It Works Better When I Do That

Interaction and Communication In Radiology Departments

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ABSTRACT

This paper investigates patterns of communication and interaction in radiology departments by utilising ethnographic and ethnomethodological techniques. We conducted 12 sessions of observations with accompanying interviews in the practitioners natural working environment, and used this to construct a model of how a report is authored from an outsider perspective. These observations revealed that practitioners have a distinct way of interacting with speech recognition systems that is unlike traditional interaction with Voice User Interfaces, that there are a myriad of ways of communicating a result to peers that are dependent on context and tacit knowledge, and that reports are rarely completed without some form of cognitive interruption in the authoring stage. We finish by recommending a codified framework for guidance on communicating results that builds on evidence-based findings tailored specifically to radiology practitioners.

CCS CONCEPTS

• **Human-centered computing** → Human computer interaction (HCI); Interaction techniques; Human computer interaction (HCI); HCI design and evaluation methods; Field studies; Human computer interaction (HCI); Interaction devices.

KEYWORDS

Ethnomethodology, Radiology, Technical Communication

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1 INTRODUCTION

Medical tools, like all safety critical devices, are designed with the requirement that they are safe, reliable, and appropriate for the demanding and high-stress environment that is healthcare [1]. Devices, tools and systems are perpetually being re-designed, reimplemented and re-evaluated to rigid metrics to make sure that they are still meeting proper standards. However, these designs often assume that they are being used in a perfect world, by the perfect user – this, naturally, is not the case in everyday life [2]. Factors such as increasing workload, user tiredness, lack of training or improper implementation can mean that tools and systems that "work" in certain environments are not always performing to the high standards for healthcare that we hope they are [3]. The disconnect between the design of systems and tools and their actual implementation and everyday use is known as "Work As Imagined (WAI) versus Work As Done (WAD)", and is a common thread amongst HCI and UX designers. The gap between "Work as Imagined" and "Work As Done" has been highlighted in several disciplines across healthcare, often through the lens of a case study where patient harm has come as a result of poor design [4].

However, previous research has mostly focused on direct administration of care to patients (infusion pumps [5], syringes, radiotherapy machines [6]), and not in areas of medicine that are more practitioner facing such as radiology. Clinical Radiology is a discipline where many practitioners may have most or indeed all of their clinical interaction with a patient through their data (radiology examinations such as X-rays or MRI studies), without any personal interaction. Radiologists and radiographers often have to answer a clinical question for peers based on digital scans, meaning they can have little to no direct contact with the patient they are offering diagnosis for [18]. Authoring and communicating these results is an imperative part of the patient journey, but little work has been done that examines the radiologist's "Work As Done" with an eye towards technical communication.

This paper utilises ethnographic methods of observation and interviewing to construct a vignette of the radiologist's praxis with regards to their interaction and communication, both with technological systems and human colleagues; we conducted 12 observational sessions of 3 hours apiece with 5 radiologists and 6 radiographers in their everyday environment with minimal interaction to gather a naturalist image of their habits and behaviours, using time at the end of the session to follow up on anything that was of particular interest. Collecting and analysing this data with an ethnomethodological lens reveals that radiologists operate in a distinctly personalised environment, with every practitioner having a preferred way of constructing a report and communicating actionable findings to the relevant clinician. We also demonstrate that practitioners have unique ways of interacting with the systems

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and tools available to them such as speech recognition, which we interpret to be as a result of "folk theories" amongst members of the department. Finally, we offer recommendations for a better suited radiological framework based on these findings for the future design, and more importantly implementation, of medical tools in safety critical environments.

2 BACKGROUND

2.1 Terminology

Prior to discussing this topic, it is worth addressing the specifics of radiology in the United Kingdom. We will use tthe terms radiologist and radiographer throughout this paper; for the purposes of this research, they undertake similar duties i.e. examining medical studies to produce a diagnostic opinion. However, radiologists have a medical degree and are qualified doctors that have specialised in radiology, whereas radiographers do not, and have instead trained to report after working in radiology departments as technicians. This means that radiographers are less likely to give medical advice and clinical direction, instead emphasising what can directly be seen and allowing the referring clinician to make their own decisions based on the available information in the report.

