Exploring patients' experience of viewing their own 3D medical imaging results during a clinical consultation

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Declaration

This thesis is submitted to the University of Warwick in support of my application for the degree of Doctor of Philosophy. It has been composed by myself and has not been submitted in any previous application for any degree. The work presented (including data collection and data analysis) was carried out by the author.

Part of this thesis has been published by the author (reference below).

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List of abbreviations

2D Images	Two-dimensional Medical Images
3D Images	Three-dimensional Medical Images
AN	Avascular Necrosis
ANOVA	Analysis of Variance
CAD	Computer Aided Detection
CT	Computed Tomography
FAI	Femoral Acetabular Impingement
FDA	US Food and Drug Administration
IPDAS	International Patient Decision Aids Standards
MIPS	Medical Interaction Process System
MDT	Multidisciplinary Team Meeting
MOT	Multiple Object Tracking
MRI	Magnetic Resonance Imaging
NICE	National Institute of Health and Care Excellence
NHS	National Health Service
NMR	Nuclear Magnetic Resonance
PET- CT	Positron Emission Tomography – Computed Tomography
RIAS	Roter Interaction Analysis System
SUFE	Slipped Upper Femoral Epiphysis
UHCW	University Hospital Coventry and Warwickshire
UV	Ultraviolet

Abstract

Background: Patients can struggle to comprehend and recall medical information, hindering their ability to participate in their own care. Research suggests that images may aid comprehension of medical information. Available for use in clinical practice, 3D medical images are relatively easy to interpret and could benefit lay people. However, little is known about patients' experience of viewing them.

Aim: The aim was to understand the role of a patient's own 3D image in a clinical consultation. Four objectives were explored, to: (i) understand the impact for patients viewing their 3D image; (ii) understand how 3D images are incorporated into consultations; (iii) compare the experience of viewing 3D images, 2D images and no image alongside a diagnosis and (iv) understand whether informing participants of the occurrence of errors within image interpretation affects their trust in a diagnosis.

Methods: A multi-method approach was adopted. Fourteen patients and four clinicians from a tertiary care orthopaedic outpatient clinic participated in semi-structured interviews and 10 clinical consultations were video-recorded. Additionally, 31 volunteers participated in focus groups and 252 volunteers participated in psychology laboratory experiments.

Results: Patients considered their 3D images to be evidence, describing them to be truthful and authoritative. 3D images were used to explain diagnoses and treatments to patients during consultations. Participants showed better recall of the diagnosis when it was accompanied by 3D and 2D images compared to no image. Additionally, participants reported greater understanding and trust when the diagnosis was accompanied by 3D images compared to 2D images or no image. There was no significant difference in trust between participants who were informed of the potential for error within image interpretation and those who were not.

Conclusion: Patients trust 3D images, perceiving them to provide authoritative knowledge. They may be a powerful resource for patients, increasing patient understanding, trust, and recall.

Introduction

Preface

The nature of the ideal doctor- patient relationship has progressed from the paternalistic model that was dominant thirty years ago (Kaba & Sooriakumaran, 2007). In many western countries, patients are increasingly encouraged to participate in their own care and make decisions about their treatment (Forster & Gabe, 2008). To achieve this, patients are required to recall and comprehend the information they are given by healthcare professionals during their consultation (Selic *et al.*, 2011). Their ability to do this can be impaired by a variety of factors including: the healthcare professional's communication style (Wiener *et al.*, 2013), their own educational level (McCarthy *et al.*, 2012; Selic *et al.*, 2011) and by their levels of anxiety (Kessels, 2003; Shapiro *et al.*, 1992). Strategies to improve patient understanding of medical information have been sought. The use of images (for example pictures, photographs and medical images) to accompany verbal or written medical information is one strategy which has been adopted by some healthcare professionals. (Carlin *et al.*, 2014; Gibbons *et al.*, 2005; Houts *et al.*, 2006; Shahab *et al.*, 2007; Vilallonga *et al.*, 2012; Wiener *et al.*, 2013).

Overall aim

The overall aim of this thesis was to understand the role of a patient's own 3D image in a clinical consultation. A multi-method approach was used, comprising four separate studies.

Objectives

The research objectives are to:

1) Explore the impact of a patient's own 3D medical image (3D image) when shown to the patient in a clinical consultation, from the perspective of the patient, clinician, an observer (the researcher who observed and video-recorded

consultations) and lay participants (volunteers who viewed 3D images while participating in focus groups). This objective aimed to learn:

   a. Are there benefits for patients of viewing their own imaging results?
   b. Are there concerns about the practice of sharing images with patients?
   c. In which (if any) circumstances should images be shown to patients?

2) Understand how 3D images can be incorporated into patient centred consultations?
3) Compare the experience of viewing 3D images alongside a diagnosis to viewing 2D medical images (2D images) or no image alongside a diagnosis?
4) Understand whether informing participants of the occurrence of errors within image interpretation and the ability to manipulate medical images affects their trust in the diagnosis or how accurate they perceive the diagnosis to be.

