1959; Tak, 2013). Younger users instead relied more heavily on coping strategies (Heyer, 2018), aiming to keep themselves in a state of equilibrium as they moved between steps of various processes. These users experienced far less negative transfer from their cognitive maps as they were used to trying different elements and returning to a stable location when the experiment went wrong.

There were still a few instances where the negative transfer remained strong for all involved, as Carroll (1986) and Anderson (1987) found. If users had expectations reinforced regularly, they would come to expect those same effects in any reasonably similar context. In the case of the new RIS, fields that allowed text entry but also provided users with dropdown selections were constantly viewed as solely dropdown selections with none of the users typing, even if it was an option. Ignoring the typing affordance of the field and the signalling of the messages on the field was encouraged by the fields in the old RIS that did not allow for typing despite signalling that this was possible; this was also the case with the location selection in the appointment search (Figure 85).

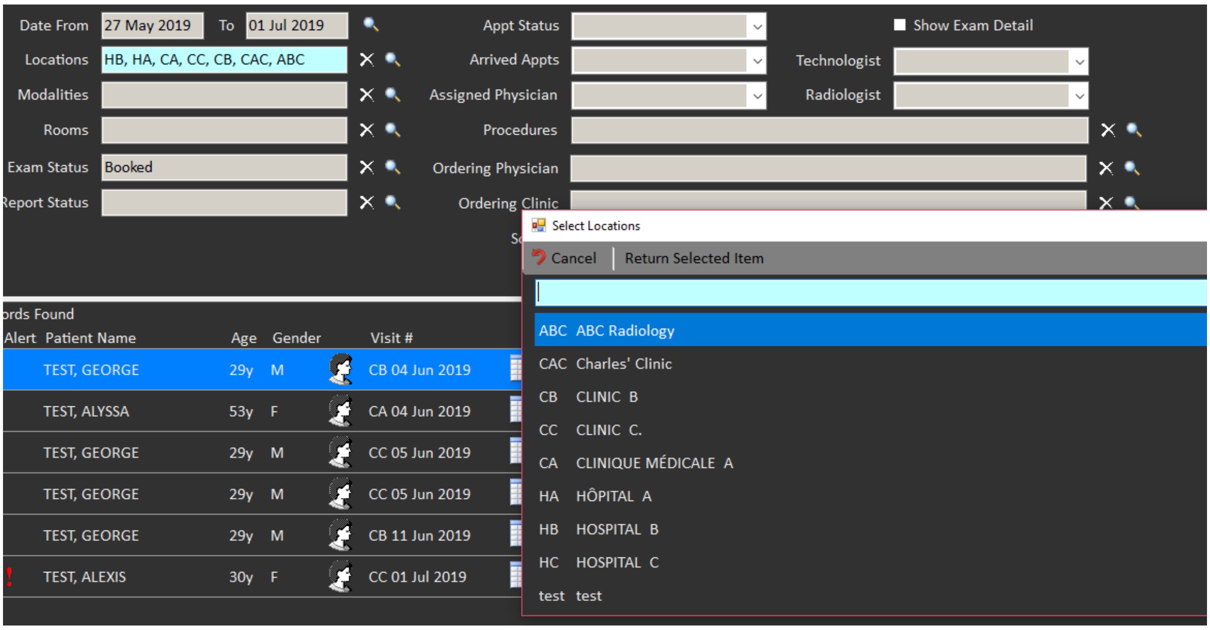


Figure 81. Old RIS Exam search location selection, the field on the modal allows typing, while the field on the main window does not and cannot be selected.

Users had also learned that a calendar had the ability to select elements on it. It must be pointed out that this was a more common expectation among the clerks who were used to booking through the calendar. The way that the clerks were discussing booking appointments when viewing the calendar exposed what Finstad (2008) explained as a dangerous side-effect of negative transfer- when users were presented with an element that retained surface similarities to previous versions, they expected that element to function the same on a system level. While not necessarily a problem in all cases, by seeing the calendar and expecting to populate it through templated times and appointments, clerks were being pulled back into the interaction metaphor that had been promoted by the old RIS, one which the new RIS was trying to move away from with appointment bookings based on rules at a more global level that required administrators to template each day of the week. By seeing and expecting the old system, administrators were also unwilling to give up some of the views that they were used to. Though a clerk would only book one appointment in one room at a time, none of the clerks or administrators believed it was sufficient for the clerks to only see the room in which they were booking. For them, rooms were and were not interchangeable- for the most part the room did not matter, but when it did, it mattered a lot- so everyone wanted to have visibility into all the rooms of the clinic when booking anything.

6.2.4 Self-efficacy

Self-efficacy was the most promising piece of the research. Although clerks were unfamiliar with the interface they were asked to use, only a few of the oldest users had significant hesitations before taking actions. The rest of the users found that their actions were guided and clear from the information they were given, despite not having a help section they could refer to at the time of the testing. The fact that the booking process was guided by a wizard, was specifically remarked upon by two of the clerks indicating they liked that they didn’t need to worry about forgetting some integral piece of the booking process because the whole process was outlined for them in the wizard. The predicted existence of a ‘rule engine’ for booking procedures was also an exciting prospect for all of the administrators as they would be able to spend less time training their clerks on the rules around procedures, potentially cutting days off of the training time for the booking clerks and increasing the comfort level front desk clerks would have booking appointments themselves, if the client chose to allow this permission.

All of this positive feedback was in direct contrast with the discomfort and hesitancy around the old RIS. Despite the system having been used by the clients for more than three years now, some clerks still were not comfortable moving outside of their personally delineated group of functions. Their fears were well founded, however, as one clerk explained. She made one mistake somewhere along the line of procedures for checking in a patient and managed to lose the client $700 for a procedure that was not properly billed. By straying beyond the path outlined by the administrators, clerks found that they could get lost in customizations, seemingly useless data fields, and strange pages. The help for users who got stuck was non-existent. The old RIS was shipped with no manual or user guide, the knowledge the IT teams at the various clients had with the system were limited to what they had experimented with and found themselves, and they had had only limited training, leaving them with more stress than they should have had (Torkzadeh, 2002; Ryan, 2000).