2.2 Communication in Healthcare

"Good" communication in a medical context requires the ability to convey rich and sensitive information as efficiently as possible, as it pertains to the provision of care, but often also requires the ability to communicate complex and tacit knowledge in a way that non-experts and patients can understand [7]. The importance of good communication in healthcare has been extensively covered Brassuer's investigation into how sonographers communicate with patients mid-exam reveals that practitioners value good communication skills above many other qualities, but often feel that there is a lack of education surrounding how proper workplace guidelines and methods of proper oral communication when trying to convey medical results to patients [8]. One of the most common mistakes made in radiology departments is the "hand off" - communicating test results, with between 4 and 8 percent of abnormal results not being followed up in a timely fashion, and inadequate follow up of test results being responsible for up to 55 percent of malpractice lawsuits in the United States [9]. Reasons provided by the radiologists in question revolved around an increasing workload, and a lack of proper guidance on standards and practice. Similarly, Aryal's work on communicating actionable findings in radiology found that, whilst the radiologist is often responsible for providing patients with end results if the referring physician is unavailable, lack of definition surrounding urgency and proper protocol often results in confusion as to who is responsible and how best they should get in touch with patients [10]. Communication systems in diagnostic contexts are often manually driven, and the digitisation process can be slow meaning inconsistencies are commonplace [11].

2.3 Work As Imagined vs Work As Done

Investigation into "Work As Done" in healthcare environments has revealed there is a fundamental misunderstanding regarding the fact that a key skill of administering care to patients is the ability to navigate situations without extant rules and guides to follow [12]. As such, patient harm due to device failure is often put down to human error. A study by Blandford et al. revealed that, regardless of where the actual fault lay, in malpractice cases design of tools was overlooked in favour of human error through lack of training, incompetence or failure to follow proper instructions [3]. Further investigation into these cases revealed that tools are often poorly designed for the way that they will be used in practice, and that often these errors are "invisible" until identified by an outsider. In addition, these invisible problems with interactive devices are often harder to identify due to an adoption of "blame culture" in the healthcare domain, whereby procurement guidelines ignore human factors and have minimal questioning of device design [13]. Further factors in poor implementation and adoption of digital systems often come from the physician's side; an analysis of electronic health record adoption came to the conclusion that bureaucracy and resources are important to consider, but having a management team foster collaboration with clinicians can reduce resistance from practitioners when choosing to adopt digital systems. Boonstra et al. found that physicians being reluctant to implement EHRs in their clinical workflow was a major barrier in their sustained adoption in hospitals, and identifying "local champions" (well respected and informed members of the department who "champion" the technology) was imperative to good implementation [14]. In a medical communication context, study of deviation from codified "standards of practice" guidance in pharmacies revealed that WAI literature often does not take into account realities of financial or temporal restrictions that may be present, instead working under the assumption that every practice operates in identical ways [15]. This demonstrates another clear issue with WAI design - it requires an in depth understanding of the dynamic nature of medical communication and practice.

2.4 Ethnographic Methodologies

Ethnographic methodologies in computational sciences has been commonplace since the late 20th century, and the need to understand "impact" of design has lead to many studies adopting a more sociological perspective when addressing design of tools and systems [16]. Specifically, non-laboratory based study has been demonstrated to reveal insights about behaviour and interaction that would not otherwise become clear [17]. In his chapter for "Fieldwork For Healthcare", Furniss demonstrates that observational techniques allowed him to access areas of the hospital that would have otherwise been off limits for structured research, and having more "conversational" interviews with participants meant they were more at ease with revealing information about their work [18]. Similarly, Coble et al.'s contextual inquiry into physicians' needs showed a far deeper level of complexity as to what a digital system would need to provide than expected, and the authors expressed surprise with the level of enthusiasm that practitioners displayed when they were "involved" in the design and evaluation process [19]. From a more generalised anthropological perspective, Briedis' phenomenological study of radiologists demonstrated the need for more attention to be paid to the design of radiological tools in American hospitals [20, 21]. This demonstrates a further benefit to utilising ethnographic methods in such environments -

users often display a higher level of satisfaction with devices and systems when they feel they have been a part of the design process [22], and so by informing radiologists that the work being carried out will be used to drive better design of their everyday tools, we can hope that it will lead to more ready adoption of future systems.