Studies one and three will use qualitative methods to meet objective one. Study one will use an orthopaedic outpatient clinic as a case study while study three will use lay participants to gain a wider perspective. Using predominantly quantitative methods, study two will seek to address the second research objective, again using data collected from an orthopaedic outpatient clinic case study. Qualitative data will also be integrated with the quantitative results in study two to better understand the findings. Objectives three and four will be addressed through study four which will use lay participants as volunteers and adopt a quantitative, experimental design. These research objectives will be broken down into research questions within the individual studies. The first three objectives were set out at the inception of the project. The fourth research objective was developed during the course of the project. This objective, as investigated in study four, was based upon the findings of studies one and three.

Structure of the thesis

This thesis has seven chapters presented in three parts. Part one (Chapters One and Two) presents the background to the thesis. Chapter One introduces the theoretical perspectives that underpin the research and will introduce medical imaging to the reader. Chapter Two discusses relevant research literature to outline the rationale for the study. Part two (Chapters Three, Four, Five and Six) describes and discusses four research studies conducted for this research project. Each chapter in part two describes one research study and includes background, method, results and discussion sections. Figure 1 demonstrates the relationship between the four studies comprising this thesis. Part three (Chapter Seven) syntheses the results of the four studies and discusses the relevance of the results to clinical practice. Chapter Seven also reflects on the strengths and limitations of the work undertaken for this thesis and indicates areas for future research. Research materials can be found in the Appendix at the end of the thesis.

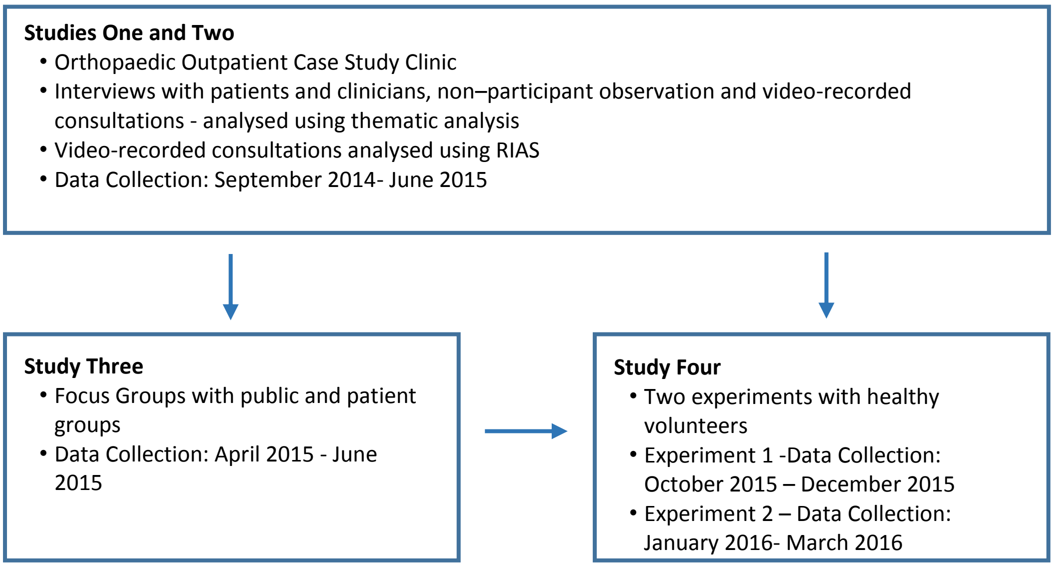

Figure 1: A diagram to show how the four studies comprising this research project fit together.

Studies one and two were conducted concurrently using the same orthopaedic outpatient clinic as a case study. Early analysis of interview data collected in study one revealed the need to explore the experience of viewing 3D medical images from a wider perspective and this lead to the design of study three. Study four, conducted last was informed by the findings of studies one and three.

Part One

Chapter One: Background

This chapter, comprising three sections, introduces the epistemological frameworks that underpin this research project. The reader will also be given an introduction to medical imaging which outlines different imaging techniques and their uses. This section will conclude with reflections on the researcher's time observing practices within a radiology department, multidisciplinary team meetings (MDT) and outpatient clinics.

1.1. Epistemological position

This project comprising four separate studies draws on both qualitative and quantitative methods. Studies one and three adopt qualitative methodologies, specifically semi-structured interviews, focus groups and observations, while studies two and four are primarily quantitative. Within study two, however, a mixed method approach will be included to integrate quantitative findings from study two with qualitative results from study one. Due to differences in study design, two epistemological frameworks will underpin this thesis. For the qualitative aspects of the research (studies one and three), an interpretivist epistemology drawing upon elements of phenomenology will be taken, while the quantitative studies will be underpinned by a post-positivist standpoint. Epistemology, that is the theory of knowledge, is concerned with what is knowledge and what can be known? These questions are crucial to social research and guide the methodologies adopted by researchers and their discussion of the results. Interpretive epistemology assumes that the study of social objects and the social world differs from the study of the natural word and argues that this difference should be acknowledged through the application of different, appropriate theoretical perspectives and research methodologies (Bryman, 2012). Natural science focuses on providing an explanation of the objects or environments it studies and generates rules and predictions that can be tested. In contrast, the application of predictions and rules to human behaviour is argued by interpretivists to be inappropriate as individuals frequently deviate from expectation and are not governed by an 'external force' (Bryman, 2012 p.30). As a result of this, interpretivists seek to understand human behaviour and social reality rather than focusing on explaining it. A post-positivist approach, in contrast to interpretivism, seeks to explain social reality but acknowledges that only a partially objective account of the world can be achieved. These two epistemologies were chosen (interpretivism and post-positivism) as the nature of knowledge generated by these approaches will most readily address the research questions. Interpretivism and post- positivism positions will now be discussed in turn.