Ryan (2000) found that users felt more self-efficacious when they knew what was going on and why- the more context they had in their actions, the better they felt. The users of the old RIS, having had none of the training or support to understand the meaning of their actions, were left rudderless; they knew some elements of the RIS, but had no overview. Even the customization available to them was only as good as how well they understood it. If anything, the high levels of customization available to the administrators and clerks resulted in ineffective use and a glut of choices, making them feel less secure about their choices in the long run (Easting 2006).

6.3 Design Recommendations

Based on the research conducted in this thesis, several recommendations were developed for how to design future updates to enterprise level systems. While informed by the work done with a RIS, the psychological background of these recommendations is founded in a broader context of human-computer interaction. The recommendations found here are only broad recommendations, not a recipe for how to design a new system-that is dependent on too many individual factors to be prescribed here.

Recommendation 1:

When researching an update project, first determine all the possible workflows and interactions that users currently have with the system. From there, decide which are the most important workflows for the purpose of the update, choosing at most a few workflows to optimize for, depending on the complexity of the system. It is important to contextualize the design of specific workflows in their interplay with other workflows, and to know how far the most important workflows extend. Reducing how efficient workflows are should be a conscious decision, unlike the unintended reduction in efficiency that was experienced in the new patient creation through the streamlined search functionality. These kinds of decisions will affect users of the system and should be justifiable when questioned. Research is best gathered straight from the source; rather than relying solely on administrators, it should also focus on the users from various clients and various locations. By collecting as many details as possible, a fuller picture will emerge.

Recommendation 2:

Sweat the small stuff. As much as the tiny interaction details seem like they should not affect the usage of the system, if the users are constantly trying to double click elements that only work if single clicked, they won't be able to get to any of the wonderful new features that have been developed. They are stuck in a constant fight against a learned behaviour that is extremely hard to shake. The same can be said for selection methods. Where possible, if they have always been able to select multiple items with a click and drag, enable that for the new interface as well.

Recommendation 3:

Location, Location, Location. Prototypicality is no joke. If possible, it is worth it to retain some level of similarity with the location of really important action items. For the clerks, they were constantly looking to the top of the page for all of their action items. It was good that the action items were kept at the top of their respective cards, but even that was often below the line of their exploration. This is also applicable to left and right orientations. The clerks had gotten used to seeing additional elements on the left side of the screen, having elements there was normal for them. However, none of the clerks noticed similar elements placed on the right side of the screen.

Recommendation 4:

Processes that can keep the same order should remain unchanged. Enterprise systems strive for efficiency; if the processes are already efficient, users should not be forced to change their process and lose the efficiency if they do not have to. They will already be dealing with visual, structural, and possibly interaction changes, so if the process can be kept the same, this reduce the number of issues they face in learning the new system. This kind of cognitive automation by knowing what is coming next is powerful. When suggesting changes to the way that clerks were booking procedures, both clerks and administrators alike supported it because they realized that the new method was faster. However, when they were asked to create new patients, they pushed back because the changed process slowed them down. They will have to undo years of habitually entering all the details before creating the new patient.

Recommendation 5:

Name it right. If changing anything on the interface, terminology can be a powerful tool. In some cases it makes a lot of sense to keep the naming the same. Although the backend standard updated the terminology to refer to appointments as encounters and exams as procedures, the old terms were retained because they were easier to understand for all of the clients. On the other hand, referring to statuses as "waiting for exam" and "waiting for report" makes no sense. Not only are the statuses long and hard to differentiate if the whole status cannot be seen, they don't actually refer to the current status of the element but are relating the state of the element in relation to a future state. It was decided to move ahead with "Arrived", "In Progress", and "Completed" to better identify when a patient is in the clinic, in an exam, or finished with their exam.

Recommendation 6:

Guide users through unfamiliar territory. Signalling and affordances can be leveraged to bring users through new or altered processes. Action items are not enabled until the required criteria are met. A search for an appointment cannot happen until the locations, modalities, and procedures the user is looking for are known. Similarly, if a patient is coming to the clinic for more than one appointment, this should be obvious to the user in a passive way. Guidance doesn't mean disruption, so popups and modals that affect the flow of the user should be avoided or used where appropriate.

Recommendation 7:

Show information. Beyond the data that the user is expecting to see, it would help to give the user context about where they are. By using clear titles and labels it will contextualize items for the users within the system. Using clear terms for action items and displaying tooltips (old fashioned but effective) are a great way to provide additional information. The added titles at the tops of all the cards on the screen tell users exactly where they are and at what level of detail they are viewing the information. Tooltips were also added to any icon that doesn't have a text label visible.

Recommendation 8:

Colours matter. If users are used to a dark display, suddenly making everything very bright will be surprising. The calendar had bright green and red as the only two colours on it for a while, causing users to get hung up on both the brightness of the colours as well as the fact that they were constantly thinking about Christmas when they saw them.

Recommendation 9:

Don't offer more options and customizations than are necessary. Having too much customization can be stressful and may result in users getting confused rather than helping them. More customization also makes it more difficult to support the system after releasing it. Updates to the old RIS are difficult for the company as they have to manage many customizations and once users have something they like that they don't want to give it up.

RECOMMENDATION 10:

Provide training and help. One of the biggest drawbacks with the old RIS was to not support some kind of help documentation. Training, while useful at the outset, is not something that users will be referencing with regularity. It is better to have robust, task-oriented help documentation that can diffuse frustration and offer concrete steps to move forward with the users' intended task. Easy to reference and access help documentation will assist users, making them feel more secure and autonomous in their actions and will reduce the number of calls to support.

6.4 Limitations

The work upon which this thesis is based was limited in scope based on the timeline of writing this thesis. As such, the author was unable to conduct a longitudinal evaluation of the real adoption of the updated RIS. Instead, the research conducted was based on successive iterations of the new RIS design. Each of these iterations was able to expose new and different usability issues that targeted the development of the new RIS. These issues often rose to the level of significance for this thesis, being common among many clerks and across different clients, however the longevity of the issues is not yet known. Not having the longitudinal data, it is impossible to confirm if the issues outlined would remain sticky patterns beyond the initial use of the system. There is evidence in the literature that they will remain issues for a significant amount of time and would affect efficiency based on their links to the psychological phenomena that others have established as effecting adoption of new interfaces, but at this point this remains conjecture.