3 APPROACH

This study focuses specifically on observing the ways in which a radiologist utilises the tools and peer social networks available to them in their office environment to diagnose and help administer care to patients - this includes software and hardware used to examine medical studies, such as Picture Archive and Communication Systems (PACS) and digital controller/microphones (dictaphones), as well as the social peer-to-peer networks found in hospitals used to communicate these diagnostic opinions, such as telephones, pen and paper, emails and in-person conversation. It has been recognised that the myriad of ways to diagnose and communicate findings has a perceived negative impact on radiologist satisfaction [23], which in turn is a result of the high volume of medical data that comes with utilising advanced digital systems, all of which needs to be analysed and synthesized into a small, easily legible report for the referring clinician [24].

Our research was approved by both Swansea University's Research Governance department and the NHS Health Care Research Wales (HCRW) ethics and approvals department. Participants were provided with an overview of the study as well as a consent form prior to undertaking either interviews or observations. Following HCRW guidance, we developed an approach that ensured that we had a methodology which was not invasive or disruptive to ongoing treatment of patients. We also worked to ensure we respected the privacy of all patients, staff, and visitors within the healthcare settings, thus focused on the use of fieldnotes rather than audio-video data for the majority of the observation.

Ethnographic methods such as observation and interview were chosen to properly investigate these patterns of interaction and communication as they were deemed the most appropriate way to understand the practitioner and their cultural structures. St Amant claims that communication designers "must" observe members of the community to learn about perceptions and patterns [25], and Sellberg's comparison of methods for workplace studies identified that all chosen codified methodologies were built upon ethnographic principles of observation and direct interview with participants [26]. The work of Crabtree and Porcheron identifies ethnographic and ethnomethodological techniques of observing participants in different settings as so to build the most accurate picture of behaviour and patterns [27–29]. Observational and interview work also aligns with Melconcon's principles for "context of use", claiming that, when embodying methods, in depth biographical attributes and past experiences must be captured [30]. This allows us to not only get an understanding from our perspective on how tools are used, but a practitioner's perspective on how they communicate between departments and inter-culturally.

We found that utilising an ethnomethodological methodology of research allowed us to approach participants in a way that they may have been previously unfamiliar with, but worked particularly well in this medical context; since radiologists (and most clinicians) train "on the job" after their formal education, senior practitioners have a wealth of experience in demonstrating to others what they are doing, but they are also very comfortable with having others "in their space", and meant that the infrastructure of the hospital allowed for us to observe and converse with participants without changing any aspects of the natural environment. We encountered little bureaucratic or social friction, and all participants were comfortable (if not enthused) by our presence when they were made aware of the nature of the research. Recreating such a study in a laboratory environment may offer more quantifiable results, but by adopting a less structured methodology, we had access to the participants normal environment without disrupting their ability to administer care to patients as normal, another factor that participants found beneficial. As such, we would advocate for ethnomethodological techniques to be used more when studying medical communication.

3.1 Participants

Participants were identified through NHS channels via an internal call for participation from that outlined the nature of the study, demographics are demonstrated in Table 1. Potential participants were asked to self-identify if they met the criteria of either being a radiologist or radiographer with reporting duties and sessions would be organised one-on-one with the principal researcher as so to fit around the participants schedule. Through this, we identified 9 participants from 2 different health boards across 3 hospital sites. 1 of the authors of this paper also partook in this research, meeting the recruitment criteria themselves (but did not undertake observations or analyse their own data); this served the purpose of "vulgar competency" – it allowed the observing researcher access to the radiology department initially as an "insider" to become familiar in the environment and understand the basic concepts of radiology before undertaking an observational session, as so to allow the data gathering to focus on the behaviour and habits of the participant [27], as well as providing us with a multidimensional perspective that allows us to observe past a computational or clinical perspective [31].

3.2 Interviews

Prior to observing participants, we carried out a brief structured interview comprising of 7 questions in order to understand more about the sample of practitioners that we were observing (found in the appendix). These questions ranged from simple, quantifiable information about the participant (2, 3, 4), to more abstract questions designed to provide us with self-reflective perspectives from participants (5, 6), as well as questions designed to ensure that the participant is aware and comfortable with the nature of the study and its intended outcomes (1, 7). The audio from these interviews would then be transcribed into text and compiled for analysis.