1.1.1. Interpretive epistemology

Interpretive epistemology seeks to understand individual accounts of the social world, believing that there are multiple subjective realities constructed by the individuals that interact with and exist within it. These realities reflect individual experiences and an individual's understanding of their experience. (Stayt, 2012) Interpretivists propose that within the social world a given phenomenon cannot be explained through one truth; instead, there are multiple truths through which a phenomenon is understood. Interpretivists argue that it is inappropriate to apply rules and predictions to human behaviour as individuals often deviate from expectations. This is in contrast to a positivist position, which is frequently applied to the study of the natural world and focuses on generating rules and predictions to explain rather than understand phenomena.

As this research sought to understand both patients' individual experiences of viewing their own 3D images and healthy participants' experiences of viewing medical images, an interpretative epistemology was chosen. Qualitative methods underpinned by an interpretivist epistemology allowed an in depth understanding of the participants' individual experiences and allowed participants to describe their experiences and beliefs about medical images in their own words (Neuman, 2003).

For patients recruited to study one, viewing their own individualised medical images was a personal experience, significant to them and it is unlikely that all patients would experience viewing their own images in the same way. For this reason, gaining subjective, individual accounts is important.

Interpretivist epistemology is particularly valuable to exploratory research such as this study. At present, little is known about patients' experiences of viewing their own 3D images. It would therefore be inappropriate to attempt to explain or predict patients' responses using quantitative methods. Quantitative methods are likely to ignore aspects of a patient's experience not considered by the researcher and could hinder the researcher's ability to understand the patients experience in depth. Gaining insight into the subjective experience of participants is an advantage of the methods associated with interpretative epistemology. Concepts drawn from subjective accounts can be used to further study of the phenomena. For example, interpretative interviews could highlight common concerns that individuals may experience. These concerns could be further investigated through a deductive, possibly quantitative study to gain greater knowledge of the frequency in which they occur and if they continue to occur in differing populations.

This research adopts a Heideggerian phenomenological perspective. Phenomenology, established by Edmund Husserl (1859-1939), is interested in peoples understanding of their lives and their social interactions and the meanings that they attribute to them (Burke Draucker, 1999; Rapport, 2005). Heidegger furthered existing thought on phenomenology through his emphasis on the significance of history. He argued that it is through history that we know the world and the everyday practices with in it (Rapport, 2005). It is this knowledge, he suggested, that allows individuals to ascribe meaning to their world (Crotty, 1998).

Heidegger argues that much of everyday life does not require conscious awareness and is instead reliant upon practiced skills and knowledge of the world (Crotty, 1998). Through knowledge of our social world and by using the skills learnt over time, actions are performed in everyday life without conscious awareness (Crotty, 1998). Heideggerian phenomenology focuses on being and the experience of being within the social world (Burke Draucker, 1999). Individuals are required to adapt constantly to changes in their environment and may be required to find new meanings in their world (Burke Draucker, 1999).

Heideggerian phenomenology also argues that humans are inseparable from the social world as their experiences take place within it (Burke Draucker, 1999). Researchers are part of the social world and have their own history and knowledge of it (Crotty, 1998). Therefore when studying the social world they are unable to detach themselves from it as they cannot detach themselves from their own experience or history (Ferguson, 2006). As a result of this, Heideggerian phenomenology acknowledges the researcher's presuppositions, with data collected using this approach reflecting the researcher's interpretation of the participants' interpretation (Inglis & Thorpe, 2012). The goal of Heideggerian phenomenology is to produce an understanding of the phenomena based upon a convergence of ideas. This includes placing the participants' interpretation of their experience within the context of existing literature within the field and the preconceptions and knowledge of the researcher (Inglis & Thorpe, 2012).

A Heideggerian phenomenological approach was selected for this study. This was because the notion of being, particularly in a changing world, is important to the lives of patients. Patients often experience some degree of change because of their symptoms or diagnosis. Their world and their role within it could change considerably because of their condition and it may continue to change as they undergo treatment and recovery. They may be required to find new meanings in their life, making sense of an aspect that has previously been unknown. The emphasis on being and historicity is important to this study as the meaning that participants reveal is likely to reflect a snapshot of their reality and reflect their interpretation of their situation at a unique but also significant time. Furthermore, the acknowledgement by Heideggerian phenomenology that individuals, including researchers, are unable to separate themselves from their social world is important. Within this study, the researcher's past experience could result in preconceptions. These experiences, for example, include previous research experience addressing health behaviour; personal experience of health services; academic study; knowledge of the existing research literature within the area and extensive observations in a radiology department and outpatient clinics. These experiences all contribute to preconceptions and ideas that may influence the interpretation of the data.

Reflection on the researcher's own bias is an important aspect of Heideggerian phenomenology. While conducting the research the researcher is continuing to participate in the social world and is interacting with participants. The researcher is also unable to remove themselves from their history and experience while analysing data. Transparency and reflexivity within the research process are ways in which the challenges associated with bias introduced by the researcher can be managed (Burke Draucker, 1999).