Within the empirical research conducted, there were also limitations in how much was recorded and reviewed. Due to the sensitive nature of patient health information the author was unable to film any of the observations as patient details were constantly displayed on the screen. Although there is a record of the audio of the interactions, in some cases it failed to relate what was being displayed on the screen as the clerks conducted their processes. This left gaps in the information that was collected. It also made it difficult to directly compare interactions from users on their old RIS with the new RIS. Relying on verbal explanation, written notes, and the recollections of what was observed helped to conduct the analysis of the data.

The usability tests that were conducted also did not go exactly according to plan. The bulk of the research was collected over a four day period while visiting a series of clients. Though usability tests with several clerks from each of the clients were planned, due to time constraints, usability tests were only conducted with clerks from Client B. The usability tests conducted at Client C were conducted outside of this intensive four-day period. All of the clinics had limitations on how much time could be taken from the clerk's regular duties, and often during the tests they would be called away to do something else. This was mostly an issue for the administrator and front desk clerks in the tests. On the one hand, this meant that clerks would have to pick up and put down the tasks of the test, sometimes restarting tasks that they had begun before, giving them more time with the product and increasing their comfort levels. On the other hand, these interruptions were very common both for the administrator and for the front desk clerks, so the usability test mirrored their day to day experience of using the system.

Additionally, the usability tests conducted at Client B were conducted in the presence of an administrator. This administrator was a great help in organizing the trip and also very supportive of having her clerks participate in the usability sessions. However, this administrator would often add her own comments into the tests, prompting users with more detail than would normally be given in a usability test. She would often tell them about an issue that had already been encountered, helping the clerk to skate by that issue. Many of her questions mirrored those asked before, making her a wonderful assistant in some cases, however her interjections throughout the usability tests did skew the results, reducing the number of times clerks could be observed making the same mistakes and affecting the possibility of pinpointing which interactions were the stickiest.

In working with a software that is distributed in a work environment, adoption is driven by executive decisions rather than the desires of individuals. As explored in the background literature section on self-efficacy, this can be problematic in how users accept the move to a new interface, making the design that much more important for users to retain their sense of autonomy. The interaction of the company with the users directly on this software was the first time these users had been asked to explain their perspectives on the software they were going to be adopting in the future. This exposure may affect their feelings of self-efficacy when they do move to this software.

Finally, the feedback sessions and semi-structured interviews that were conducted were very helpful indicators of broad trends across clinics, but they had some drawbacks. The sessions were generally held with administrators and IT staff, not with clerks. A few of the administrators would pull a clerk in to answer some specific questions, but on the whole, they would express clinic level business requirements, not user needs. The feedback sessions were very helpful in identifying some of the broad trends within the clinics, specifically the prevalence of calendar versus appointment search bookings, and worklists. But seeing those functions in actions at all the clinics would have been preferable. Though observations were completed at three different clinics, usability testing was only conducted at two, meaning the results are limited in how broadly they can be applied to all users of the RIS.

7 Conclusion

Designing an updated system is difficult. The decisions to change something against the familiarity that users have with the old system have to be weighed carefully. The more common the action, the stronger the interaction pattern will be, and the stronger the negative transfer experienced by users.

1. What are the interactions that remain most ingrained and difficult to overcome when being asked to upgrade to a new version of a RIS?
2. Are there underlying psychological or mental models that explain which interactions are most difficult to learn anew and why is that?
3. How can we design and develop a system that facilitates the adoption of the new solution?

Firstly, there are several interaction patterns that need to be overcome when users are asked to update their system to a new version. Each clinic had developed their own specific processes and their own ways of using the old RIS. The clinics had taught their clerks to use the RIS only in certain ways, and clerks at the various clinics had customized and adapted the old RIS to their needs. Everyone has spent years developing their interaction patterns. Not surprisingly, the greater the change to the interface, the greater the resistance and excitement- depending on if they thought it would make them faster or not.

Secondly, these interaction patterns fall into four general psychological categories: cognitive mapping, cognitive automation and procedural memory; negative transfer; and self-efficacy. Cognitive mapping, cognitive automation and procedural memory provide the baseline by which users experience negative transfer when learning a new interface. The individual specific interaction patterns that will be sticky will depend on the specific product being designed for, but generally if certain guidelines are followed it is possible to mitigate many of the potential issues that one could face.

Finally, there are several recommendations discovered through this research that make it possible to reduce the friction users experience when they are asked to use a new interface. The recommendations, though developed from a RIS, have broader applications as they are tied not to the RIS itself, but generalized to the theoretical foundations of sticky interactions.

7.1 Future Work

Based on the research conducted here and in the section of the paper comprising the background research, a question that remains is the effect of age or generational differences on the adoption of new interfaces. Much of the research into adoption and the move from novice to expert interactions does not disaggregate the data by age or

by gender. However, from the few tests that were run with younger and older users there appears to be a distinct difference in the learning and adoption patterns of users from different generations. The ease with which the younger users adapted to the new interface would appear to bode well for upgrading interfaces in the future, however the sample size was not large enough to be sure about this difference.
If possible, it would also be very interesting to expand the scope of this research to include more longitudinal data about the effects of the changes that were implemented based on this research and how the final product will be adopted by users once they have full access to the system. Furthermore, a longer study would expose the half-life of the sticky patterns discovered in this research. While years spent with one interface will leave behind interaction patterns that are difficult to drop in the new interface, these patterns must not remain forever, as users continue to use the new product and gain speed, efficiency, and comfort in the new system like they had in the old system over time. A better sense of how long it takes users to adapt to an updated system would help companies determine how often they can update their system without causing extra levels of stress among the staff, and how long large corporations should wait before making large updates to their interfaces.