3.3 Observations

We made sure to observe participants with minimal interaction in an environment that they were comfortable with, this being their standard workplace setting. This meant that we mostly observed participants in their own offices, with the exception of P8, who worked in an open plan hub with multiple other practitioners. Only one researcher would observe participants at a time, both to reduce

the space taken up in the office and to prevent it from becoming something akin to an evaluation of their work. After meeting with participants and introducing ourselves, we conducted the interview in their office before informing them of the passive nature of the study. This meant asking that they attempt to "ignore" us as much they could, and reinforce that we were not observing the outcomes of their work – prior to agreeing to participate, some participants expressed anxiety over whether or not we would be recording the accuracy of their reporting, and so it was imperative that we explained this before undertaking the study. The observational periods were not rigidly timed to allow for breaks in the session, with all of the sessions lasting between 2 and 3 hours depending on availability, shift patterns and emergencies. 3 hours was landed on as an appropriate length as NHS contracts deem a session to last 3.75 hours, and when accounting for administrative work and urgent queries that require the reporter to leave their office it means that the tangible time spent reporting averages out to 3 hours. The sessions were evenly split between morning, beginning at 9am, and afternoon, beginning at 2pm, with 1 session occurring in the evening starting at 5:30pm.

Data was recorded as fieldnotes on a tablet during the observation. This allowed for easy consolidation of session notes and ensured our data was properly backed up. We found that keeping observational notes to the dimensions of Space; Actor; Activity; Object; Act; Event; Time; Goal and Feeling meant that we maintained an element of structure and cohesion across all of our observing sessions. These dimensions follow those proposed by Spradley to organise ethnographic research [32]. Notes would be made with these dimensions in mind for better analysis after the session - for example, an observation may start with recording the nature of the room. Similarly, procedural information would be noted such as the order in which a participant loaded and examined a scan, the keyboard commands used, how they handled the dictaphone and other details that made up the encompassing behavior of authoring a report. Events such as the phone ringing, a colleague interrupting a scan or a program crashing would be recorded each and every time they happened.

At the end of the observational period, we would take the opportunity to follow up on any questions that arose throughout the session as so to not interrupt practitioners whilst they worked. The answers to these would be recorded by hand as an addendum to the fieldnotes. This allowed us to properly interpret our results without a cultural bias affecting our conclusions - by presenting our findings back to participants, we were able to address possible reasons for patterns from a collaborative perspective [31]. After finishing data collected, we would consolidate these notes for analysis. As this data comprised of fieldnotes, we would first transcribe every note as an individual entry categorised into a spreadsheet under one of 9 dimensions as previously described. These entries would then be reviewed with discussion between the researchers to determine two things - an overview of general habits and behaviours exhibited by all participants that could be categorised as "writing a report", and events and activities of interest that seem to be contrary to a textbook understanding of how a radiologist would work in a perfect environment. The goal was to develop an understanding of and then codify the behaviours and actions of a general radiologist (i.e. the mundane) from an ethnomethodological perspective that allowed us to engage with aspects that the participants themselves may not pick up on.

4 ANALYSIS

4.1 Interview Results

We have made the decision to focus our analysis on two particular interview questions, those intended to give us an insight into participant's perspectives on their day-to-day habits - this allows us a relatively direct comparison between an insider, expert view on the role of communication in radiology care and our outsider, vulgar perspectives.

4.1.1 How Do You Write Reports. Most participants did not offer a specific structure for what one of their reports would look like (with the notable exception being P1; "Yes, title, clinical indication, report and a conclusion if it's a long one") but did acknowledge that there was a strong element of personal choice and variety to how a report was made. Comments such as "I guess I do, in my head ... it's very formulated" (P9); "I would say I do, but it's hard to describe" (P2); "There are standardised things that I aim for" (P8); "If you asked me for my style, I would say 'succinct' " (P7) indicate that, whilst participants know their reports may follow a particular structure and style, there is a distinct lack of standardisation and guidance across the hospital or health board as a whole. In addition, participants offered their perspectives about this lack of standardisation individually and unprompted, commenting "I read lots of other people's reports and just skip to the conclusion" (P7) and "There have been studies that show reporting proformas have value in their consistency" (P6) demonstrating an awareness that this lack of standardisation and structure can be frustrating to the clinician on the other end who has to read and interpret these reports before administering care to the patient in question.