Phenomenology, along with most other theoretical perspectives and methodologies underpinned by interpretive epistemology, focuses on individuality and subjective understandings of a phenomena rather than seeking generalisable findings and conclusions. Researchers should not seek to draw conclusions that they can generalise to other populations but instead use the data to examine common meanings that individuals attribute to the phenomena they encounter. These meanings can be used as a guide for further research or review of practices. Research seeking generalisable findings is typically judged upon the validity and reliability of the results; that is, is the researcher measuring what they think they are measuring and if they measured it again would they generate the same results? (Bryman, 2012). Validity and reliability are inappropriate criteria to evaluate qualitative work, underpinned by interpretivist epistemology. Therefore, alternative tools have been proposed (Bryman, 2012). Yardley's (2000) criteria include consideration of four factors: sensitivity to context, commitment and rigour, transparency and coherence, and impact and importance (Yardley, 2000). These criteria will be discussed in relation to the qualitative findings of this research project in Chapter Seven.

1.1.2. Post-positivism

Post positivism rose to prominence in the 1970s, challenging some of the criticism faced by the positivist epistemological paradigm (O'Reilly & Kiyimba, 2015). Post-positivism, in a sense, begins to bridge the gap between positivist and interpretivist epistemologies and is appropriate for use with qualitative as well as quantitative research methods (Clark, 1998). Positivism and post-positivism favour empirical methods including the manipulation of variables, experimental designs and statistical analysis where the researcher and the object of study tend to be detached (Corbetta, 2003). Post-positivism, however, does not consider the researcher and their perceptions to be completely detached, recognising the researcher's personal involvement and the interpretative nature of research processes (Corbetta, 2003).

Similar to positivism, post-positivism proposes that there is one singular reality – a world that exists independently of our awareness of it. However, unlike positivism, post-positivism claims that the whole reality or the truth can never really be captured (Kennedy & Lingard, 2006). Through research, the truth can be approached but not proven. The existence of unobservable factors is acknowledged by post-positivism and these, for example, may explain phenomena observed in the social world. Furthermore, self-reporting is also acknowledged as evidence by the post-positivist paradigm (Corbetta, 2003).

Post-positivists emphasise the notion of falsification and the provisional nature of scientific theory (O'Reilly & Kiyimba, 2015). They highlight that research has been proven false, demonstrating that the results from empirical research cannot be an absolute truth (O'Reilly & Kiyimba, 2015). Post-positivists argue that data cannot positively confirm a theory. Instead, researchers should seek to falsify hypotheses, with post-positivists claiming that if a hypothesis withstands multiple attempts at falsification then the results can be interpreted with confidence (O'Reilly & Kiyimba, 2015).

A post-positivist approach was deemed most appropriate for studies two and four. Studies two and four sought to test hypotheses about the content of orthopaedic clinical consultations and the experience of viewing medical images in a simulated clinical consultation, respectively. Study four sought to falsify the null hypotheses, acknowledging that the alternative hypothesis cannot be proven nor an absolute truth discovered. This epistemological position was also favoured due to its recognition of the researcher's interpretation within the research process. For example, in designing the studies, collecting, and analysing the data, the researcher may be influenced by their existing knowledge.

1.2. An introduction to medical imaging

Since the discovery of X-rays by Wilhelm Rontgen in November 1895, Radiology has become one of the most valuable tools for diagnosing disease or injury and planning and evaluating treatments (Porter, 1997). Vast technological and IT developments have led to increasingly advanced methods of imaging including: Computerised Tomography (CT); Magnetic Resonance Imaging (MRI) and Positron Emission Tomography- Computerised Tomography (PET-CT) (McRobbie *et al.*, 2007). From these developments the potential to generate 3D images creating an extremely detailed representation of the human body, depicting organs, bones, tissue and vessels and how they intertwine and relate to one another has emerged (Harvard Medical School, 2014). This section will describe the following medical imaging modalities: X-ray, CT, MRI, Ultrasound and Endoscopic imaging; along with their uses before introducing 3D images.

1.2.1. X-Ray

Rontgen's accidental discovery of X-rays occurred whilst he was testing cathode rays in a darkened room. He observed that the cardboard tube containing the cathode ray projected a faint green colour onto his fluorescent screen, which could pass through a variety of materials and was only completely barred by lead. When experimenting to see whether the rays could pass through lead he saw the shadow of his hand with his bones visible on the screen (Porter, 1997).

The introduction of X-rays was met with eagerness and interest, with the potential for use within medicine quickly explored (Porter, 1997). The first clinical radiograph was taken in January 1896, just a few months after Rontgen's discovery (Porter, 1997). X-rays were initially used to look at bones and diagnose fractures but their utility soon increased and they quickly became tools for diagnosing gallstones and locating foreign bodies (Porter, 1997). Today, their use is still widespread with over 22.6 million X-ray examinations taken in the United Kingdom in the year 2012- 2013 (Office for National Statistics, 2013). Their use today includes examining bone growth, fractures and breaks; identifying osteoporosis by inspecting the thinning and weakening of bones; identifying bone infections and bone cancers as well as aiding diagnosis of heart and lung conditions (National Health Service, 2013b).

Traditional X-rays using X-ray sensitive films produce only 2D images. X-rays capture internal structures by measuring density. These measurements are then mapped to create an image of the area under investigation (National Health Service, 2013b). During an X-ray examination, the X-ray machine transmits X-rays through the body. Photons, energy particles from the X-rays, are absorbed at different rates depending on the density of the area of the body they are passing through. A camera records the absorption rate of all the photons that pass all the way through the body (National Health Service, 2013b). Hard materials such as bones absorb photons well in comparison to soft tissues that do not absorb X-ray photons well. These soft materials appear black or grey on the image generated from the X-ray data whilst denser materials appear white (National Health Service, 2013b).