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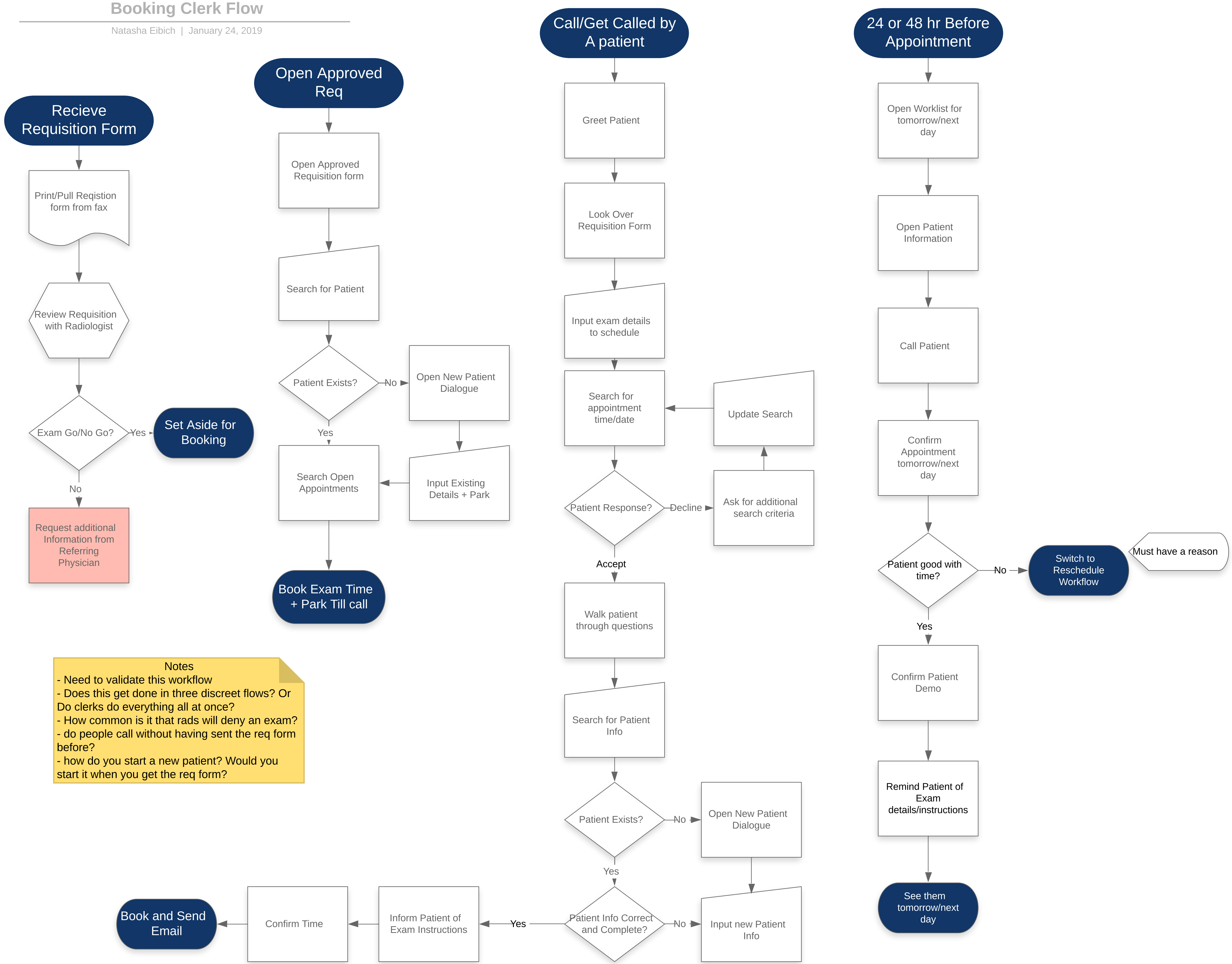
Appendices