4.1.2 How Do You Perceive Radiology In Relation To Other Fields Of Healthcare. When asked how they perceive radiology in relation to other fields of healthcare, participants overwhelmingly offered two particular aspects of radiology that make it unique: other fields of clinical medicine's reliance on diagnostic imaging, and the lack of patient interaction. Due to the prevalence of imaging in the patient's journey, participants perceived themselves to be one of the most important stops in the hospital; "One of the specialities all others rely on" (P11); "There's a lot of other disciplines that wouldn't be able to function without radiology in the background" (P4). An extension of this belief seems to be the perspective that radiology is misunderstood by other specialities. Participants discussed that many other clinicians visit the radiology department to get a clinical opinion expect their request for referral to be immediately approved and the result to align with their suspected outcome; "I don't think a lot of people understand radiology from other disciplines" (P6); "Their perception doesn't always line up with your perception, and that's why you're important" (P9). These views compound to produce a self-reflective image of the radiology practitioner to be (in the words of P3) a "**Gatekeeper**" of diagnostic imaging.

Regarding the lack of patient interaction, participants deemed this to be one of the most important elements that sets radiology and radiography apart from other fields of clinical medicine; "I think there's generally less patient interaction" (P9); "I don't have

Table 1: Participant Demographics

P	Occupation	Speciality	Years Spent Reporting
1	Radiologist	MSK	16
2	Radiographer	Chest and Abdomen	2
3	Radiographer	CT and Plain Film	6
4	Radiographer	MSK	4
5	Radiographer	Chest and Abdomen	3
6	Radiologist	PET and CT	6
7	Radiologist	Paediactrics	23
8	Radiologist	Paediactrics	5
9	Radiographer	Paediactrics	9
10	Radiographer	MSK	4
11	Radiologist	Neuroradiology	2

a lot of patient contact at all" (P11). Practitioners self-identified that this is unusual, with P7 claiming the ability to be comfortable with it to be one of the key skills that a radiologist should work on; "You have to have the ability to focus and have your attention on something for longer". This connection to patient data but not the patient themselves was also established as a separation factor between radiology and other disciplines; "We've a very different relationship to patients" (P10); "You have to bear in mind that we've not seen the patient when we report on them" (P3). One participant claimed "I don't want to use the term 'conveyor belt', but we'll only see a patient's data for a very short amount of time" (P10). These two aspects combined show that radiologists and radiographers view their work as very different to how traditional doctors and practitioners may work in the same hospital, treating the same patients, and perceptions of them should be adjusted as such.

4.2 Observational Findings

In total, we gathered 35 hours of observation data with 11 participants. 10 participants undertook a singular session with P1 being observed twice at 2 different hospital sites. We opted to display this data in a way that best suited the nature in which it was gathered and analysed, utilising "thick descriptions" that demonstrate areas of interest when it came to the ways in which participants interacted with digital systems and communicated with their peers. These descriptions do not aim to quantify radiology practitioners in general, but instead offer insights in the form of vignettes that can be used to identify areas of further investigation and laboratory based study.

4.2.1 Radiology Workflow. An overview of the generic reporter's behaviour when constructing a report in a "perfect world" would look as follows: Every participant had a desktop computer, keyboard, mouse, 3 computer monitors in portrait layout, and dictaphone microphone. The reporter selects a study from the Picture Archiving and Communications System and reviews the Request for Referral document from the consulting physician. They then consult the patient's clinical notes and history before turning their attention to the relevant study in front of them. This is used to inform them on what they are seeing and the clinical question they have been requested to answer. The reporter begins pressing record on the dictaphone. This turns the reporting window to green, and as they communicate their findings the words appear in real time in the reporting window in front of them. In addition, there is a small recording icon that demonstrates the volume at which the user is speaking into the microphone. As they report on what they see, they include details about the patients history and prior scans, and their expert opinion on what should be done on it. A further investigation of the study may or may not reveal other actionable findings that should be included on the report. Practitioners are able to manipulate their scans with contrast, brightness and zoom tools, as well as being able to utilise tools such as ruler functions to measure scale on the scan. Once they have finished, they consult the report that has been generated by speech recognition software in the reporting window for typographical errors and mis-translated words. Any mistakes are corrected by highlighting the word with the computer mouse and speaking the replacement into the dictaphone. The report should then be finally proofread, signed by the practitioner, and sent off via the Radiology Information System. The process then repeats.