1.2.2. Computed Tomography (CT)

In 1971, the first CT scan used in clinical practice was taken to image the brain (Duffin, 2000). A CT scanner, developed in the late 1960s by Sir Godfrey Hounsfield, is a machine that is used to create a detailed representation of a specific area of the body by taking numerous X-rays of different cross sections (McRobbie et al., 2007). The individual X-ray images are often referred to as slices of the body, which when stacked together can provided an extremely detailed picture. Advances in technology have allowed the option of extremely thin slices measuring 2mm (Banerjee, 2006). This can aid detection of abnormalities that are exceptionally small or are in locations that could be easily hidden in a larger slice. The CT scanners offer higher contrast and greater detail, particularly of structures within the body such as bones, blood vessels and tumours, than any existing forms of imaging (National Health Service, 2013c). CT, widely used today, is a fundamental tool for the diagnosis of many conditions (National Health Service, 2013c).

CT scans are used routinely to examine and detect a range of abnormalities. CT scans are frequently used to examine the head and brain, abdomen, bones and vascular system. They are also used extensively within oncology (National Health Service, 2013c). Head scans are used to examine the brain for bleeding or swelling; to check for suspected tumours and to study the brain after a stroke (National Health Service, 2013c). Abdominal CT scans can be used to detect tumours within the internal organs or to diagnose diseases that cause the internal organs to become inflamed (National Health Service, 2013c). Additionally, abdominal CT scans are used to look for internal bleeding or injury after a trauma. Bone CT scans allow examination of injuries or disease to the bones, particularly the spine, whilst vascular CT scans aid the assessment of blood flow within the body (National Health Service, 2013c). Within oncology, CT scans are used for diagnosis, treatment planning and evaluation and follow up (National Cancer Institute, 2013). Within diagnosis, CT scans are used to detect the growth of abnormal cells; to diagnose the presence of a tumour and to provide information that aids the staging of tumours. CT scans used to aid treatments within oncology can guide where to perform interventions such as biopsies; guide local treatments, such as cryotherapy, and can inform surgical planning and radiation therapy. CT scans are also used to evaluate treatments by monitoring whether the cancer has responded to treatment and within patient follow up they are used to detect the recurrence of tumours. Additionally, CT scans have been found to be effective in screening for certain cancers including lung and colorectal cancers (National Cancer Institute, 2013).

CT exams tend to be short, usually lasting between the length of a breath hold and no longer than ten minutes, depending on the areas of the body being studied (National Health Service, 2013c). This is imperative for trauma patients who are often unable to lie in a scanner for a greater period without needing medical attention or have injuries so severe that information must be generated extremely quickly. This can also be of benefit to other patients as well, as the majority of medical imaging tests require the patient to remain as still as possible to prevent the images from becoming blurred. This can be uncomfortable or difficult for prolonged periods.

Both X-rays and CT use small amounts of ionising radiation. Exposure to radiation can cause damage to cells and slightly increase cancer risk (National Health Service, 2013a). People are exposed to small amounts of ionising radiation every day as radioactive material exists naturally within the environment (National Health Service, 2013a). CT scans in particular expose patients to more radiation than the majority of other imaging tests. The amount of radiation varies depending on the type of test required. A whole body scan, for example, exposes the body to an amount of radiation that is equivalent to four and a half years of background radiation (National Health Service, 2013a). Due to the exposure of radiation from the X-rays, pregnant women and children are only referred for CT scans in extreme cases. This is because children are at increased risk of radiation build up and because radiation could cause harm to the foetus (National Health Service, 2013a). Before being referred for a CT scan, the referring clinician will considered the potential benefits in relation to the possible risk and the staff within the X-ray department will review the request. Although the exposure to radiation does pose some risk to patients, the benefits of being able to detect and diagnose a condition in symptomatic patients will usually outweigh this greatly (National Health Service, 2013a).

1.2.3. Magnetic Resonance Imaging (MRI)

MRI is frequently portrayed as the "gold standard" imaging technique, fundamental for truthful diagnosis (Joyce, 2008). It provides greater contrast between tissues than other imaging methods such as X-ray and ultrasound (McRobbie *et al.*, 2007)

MRI creates images that reflect the activity of hydrogen atoms within the body, which are altered by using magnetic fields and radio waves. Radio waves are transmitted through the body and are absorbed by the nuclei of hydrogen atoms. This causes them to rotate and align with the magnetic field. The new positions of the atoms are recorded along with their relaxation time - the time taken for the atoms to realign to their original positions (National Health Service, 2013d). As they realign the atoms release a radio signal of their own. A large proportion of tissues within the body are made up of at least 70% water (McRobbie et al.., 2007) When a tissue is diseased the amount of water is often altered substantially and as a result of this the presence of hydrogen atoms, which along with oxygen make up water, is altered too. MRI is therefore a very sensitive method of detecting diseased tissues (McRobbie et al., 2007).