Appendix 1: Booking Clerk Workflow

Booking Clerk Flow

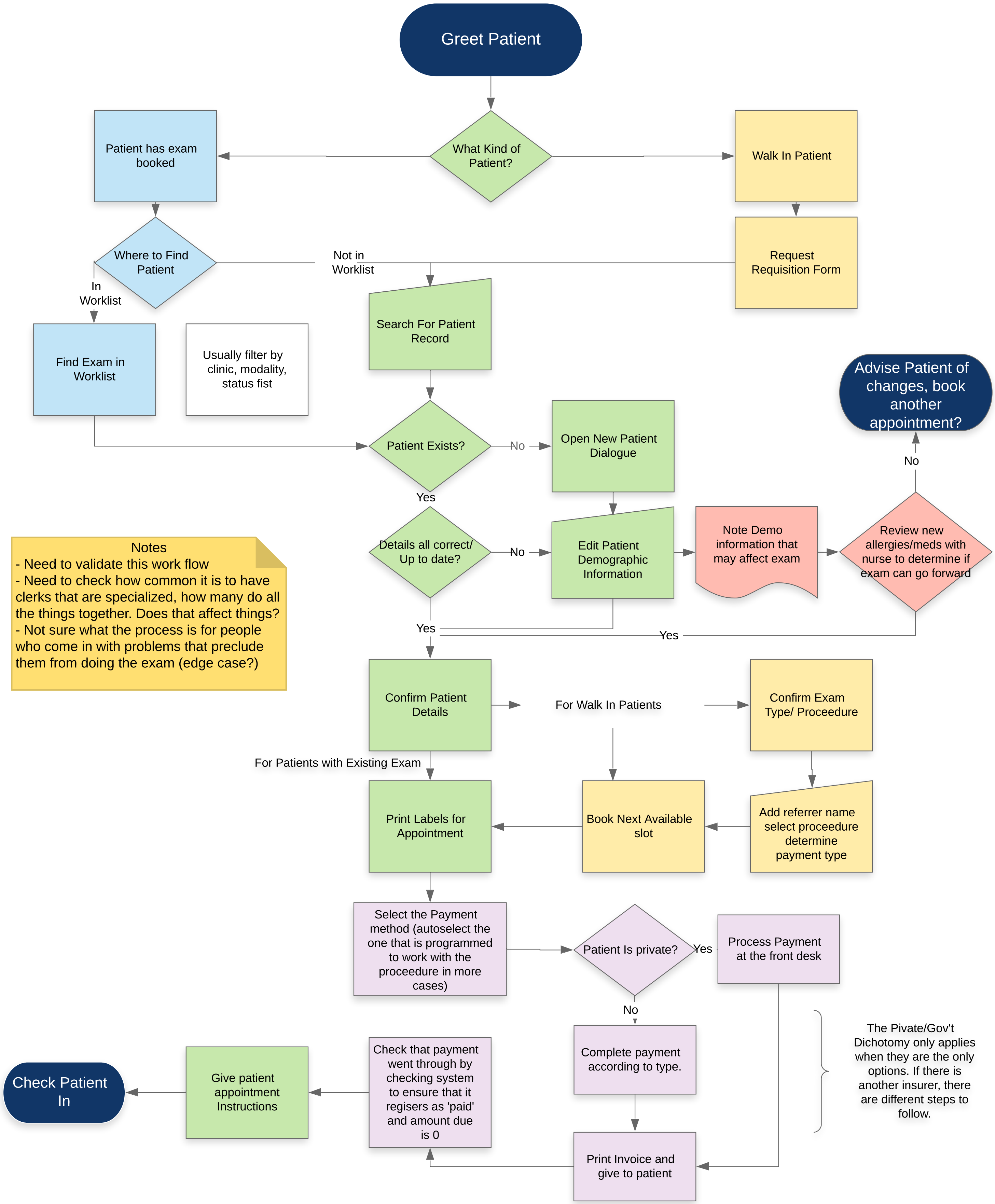
Natasha Eibich | January 24, 2019



Appendix 2: Front Desk Workflow

Front Desk Clerk Flow

Natasha Eibich | January 24, 2019



Appendix 3: Participants

Client	Clinic	Role	Gender	Experience at C	Age	
A	1	Clinic Manager	M	7+	45-55	
A	2	Gen. Book	F	1 - 3	25-35	
A	2	Gen. Book	F	1 - 3	25-35	
A	2	Gen. Book	F	4 - 6	55-65	
A	2	Gen. Book	F	4 - 6	45-55	
A	2	Pain Mgmt Book	F	4 - 6	35-45	
A	2	Pain Mgmt Book	F	4 - 6	35-45	
A	2	CT Book	F	4 - 6	45-55	
A	2	MRI Book	F	4 - 6	45-55	
A	2	US Book	F	4 - 6	35-45	
A	1	XRay Front	F	1 - 3	25-35	
A	1	XRay Front	F	7+	45-55	
A	1	XRay Front	F	1 - 3	25-35	
A	1	Front	F	4 - 6	45-55	
A	1	Front	F	1 - 3	25-35	
A	1	Front/Tech	F	7+	45-55	
A	1	SwitchBoard	F	4 - 6	45-55	
A	1	SwitchBoard	F	4 - 6	45-55	
A	1	SwitchBoard	F	4 - 6	55-65	
A	1	Mammo	F	7+	55-65	
B	1	IT Manager	F	7+	45-55	
B	1	Front - No MR	F	<1	25-35	
B	1	Front - No MR	F	1-3	25-35	
B	1	Front - No MR	F	4-6	25-35	
B	1	Front - No MR	F	1-3	25-35	
B	1	Front - No MR	F	1-3	25-35	
B	1a	MR/CT Front	F	1-3	25-35	
B	1a	MR/CT Front	F	4-6	35-45	
B	1a	MR/CT Book	F	4-6	25-35	
B	2	Front - All	F	7+	45-55	
B	2	Front - All	F	<1	25-35	
B	2	Front - All	F	4-6	25-35	
B	2	Front - All	F	7+	55-65	
B	3	IT Director	M	7+	45-55	
B	3	CFO	F	7+	45-55	
B	3	Gen Book	F	1-3	25-35	
B	3	Gen Book	F	7+	45-55	
B	3	Book Manager	F	7+	45-55	
B	3	Billing Clerk	F	7+	55-65	
B	3	Billing Clerk	F	7+	45-55	
B	3	Billing Clerk	F	7+	55-65	
C	1	PACS Admin	M	7-15	45-55	Prior Research
C	1	PACS Admin	M	7-15	45-55	Prior Research
C	1	Billing Clerk	F	7-15	45-55	Prior Research
C	1	Billing Clerk	F	7-15	45-55	Prior Research
C	1	Booking	F	7-15	55-65	Prior Research
C	1	Booking	F	7-15	35-45	Prior Research
C	1	Coordinator	F	7-15	35-45	Prior Research

Client	Clinic	Role	Gender	Experience at C	Age	
C	1	Booking	F	4-6	35-45	Prior Research
C	1	Front	F	4-6	55-65	Prior Research
C	1	Front	F	7-15	45-55	Prior Research
C	1	Booking	F	4-6	45-55	Prior Research
C	1	Booking	F	4-6	45-55	Prior Research
C	1	Front	F	4-6	45-55	
D	1	Booking	F	4-6	35-45	
D	1	Booking Manage	F	4-6	45-55	
E	1	IT Manager	M	7-15	45-55	
E	1	Booking	F	7-15	35-45	
F	1	IT Manager	M	7-15	35-45	
F	1	Clinic Manager	F	7-15	45-55	