4.2.2 Speech Recognition and Interaction. Often, when the practitioner is actively reporting, their focus will be split between the study in front of them and the report being translated from speech to text. We observed that the gaze of the practitioner frequently moves across all three screens, and often when a longer clinical statement is being made the focus will be entirely on the report waiting for the speech recognition software to "catch up". When queried about this, P7 bemoaned the quality of the speech recognition software, calling it "daft"; "If its going to leave a word out, it'll always be the most important one". In the same session, we saw that the system frequently recorded the words "in changed" instead of "unchanged". This could present a serious error if not caught during the proofreading stages, implying that the reason the focus is often split between the study and the report is to provide a greater level of security to the user that their mistakes are being caught. Similarly, we observed P7 utilising an extra function of the PACS system that gave auditory feedback in the form of a short beep when the recording button was triggered. However, we observed that the tone did not change for the recording being on and the recording being turned off. This meant that, despite activating what is designed to assist practitioners in reporting without focusing on

their reporting window, P7 would continuously be checking the screen to ensure that they had pressed the recording button in the right way. Participants would also be limited in their allowances for mistakes made by the speech recognition system – often if the system did not recognise their first attempt to verbally correct a typographical error, they would correct it by typing the word with the keyboard instead. Some participants were more forgiving with others, with P3 always giving the system 3 opportunities with the dictaphone before manually correcting whereas P8 would resort to manually typing most of their report if the system seemed to be producing errors to save time.

Another interesting outcome was that we observed 73 percent of the practitioners interacted with the speech recognition system and dictaphone with a different tone and timbre of voice, instead communicating with their dictaphones in a "hushed" and monotonous manner. Contrary to their normal speaking voices, 8 participants spoke in a voice that was considerably quieter with less tonal variation and unnatural pauses when the system was actively recording, switching back to their standard speaking voices in all other situations. This would even happen rapidly if they were interrupted e.g. if the phone rang whilst they were midway through authoring a thought, their tone would switch instantaneously. It appeared to be a conscious decision to utilise a different voice when interacting with the speech recognition interface. We classify this as a form of "Inverse Lombard Effect", drawing upon the social phenomenon that vocalised noises will shift in noisier environments. This method of interaction with the dictaphone (Voice User Interface) appears to juxtapose to existing findings in literature; previous literature investigating interaction with speech recognition and automated systems would suggest that participants should *hyper* articulate and offer simpler terms in an attempt to get the system to recognise them properly [33], [34], [35], [36], [37], [38]. Whilst offering a simplified clinical opinion is impossible for a practitioner working with a specfic and codified medical lexicon, we did not experience participants speaking slower, louder or with more emphasis on consonants as would be expected. Whilst 1 participant claimed they were unaware of their voice changing at all (P2), some participants offered explanations that seemed to be informed by personal experience or discussion with peers, such as it just works better when I do that ($_{\text{P5) and}}$ The dictaphone doesn't like noise, that can mess with it, so you try to get it really close to you $^{\text{(P3).}}$

Two participants who demonstrated this phenomenon wore headphones with music playing whilst reporting, and proffered that they do not notice if their voice changes due to the presence of other noises. However, it was noticeable that P1 wore headphones with loud music playing and P6 regularly kept the dictaphone far away from their face and down by the desk top – both did not change their voice between reporting and conversations, and did not seem to experience great difficulty with their speech recognition systems.