Nuclear Magnetic Resonance (NMR), as MRI was previously labelled, emerged in the 1930s. Isidor Rabi observed and explained how the different atoms rotated when subjected to magnetic fields (Bharath, 2009). NMR was initially used within chemistry to examine the structures of different molecules but was soon applied to medical diagnosis after Raymond Vahan Damadian observed that non-cancerous and cancerous tissues can be identified based on their relaxation times (Joyce, 2008). The technique was introduced into clinical practice in the 1970s with the first full body scan taken in 1977 (Bharath, 2009). Soon after, the name was changed from NMR to MRI. This was due to the strong negative connotations of the word 'nuclear' that made the public wary of the technique (Joyce, 2008).

MRI is used to examine the brain and the spinal cord; the heart and blood vessels; internal organs; bones and joints and the unborn foetus in pregnancy (National Health Service, 2013d). MRI can be used to study the entire body or to focus on an extremely specific area. The use of MRI is continuing to expand. Not only is MRI a widely used tool for diagnosis, it is becoming increasingly used: in surgical planning; to guide interventions and to plan and monitor treatments such as radiotherapy and chemotherapy (National Health Service, 2013d). The value of MRI as an alternative to autopsy is also being explored as the utility of the technology is furthered.

1.2.4. Ultrasound

In the 1950s ultrasound was developed for use within medicine. It was based on Sound Navigation and Ranging (SONAR) techniques used during World War Two for navigation, communication and detection of other vessels or objects underwater (McRobbie *et al.*, 2007). The technique involves emitting waves of sound then listening and recording the echoes. At the time of introduction, ultrasound was the first imaging technique to offer a safe, non-invasive method of imaging. This is due to the use of sound waves as opposed to ionising radiation (McRobbie et al., 2007). Ultrasound images can be presented in real-time and can demonstrate movement such as blood flow (McRobbie et al., 2007).

Ultrasound has a variety of uses including examination of the kidney, liver, abdomen and heart. Ultrasound of the heart can be used to study blood flow and examine the structure of the heart’s vessels and chambers (National Health Service, 2014b). Ultrasound is also used during procedures as it can produce real -time images, allowing the clinician performing the procedure to see, through the ultrasound image, the results of their actions and the location of their instruments within the patient. Ultrasound can be used to guide minimally invasive procedures. One example is ultrasound guided lung biopsy, where a small sample of cells is taken from a tumour for further examination under microscope (Cancer Research UK, 2014). During this procedure, a needle is inserted through the skin and muscle in the chest to the lung and a small sample of cells removed with a syringe. Ultrasound images are used to ensure the location of the tip of the needle is accurate and inserted into the tumour (Cancer Research UK, 2014). Ultrasound of the foetus during pregnancy (foetal ultrasound as referred to from here on) is offered routinely, with most women offered two scans (National Health Service, 2014b). The first is offered between eight and 14 weeks, and is a dating scan used to confirm and date the pregnancy, giving expectant mothers an estimated due date. The second routine scan during pregnancy is usually offered between 18 and 21 weeks and is used to check for structural abnormalities with particular focus on monitoring the development of the head and spine (National Health Service, 2014b). Routinely, 2D ultrasound images are used but 3D and 4D foetal ultrasound images are available privately (Birmingham Women's NHS Foundation Trust, 2014; Imperial College Healthcare NHS Trust, 2014; Peek A Baby, 2014) (This will be further discussed in Chapter Two, Section Two).

In addition to the medical reasons for foetal ultrasound scans, they also have social use. During the second routine scan, expectant parents can ask to find out the sex of their baby, depending on its position in womb (National Health Service, 2014b). Foetal ultrasound scans are also argued to promote bonding between the expectant parents and the foetus, with many hospitals giving expectant parents the opportunity to take home a copy of their ultrasound images (Ji *et al.*, 2005; Roberts, 2012). Support and concerns regarding the use of ultrasound as a tool to promote bonding will be discussed further in Chapter Two, Section Two.

1.2.5. Endoscopic imaging

The imaging techniques described above are all generally non-invasive, with images generated from numerical data. Endoscopic images, on the other hand, are images of inside the human body taken with a camera (National Health Service, 2014c). An endoscope, a thin and flexible tube with a light source and camera at one end, can be used to aid diagnosis and laparoscopic surgery (National Health Service, 2014c). The endoscope is inserted into the body through either the mouth, anus or through a small incision. Endoscopy can be used to examine a range of organs within the body including: the womb, referred to as hysteroscopy; the joints, referred to as arthroscopy and the large intestine, referred to as colonoscopy (National Health Service, 2014c). During the procedure, tissues can be removed. For example, polyps - precancerous or benign growths - can be removed from the large intestine during colonoscopy (National Institute for Health and Care Excellence, 2005). Endoscopy can also be used help perform laparoscopic surgery such as an appendectomy. This allows large incisions to be avoided and reduces scarring and recovery times (National Health Service, 2014a).

1.2.6. <u>3D imaging</u>

Digitalisation has enabled the development of 3D images. Machines now have the ability to take hundreds and potentially thousands of images during one examination. Images, which were previously immutable once recorded, can now be changed and enhanced. They can be presented in colour and motion and can be manipulated to create 3D displays. 3D images are created by using the digital data of the image to, in a sense build up many 2D grey scale images. Identifying organs and normal structures in 2D grey scale images tend to be difficult for lay people without specialist radiology training. To the untrained eye, the properties of abnormalities often appear to closely resemble the properties of normal tissues (Harvard Medical School, 2014). 3D images, on the other hand, are more easily interpreted and could therefore be of benefit to both lay people and clinicians who have not specialised in radiology. They enable the viewer to visualise the relationships between different structures more easily and can be rotated to view the area of interest from different angles (as shown through the 3D CT images of a hip in Figure 2) This allows the viewer to gain a clearer picture of the desired area (Brigham and Women's Hospital, 2014a).