Appendix 4: RIS Workflow Keystroke Level Modelling

OLD RIS

Action	Code	Proba	Distan	Size	# Char	Read	Click	Typing	Hick-Hyman	Fitts	Total
Patient Search											
Select Reception	Recall (most com	0.9						0	0.03136024748		0.03136024748
	Move		1100	80						1.183289001	1.183289001
	Click						0.2				0.2
Select Patient Se	Recall (one of thr	0.3							0.1581572475		0.1581572475
	Move		10	260						0.7106915204	0.7106915204
	Click						0.2				0.2
Type Name	Type				4			0.8			0.8
Locate Patient	Locate (of 5 options)					1.8181					1.818181818
	Move		450	35						1.173953954	1.173953954
	click						0.2				0.2
Review Note	Read (5 words)					1					1
	Move		500	35						1.188613204	1.188613204
	Click						0.2				0.2
Review Details	11 Fields (20 wrds)					3.6					3.6
TOTAL											12.46424699
Worklist - the visual search/decision is still logarithmic as the patient should have told you the time.											
Select Reception	Recall (most com	0.9						0	0.03136024748		0.03136024748
	Move		1100	80						1.183289001	1.183289001
	Click						0.2				0.2
Select System D	Recall (one of thr	0.3							0.1581572475		0.1581572475
	Move		30	260						0.7299560282	0.7299560282
	Click						0.2				0.2
Locate Patient	Locate (of 10 opts)					3.6363					3.636363636
	Move		580	35						1.209351189	1.209351189
	Click						0.2				0.2
Review Note	Read (5 words)					1					1
	Move		500	35						1.188613204	1.188613204
	Click						0.2				0.2
Review Details	11 Fields (20 wrds)					3.6					3.6
TOTAL											13.53709055
Schedule - visual search is not logarithmic as there is no alphateization on the calendar											
Select Reception	Recall (most com	0.9						0	0.03136024748		0.03136024748
	Move		1100	80						1.183289001	1.183289001
	Click						0.2				0.2
Select Schedule	Recall (one of thr	0.3							0.1581572475		0.1581572475
	Move		50	260						0.7469485283	0.7469485283
	Click						0.2				0.2
Locate Patient	Read (3 columns, 56 opts, 2 wrds each)					20.36					20.36
	Move		375	400						0.8523561956	0.8523561956
	Click						0.2				0.2
Review Note	Read (5 words)					1					1
	Move		500	35						1.188613204	1.188613204
	Click						0.2				0.2
Review Details	11 Fields (20 wrds)					3.6					3.6
TOTAL											29.92072442

NEW RIS

Action	Code	Probal	Distan	Size	# Char	Read	Click	Typing	Hick-Hyman	Fitts	Total
Patient Search											
Select Search Ba	Recall (most com	0.3						0	0.1581572475		0.1581572475
	Move		350	1000						0.7765534746	0.7765534746
	Click						0.2				0.2
Homing											
Type Name	Type				4			0.8			0.8
Homing											
Locate Patient	Locate (of 5 options)					1.8181					1.818181818
	Move		400	1830						0.7523219151	0.7523219151
	click						0.2				0.2
Review Details	11 Fields (20 wrds)					3.6					3.6
TOTAL											8.305214455
Worklist											
Select Worklist Ic	Recall	0.2							0.2049542476		0.2049542476
	Move		800	40						1.2357552	1.2357552
	Click						0.2				0.2
Locate Patient	Locate (of 10 opts)					3.63					3.63
	Move		400	1830						0.7523219151	0.7523219151
	Click						0.2				0.2
Select "Open Pat	Move		700	160						1.028540222	1.028540222
	Click						0.2				0.2
Review Details	11 Fields (20 wrds)					3.6					3.6
TOTAL											11.05157159
Calendar											
Select Calendar	Recall	0.2							0.2049542476		0.2049542476
	Move		750	40						1.226678654	1.226678654
	Click						0.2				0.2
Locate Patient	Reading Time (3 columns, 56 opts, 2 wrds each)							20.36			20.36
	Move		500	360						0.891753784	0.891753784
	Click						0.2				0.2
Select "Open Pat	Move		1100	160						1.088264305	1.088264305
	Click						0.2				0.2
Review Details	11 Fields (20 wrds)					3.6					3.6
TOTAL											27.97165099

New Patient

OLD RIS

Action	Code	Probat	Distan	Size	# Char	Read !	Click	Typing	Hick-Hyman	Fitts	Total
Select Reception	Recall (most com	0.9							0.03136024748		0.03136024748
	Move		1100	80						1.183289001	1.183289001
	Click						0.2				0.2
Select Patient Se	Recall (one of thr	0.3							0.1581572475		0.1581572475
	Move		10	260						0.7106915204	0.7106915204
	Click						0.2				0.2
Homing											
Type Last Name	Test				5			1			1
Tab							0.2				0.2
Type First Name	George				7			1.4			1.4
Tab							0.2				0.2
Type DOB	03 Oct 1989				11			2.2			2.2
Tab							0.2				0.2
Type MRN	3452				4			0.8			0.8
Tab							0.2				0.2
Type Phone	3453453456				10			2			2
Tab							0.2				0.2
Type Address	432 Main Street				17			3.4			3.4
Tab							0.2				0.2
Type City	Montreal				9			1.8			1.8
Tab (SSN)							0.2				0.2
Tab							0.2				0.2
Type Gender	m				1			0.2			0.2
Tab							0.2				0.2
Type State (1)	q				1			0.2			0.2
Tab							0.2				0.2
Type Country (1)	c				1			0.2			0.2
Tab							0.2				0.2
Type ZIP	d4f3e2				6			1.2			1.2
Homing											
Select New Patie	Recall	0.8							0.04495424759		0.04495424759
	Move		100	150						0.8222392421	0.8222392421
	Click						0.2				0.2
											20.15069151

NEW RIS

Action	Code	Proba	Distar	Size	# Cha	Read	Click	Typin	Hick-Hyman	Fitts	Total
Patient Search											
Select Search Ba	Recall (most com	0.3						0	0.1581572475		0.1581572475
	Move		350	1000						0.7765534746	0.7765534746
	Click						0.2				0.2
Homing											
Type Name	Type				4			0.8			0.8
Homing											
Select Add Patie	Recall (most com	1							0.0192		0.0192
	Move		850	40						1.24429435	1.24429435
	Click						0.2				0.2
Select First Nam	Recall (most com	1							0.0192		0.0192
	Move		1100	40						1.280735492	1.280735492
	Click						0.2				0.2
Homing											
Type First Name	George				7			1.4			1.4
Tab							0.2				0.2
Type Last Name	Test				5			1			1
Tab							0.2				0.2
Type DOB	03 Oct 1989				11			2.2			2.2
Tab							0.2				0.2
Type Gender	m				1			0.2			0.2
Tab							0.2				0.2
Type PHN	3452				4			0.8			0.8
Tab							0.2				0.2
Type Phone	3453453456				10			2			2
Tab (use)							0.2				0.2
Tab							0.2				0.2
Type Address	432 Main Street				17			3.4			3.4
Tab							0.2				0.2
Type City	Montreal				9			1.8			1.8
Tab							0.2				0.2
Type Province	q				1			0.2			0.2
Tab							0.2				0.2
Type ZIP	d4f3e2				6			1.2			1.2
Tab							0.2				0.2
Type Country	c				1			0.2			0.2
Homing											
Select Save	Recall	1							0.0192		0.0192
	Move		600	70						1.118132976	1.118132976
	Click						0.2				0.2
											22.83547354