4.2.3 Internal and External Communication. Practitioners would mostly utilise the internal PACS system to send off reports, but also had a myriad of other methods of communicating with peers and patients. Microsoft Teams, WhatsApp, Outlook, the internal telephones, mobile phone calls to personal lines, the PACS instant messaging services, writing notes with pen and paper and physically leaving the office to find the relevant physician were all methods utilised to either ask for assistance from other practitioners or to query results. It was noticeable that at the 1st Health Board participants seemed to switch between these channels of communication depending on who they were trying to communicate with - when attempting to get in touch with more senior colleagues, they would utilise the telephone or email, whereas for peers they would prefer to use instant messaging systems such as WhatsApp and Teams. At the 2nd Health Board, we was informed by P9 that they had undergone training to learn how to use the inbuilt messaging system in the PACS system to communicate internally amongst the department but "It's not very good, we'd rather just try and chat through WhatsApp or text if we're trying to find each other" (P9).

The ability to rapidly get in touch with another member of the department or a referring clinician seemed to be of the highest priority, but there was not a structured system in place. In one instance, P6 found an actionable finding in a medical study and tried to get in touch with the physician who had requested the original scan – they first attempted to do so by calling the physician's local health board's switchboard to ask to be connected. This in itself took roughly 5 minutes of waiting, during which time P6 was not looking at any other studies or authoring any other reports. When the switchboard answered, they informed P6 that they were unable to connect them to the physician. P6 then used a 3rd party search engine to find the physician's contact details and left them a voicemail. This whole interaction took over 10 minutes and was the result of having an unclear line of communication with the person who requested a

clinical opinion.

4.2.4 Interrupted Activity. We also found that participants suffered from considerable interruptions when working. Here, we define "interruption" as any factor or event caused by another person that stops the participant from continuing the task they are currently working on. Common interruptions included a peer reporter calling on the telephone and or coming into the office to ask for a clinical opinion or present a high priority case, colleagues asking for patient details via an instant messaging service, other physicians calling or emailing to ask on updates for one of their referrals, junior members of staff asking for help and casual interruptions to discuss personal or leisure matters. For phone calls and instant messages, it would often be up to the participants discretion when they addressed the notification. However, it was noted "We're told to answer the phone as quickly as we can because some times it can be very important, but we don't know until we've picked it up. That can be annoying when its ringing all the time" (P2).

When faced with an in-person interruption, participants would remove headphones (if they were wearing them) and actively face away from the report on which they were working on to focus on the interruption. They would then wait until the other person had left completely to re-focus on their report. For most, this would involve re-reading the report up until the point at which they had been interrupted, reviewing the patient notes, resettling into place and repeating the last few words before re-committing to the study in question. These compounded to the extent that, in the case of P2, we counted over 20 occasions in a single session, in which they

were disturbed by an outside influence to the extent where they were unable to continue reporting. This naturally culminates in a large amount of re-focusing on the task at hand when the interruption has ended. The nature of being interrupted was recognised as inevitable by participants; "Radiologists are used to working in an environment like this, with lots of interruptions" (P7). However, as identified, the key reason these interruptions caused such a cognitive disruption is that their purpose and urgency could not be communicated without the participant halting their work entirely.

5 DISCUSSION

The overarching narrative of these results shows us that, contrary to our prior understanding of diagnostic medicine being rigid, with rules and regulations in place to ensure that every patient receives equal standards of healthcare, the radiology department is unstructured and highly personalised to every single practitioner. Interviews showed that most participants acknowledged that the way in which they author reports is unique to them and has developed over time, and the ways in which they communicate results to other practitioners in the hospital is dependent on personal preference and tacit knowledge of the colleague they are trying to communicate to.

5.1 Methodology Implications

By having a focus on Work As Done, we have been able to highlight aspects of interaction and communication that would not have previously been seen; with more procedural activities such as interfacing with their speech recognition system to author reports, practitioners adopt different aspects of speech to alter their tone, volume and cadence. This is something that may not arise in the original testing and design of a tool, and as such may have either positive or negative affects on the end accuracy of the report. As it is not a taught behaviour but is instead learned through experiences, there are few ways of testing the "folk theory" against the claims made by participants, and is similarly only discovered through using alternative research methods through the lens of ethnomethodology. As highlighted, there are beliefs regarding these complex systems that have evolved with use over time: It works better when I do that. The key implication of these findings is that digital systems and medical tools need to be adaptive, and designed with an environment in mind that is unstructured and idiosyncratic, dependent on the user and their individual training.