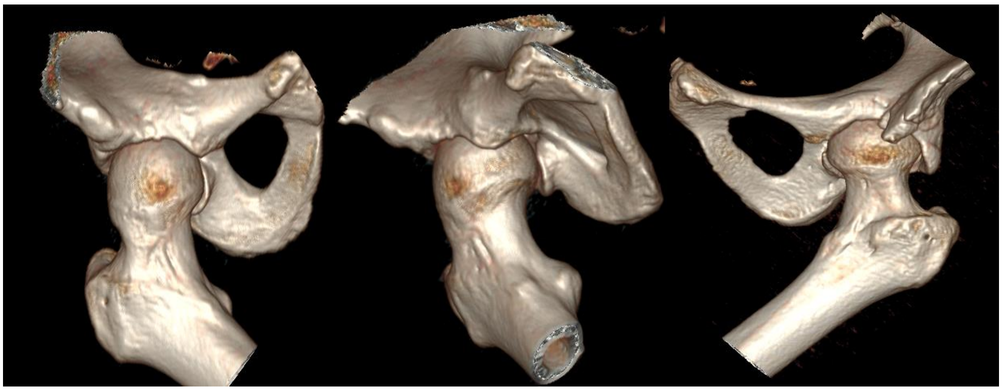

Figure 2: 3D CT images of the hip from different angels

3D images can be built up in a variety of ways to include different amounts of information. For example, the tissues surrounding an organ or blood vessels can be removed to allow the structure of interest to be more easily visualised (Harvard Medical School, 2014). This is demonstrated in Figure 3 below; with the image to the left displaying the heart and the image to the right displaying the coronary arties with the heart tissues removed.

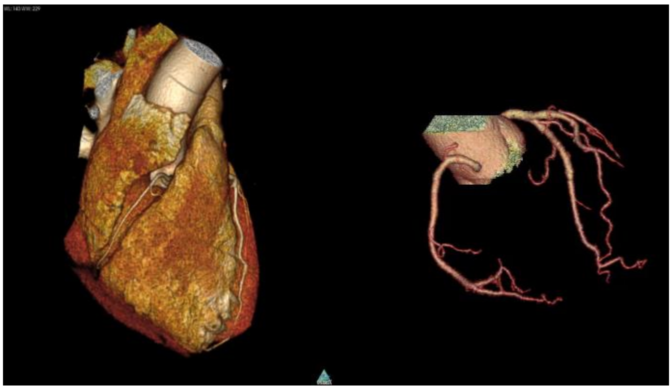

Figure 3: Still images from 3D video clips of the heart and blood vessels

3D images are availably publically, both online and through the media, and have potential for a wide range of use within medicine. 3D can be utilised within diagnostic radiology to aid the detection of abnormalities. When interpreting 2D images, radiologists scroll through stacks of 2D images, creating an internal 3D representation within their mind. 3D images can be used alongside 2D stacks of images. Rotation of 3D images for example can allow a suspicious tissue and the structures that surround it to be examined from more than one angle. Visualisation of the surrounding tissues and the relationship between a suspicious tissue and surrounding tissues can help decision-making.

In addition to these uses, 3D images are being implemented within screening. 3D mammography, known as digital breast tomosynthesis, has recently been introduced at the Brigham and Women’s hospital in Boston (Brigham and Women's Hospital, 2014b). The Brigham and Women’s Hospital, affiliated with Harvard Medical School, is a teaching institution leading research into 3D imaging technology. Initial research has indicated that

3D mammography may improve cancer detection by approximately 10% compared to 2D mammography and may reduce the number of callbacks by 30-40% (Brigham and Women's Hospital, 2014b). Virtual (CT) colonoscopy, using 3D CT images to create a detailed representation of the colon, has been approved by the National Institute for Health and Care Excellence (NICE) as an alternative to conventional colonoscopy or barium enema (National Institute for Health and Care Excellence, 2005). Colonoscopy, barium enema and virtual colonoscopy, are used to detect abnormalities such as polyps and cancer in symptomatic patients or asymptomatic patients who are considered to be at high risk of colorectal cancer. They can also be used to screen asymptomatic patients with average risk of developing colorectal cancer (National Institute for Health and Care Excellence, 2005). Virtual colonoscopy may be preferable to some patients as sedation is not required and the procedure is more comfortable and quicker (Bupa, 2014). A virtual colonoscopy is less invasive than a conventional colonoscopy as the images are created using digital data from CT scans. The digital data can be presented as still images or as a fly-through 'stereoscopic' video clip, similarly to the images gained through conventional colonoscopy (National Institute for Health and Care Excellence, 2005).

Subtle changes in size, shape and volume of an abnormality can be visualised clearly using 3D images (Harvard Medical School, 2014). This can be used to monitor disease progression and evaluate treatment effectiveness. An example of this could be to compare tumours before and during chemotherapy to see if the tumour is responding to the treatment.