The book appointment workflows begin from the patient record as users need to begin there anyway. The most common way to reach the Patient record is the patient search

OLD RIS

Action	Code	Probal	Distan	Size	# Chai	Read	Click	Typing	Hick-Hyman	Fitts	Total
Appointment Search											
Select New Appc	Recall (1 of 3 cor	0.3							0.1581572475		0.1581572475
	Move		600	80						1.1	1.1
	Click						0.2				0.2
Select Appointen	Recall (1/2)	0.5							0.0992		0.0992
	Move		30	120						0.7584962501	0.7584962501
	Click						0.2				0.2
Select Search Lc	Recall (1/3)	0.33			5			1	0.1471569656		1.147156966
	Move		100	35						0.974723393	0.974723393
	Click						0.2				0.2
Select Clinic	Recall (1/10)	0.1							0.2849542476		0.2849542476
	Move		250	1050						0.7561878888	0.7561878888
	Click						0.2				0.2
Return Selected	Recall	0.9							0.03136024748		0.03136024748
	Move		140	150						0.8519374159	0.8519374159
	Click						0.2				0.2
Select Add appoi	Recall (only 2 reg	0.45							0.1113602475		0.1113602475
	Move		340	110						0.984434913	0.984434913
	Click						0.2				0.2
Homing							0.4				0.4
Type Modality	U [ltrasound]				1			0.2			0.2
Return Modality							0.2				0.2
Type Procedure	Abd[omen complete]				3			0.6			0.6
Return Procedure	Name						0.2				0.2
Homing							0.4				0.4
Select "Save anc	Recall	0.6							0.07815724753		0.07815724753
	Move		200	120						0.9115477217	0.9115477217
	Click						0.2				0.2
Select Execute S	Recall	0.45							0.1113602475		0.1113602475
	Move		500	130						1.011973924	1.011973924
	Click						0.2				0.2
Select 1st option	Read (14 opts, 42)					7.7					7.7
	Move		440	1080						0.7859822342	0.7859822342
	Double Click						0.4				0.4
Read Patient Not	Read (5 wrd)					1					1
	Move		300	35						1.118132976	1.118132976
	Click						0.4				0.4
Select "Manage I	Recall (always ne	0.8							0.04495424759		0.04495424759
	Move		360	205						0.9173829456	0.9173829456
	Click						0.2				0.2
Select "Change (	Recall	0.9							0.03136024748		0.03136024748
	Move		10	320						0.7087462841	0.7087462841
	Click						0.2				0.2
Homing							0.4				0.4
Type Physician n	Test				4			0.8			0.8
Homing							0.4				0.4
Select 1st option	Read (9 opts- 36)					6.5					6.5
	Move		270	800						0.7744161096	0.7744161096
	Click						0.2				0.2
Select Save	Recall (one in 9)	0.1							0.2849542476		0.2849542476
	Move		500	35						1.188613204	1.188613204
	Click						0.2				0.2
TOTAL											37.22555045
Calendar Search											
Select New Appc	Recall (1 of 3 cor	0.3							0.1581572475		0.1581572475
	Move		600	80						1.1	1.1

NEW RIS

Action	Code	Probability	Distan	Size	# Chai	Read	Click	Typing	Hick-Hyman	Fitts	Total
Appointment Search											
Select Book App	Recall (1 of 3 cor	0.6							0.07815724753		0.07815724753
	Move		350	40						1.120945337	1.120945337
	Click						0.2				0.2
Open clinic drop	select field	1							0.0192		0.0192
	Move		1000	380						0.964689025	0.964689025
	Click						0.2				0.2
Select correct cli	Choose from list	0.33			5			1	0.1471569656		1.147156966
	Move		40	430						0.7246160587	0.7246160587
	Click						0.2				0.2
Click out	Click						0.2				0.2
Open Modality dr	Recall	0.9							0.03136024748		0.03136024748
	Move		100	120						0.8415037499	0.8415037499
	Click						0.2				0.2
Homing							0.4				0.4
Select Select Mo	C(T)						0.2				0.2
	Enter						0.2				0.2
Homing							0.4				0.4
Open Procedure	Recall	0.8							0.04495424759		0.04495424759
	Move		100	300						0.7736965594	0.7736965594
	Click						0.2				0.2
Homing							0.4				0.4
Type Procedure	Abd[omen complete] + down arrow				4			0.8			0.8
Return Procedure	Name						0.2				0.2
Homing							0.4				0.4
Select "search av	Recall	0.9							0.03136024748		0.03136024748
	Move		500	150						0.9938599455	0.9938599455
	Click						0.2				0.2
Read first Option	read suggestion (6 wrds)					1.1					
Confirm Availabil	find button	0.8							0.04495424759		0.04495424759
	Move		0	150			0.2			0.7	0.9
	Click						0.4				0.4
select Referring I	Recall (always ne	0.9							0.03136024748		0.03136024748
	Move		550	380						0.8961525852	0.8961525852
	Click						0.2				0.2
Homing							0.4				0.4
Type Physician n	Test (+ down arrow)				5			1			1
Homing							0.4				0.4
Select Book app	Recall (one in 9)	0.9							0.03136024748		0.03136024748
	Move		550	150						1.005889369	1.005889369
	Click						0.2				0.2
TOTAL											16.68121633