5.2 Cultural Separation

One particular aspect that arose between both self-identification and observation was the cultural separation between diagnostic medicine and administrative medicine; not only are there physical barriers between the departments that inhibit peer to peer communication, but there seems to be a radiological culture surrounding the nature of constructing reports and communicating opinions and results to non-radiologists. Terms such as "gatekeeper" were identified by participants to describe how they felt in relation to other fields of healthcare, and radiologists have their own lexicon for diagnostic imaging that mean they are distinct from other disciplines. This means that interactive systems and tools for communicating findings should take into account that there is an element of intercultural communication happening that does not exist across other medical borders [25]. This study has demonstrated that there is a distinct lack of standardisation in the way that clinical opinions are authored and communicated to peers, superiors and referring physicians.

5.3 Move Towards Standardisation

Accounting for this lack of structure, we believe that this study has demonstrated the necessity for an updated framework that addresses implementation and evaluation of technology. Standardisation would work to reduce the cognitive issue of in-the-moment decisions of how best to communicate an actionable finding with referring clinicians, as well as easing the load of the receiver of reports - they would know what is coming, where from, and what it will look like. Whilst we acknowledge the dynamic and personalised nature of technical communication in medical environments, these factors need to be made clear from a design and evaluation standpoint. This framework should include guidance for more consistent use of terminology, restrictions and enhancement of required communication methods and the establishment of training for the proper use of Voice-User Interface technology. The resulting framework would then be subjected to regular audits of effectiveness and efficiency through methods akin to what has been carried out in this paper.

5.4 Limitations and Future Work

This work is naturally limited by small sample size and the data gathering techniques that were available. We have already mentioned that we had to utilise fieldnotes, and it is recognised that, in healthcare-based research, domain experts can be difficult to engage with on account of a busy schedule and ethical limitations regarding access to sensitive data. In this study, we had to find a balance between longitude and pragmatism, and were limited by the number of participants that were willing to engage with us [31]. As such, we recognise that many of our findings may be specific to the NHS, but nevertheless display in this context that there are differences between Work As Imagined and Work As Done. Future work in this domain would ideally identify laboratory based studies for the findings that we have identified such as quantifying practitioners vocal modulations in a way that can be statistically analysed, and examining the effects on an interruption on report quality. The use of a controlled environment and video recordings would allow us to more accurately describe the phenomenon we have described in this paper.

6 CONCLUSIONS

This paper has presented a "slice of life" of interactivity and communication methods in radiology departments. By collecting 35 hours of observational data and conducting 12 structured interviews, we were able to garner a deep and naturalistic insight into the behaviours and habits of radiology practitioners, and by utilising an ethnomethodological lens when analysing this data we have revealed a significant level of variance and unique behaviour to each individual participant. However, we have also shown that there are common themes that arise amongst the whole department

that demonstrate a difference between an idealistic "Work As Imagined" to a more pragmatic "Work As Done"; the implementation of real-time speech recognition software has resulted in a split focus for the practitioner, and the frequent inaccuracies associated with this software has lead to an adoption of a voice modulation when interacting with it. In addition, the rise of instant messaging channels has meant that the practitioner now has a myriad of choices at their disposal with how they may choose to communicate a patients results, leading to a tacit context-dependent choice each and every time there may be a clinical question that requires answering.

We propose a framework intended to address these findings and ensure that the radiology department maintains a high level of efficiency and practice – methods of communicating results to peers and patients should be codified, and guidelines for interacting with clinical technology should be more heavily investigated. A more structured approach to evaluation and implementation of digital systems could benefit practitioners in safety critical environments by introducing standardisation to a personalised discipline.

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A APPENDICES

Interview Questions

(1) Do You Understand What This Study Is About?
(2) How Long Have You Been Practicing In This Field?
(3) Where Did You Train?
(4) What Modality Of Radiology Are You In?
(5) How Do You Write Reports?
(6) How Do You Percieve Radiology In Relation To Other Fields Of Healthcare?
(7) Do You Have Any Questions Before The Study Commences?