Action	Code	Probal	Distan	Size	# Chai	Read :	Click	Typing	Hick-Hyman	Fitts	Total
	Click						0.2				0.2
Select Schedule	Recall (1/2)	0.5							0.0992		0.0992
	Move		10	120						0.7222392421	0.7222392421
	Click						0.2				0.2
Select Location	Recall (1/13 - 3 h	0.07							0.3261201014		0.3261201014
	Move		350	160						0.9426264755	0.9426264755
	Click						0.2				0.2
Select Time Slot	Read (56 opts, 4					41					41
	Move		450	225						0.9321928095	0.9321928095
	Double Click						0.4				0.4
Homing							0.4				0.4
Type Procedure	Abd[omen]				3			0.6			0.6
Enter							0.2				0.2
Homing							0.4				0.4
Read Through	Review the Appt.					3.63					3.63
Book Appointme	Recall	0.9							0.03136024748		0.03136024748
	Move		250	160						0.9044394119	0.9044394119
	Click						0.2				0.2
Select "Manage I	Recall (always ne	0.8							0.04495424759		0.04495424759
	Move		360	205						0.9173829456	0.9173829456
	Click						0.2				0.2
Select "Change (	Recall	0.9							0.03136024748		0.03136024748
	Move		10	320						0.7087462841	0.7087462841
	Click						0.2				0.2
Homing							0.4				0.4
Type Physician n	Test				4			0.8			0.8
Homing							0.4				0.4
Select 1st option	Read (9 opts- 36)					6.5					6.5
	Move		270	800						0.7744161096	0.7744161096
	Click						0.2				0.2
Select Save	Recall (one in 9)	0.1							0.2849542476		0.2849542476
	Move		500	35						1.188613204	1.188613204
	Click						0.2				0.2
TOTAL											65.49676282

Action	Code	Probability	Distan	Size	# Chai	Read :	Click	Typing	Hick-Hyman	Fitts	Total

OLD RIS

Action	Code	Probab	Distanc	Size	# Char	Read S	Click	Typing	Hick-Hyman	Fitts	Total
Patient search											
Select Patient Ta	Recall	0.5							0.0992		0.0992
	Move		500	110						1.033498425	1.033498425
	Click						0.2				0.2
Homing							0.4				0.4
Type Last name	test				4			0.8			0.8
Enter							0.2				0.2
Homing							0.4				0.4
Select Head	Read (9 results, 3 wrds each)					5					5
	Move		360	35						1.143104982	1.143104982
	Click						0.2				0.2
Review Patient D	Read (11 fields, 20 wrds)					3.6					3.6
Select Future Ap	Recall (/21 optior	0.2							0.2049542476		0.2049542476
	Move		260	140						0.9237039197	0.9237039197
	Click						0.2				0.2
Select Appointme	read (7 opts, 2 wrd each)					2.5454					2.5454
	Move		100	35						0.974723393	0.974723393
	Click						0.2				0.2
Select Check in	Recall	0.7							0.06036585383		0.06036585383
	Move		400	125						0.9887525271	0.9887525271
	Click						0.2				0.2
TOTAL											19.37370335
Worklist											
Select System D	Recall	0.2							0.2049542476		0.2049542476
	Move		500	110						1.033498425	1.033498425
	Click						0.2				0.2
Select Patient "h	Read (6 options, 2 wrds each)					2.2					2.2
	Move		480	35						1.18292697	1.18292697
	Click						0.2				0.2
Review Details	Read (11 fields, 20 wrds)					3.6					3.6
Select Future Ap	Recall (/21 optior	0.2							0.2049542476		0.2049542476
	Move		260	140						0.9237039197	0.9237039197
	Click						0.2				0.2
Select Appointme	Recall	0.9							0.03136024748		0.03136024748
	Move		100	35						0.974723393	0.974723393
	Click						0.2				0.2
Select Check in	Recall	0.7							0.06036585383		0.06036585383
	Move		400	125						0.9887525271	0.9887525271
	Click						0.2				0.2
TOTAL											12.40523983
Calendar											
Select Calendar	Recall	0.2							0.2049542476		0.2049542476
	Move		500	110						1.033498425	1.033498425
	Click						0.2				0.2
Right Click Appo	Read (56 opts, 2					20					20
	Move		290	400						0.8292781749	0.8292781749
	Click						0.2				0.2
Select "Edit Appo	Recall	0.5							0.0992		0.0992
	Move		10	200						0.7137503524	0.7137503524
	Click						0.2				0.2
Select Patient "h	Recall	0.3							0.1581572475		0.1581572475
	Move		460	80						1.064385619	1.064385619

NEW RIS

Action	Code	Probab	Distanc	Size	# Char	Read S	Click	Typing	Hick-Hyman	Fitts	Total
Patient search											
Select Patient se	Recall	0.6							0.07815724753		0.07815724753
	Move		400	900						0.791753784	0.791753784
	Click						0.2				0.2
Homing							0.4				0.4
Type Last name	test				4			0.8			0.8
Homing							0.4				0.4
Select Patient Ro	Read (9 results, 3 wrds each)					5					5
	Move		171	1230						0.7353942902	0.7353942902
	Click						0.2				0.2
Review Patient D	Read (11 fields, 20 wrds)					3.6					3.6
Select Appointme	Read (7 opts, 2 wrd each)					2.5454					2.545454545
	Move		320	560						0.8099535674	0.8099535674
	Click						0.2				0.2
Select "more"		0.6							0.07815724753		0.07815724753
			570	40						1.188264305	1.188264305
							0.2				0.2
Select Check in	Recall	0.25							0.1792		0.1792
	Move		50	210						0.7561878888	0.7561878888
	Click						0.2				0.2
TOTAL											18.36252288
Worklist											
Select Worklist	Recall	0.3							0.1581572475		0.1581572475
	Move		800	40						1.2357552	1.2357552
	Click						0.2				0.2
Select Exam reco	Read (6 options, 2 wrds each)					2.2					2.2
	Move		350	1830						0.7467293736	0.7467293736
	Click						0.2				0.2
Review Details	Read (11 fields, 20 wrds)					3.6					3.6
Select Check in	Recall	0.3							0.1581572475		0.1581572475
	Move		700	40						1.2169925	1.2169925
	Click						0.2				0.2
TOTAL											9.915791569

Action	Code	Probab	Distanc	Size	# Char	Read S	Click	Typing	Hick-Hyman	Fitts	Total
	Click						0.2				0.2
Review Details	Read (11 fields, 20 wrds)					3.6					3.6
Select Exam Tab	Recall	0.8							0.04495424759		0.04495424759
	Move		200	100						0.9321928095	0.9321928095
	Click						0.2				0.2
Check in	Recall	0.6							0.07815724753		0.07815724753
	Move		100	120						0.8415037499	0.8415037499
	Click						0.2				0.2
TOTAL											30.80003212

Action	Code	Probab	Distanc	Size	# Char	Read S	Click	Typing	Hick-Hyman	Fitts	Total