They can also be used to aid treatment or surgical planning, particularly neurosurgery (Harvard Medical School, 2014). Surgeons can use 3D images to see the exact location of the abnormality in relation to surrounding blood vessels. Relationships can be more clearly visualised through 3D, especially for surgeons who will not all have radiology training. This can help surgeons to determine whether surgery is an appropriate treatment option and where applicable surgeons can use the 3D images to plan the approach they will use, bearing in mind the location of blood vessels and other structures. It is expected that the increasing use of minimally invasive procedures will be accompanied by a growing demand from surgeons for 3D images (Harvard Medical School, 2014).

There are however, some limitations to 3D image production. For hard tissues (i.e. bones), 3D images are relatively easy to produce. For soft tissues (such as blood vessels) on the other hand, contrast (i.e. a dye) may be required to produce 3D images. Additionally, if different tissues have similar density it can be difficult to separate them.

Not all 3D images will be useful for clinical decision-making but they may be useful to other audiences. At the University of Monash in Australia, the use of 3D images within medical education is currently being explored (Hare, 2013). It has been suggested that they could be used to teach anatomy and can be printed with a 3D printer to make anatomical structures. 3D printing of anatomical structures has developed to allow printing of a structure that includes tendons and tissues as well as bones (Hare, 2013). The development of 3D printed structures could bring several advantages. Firstly, they are relatively cheap to produce and could be beneficial to universities and hospitals in remote areas or developing countries (Hare, 2013). They could also be beneficial in some Asian countries where the use of human tissue is frowned upon (Hare, 2013). A further advantage of 3D printed anatomical structures is their availability. Students could have much more time with the printed structures than they would get with a human specimen and several structures based on the same imaging data can be produced. Finally, there are fewer ethical issues associated with 3D printed structures than the use of cadavers (Hare, 2013).

3D images are also used to aid clinical communication (Harvard Medical School, 2014). They can be utilised to communicate information to consultants and to patients. Radiologists can use 3D images to communicate information to referring clinicians who are unlikely to have specialist radiology training (Harvard Medical School, 2014). They are also helpful as radiologists and referring clinicians cannot always communicate face to face. The accompaniment of a 3D image, along with the radiologist's written interpretation of the 2D images, may help the clinician to better see and understand the interpretation. 3D images can also be used to communicate information to patients. They are used during orthopaedic outpatient consultations at University Hospital Coventry and Warwickshire (UHCW) (R. Wellings, personal communication, November 12 2013). Within Orthopaedics, along with several other specialities, the demand for 3D images is increasing. 3D images enable orthopaedic clinicians to better visualise fractures or bones that could cause impingement.

One hip clinic at UHCW uses 3D images to discuss diagnosis and treatment with patients (as observed by E. Phelps, December 20 2013). Patients attending this clinic often suffer from Femoral Acetabular Impingement (FAI) or hip dysplasia.

1.3. Reflections on observations in a radiology department and outpatient clinics

I undertook observations in a large teaching hospital at the start of this research project. Having only limited experience of the NHS from a patient's perspective, these observations allowed me to access everyday practices within a radiology department and outpatient clinics that I would not have otherwise been aware. These observations, therefore, were valuable in informing the study design. This section will highlight practices that I considered most noteworthy during the observations.

1.3.1. Radiology department

Within the radiology department, half a day was spent observing the following imaging modalities: X-rays, CTs, MRIs, Ultrasounds and PET-CTs. Half a day was also spent observing image interpretation and learning how to generate 3D images from the digital data from CT scans.

One thing most notable to me was how still patients were required to lie during their scans, particularly during CT and MRI scans. Stillness was required to produce clear images and was a challenge for some patients. On two occasions, language was a barrier to patients' understanding of the instructions for their scan. For example during a CT scan, patients were required to breathe in and out when instructed to by a radiographer, who gave instructions via a microphone from the next room. One patient was unable to understand these instructions, which made the scan difficult. Similarly, during an x-ray of the knee a patient whose first language was not English found it difficult to understand the position their knee should be in for the scan. While observing ultrasound guided biopsies, I noticed an additional challenge for clinicians. This was the only scan I observed where patients, the clinician and the image were all present together with the patient and clinician both able to see the image during the procedure. The clinician therefore had to be aware of how they responded to what they saw on the image so not to cause any distress to the patient. During all other imaging modalities that I observed, patients did not see their image or speak to a radiologist who could interpret their image.

1.3.2. Outpatient clinics

Several outpatient clinics were observed, specifically a cardiology clinic, a colorectal cancer clinic, and three orthopaedic clinics (a hip clinic, a knee clinic and a shoulder and elbow clinic). The focus of these observations was communication between patient and clinician, which I found to vary across the clinics. In some clinics, issues with communication were observed. For example, in two clinics, clinicians appeared to avoid answering difficult questions asked by patients. In contrast, clinicians consulting with patients in the hip clinic spoke slowly and clearly and explained everything to patients throughout the consultation (for example explaining the purpose of a physical examination when conducting it or explaining the reason behind asking a specific question). Images were shown to patients in four of the five clinics that I observed. The setup of the fifth clinic (the knee clinic) did not lend itself well to sharing images with patients as computers, which images are usually viewed on, were separate to the cubicles in which the patients met the clinician. However, some patients in this clinic were shown a model of the knee. In one clinic (the colorectal cancer clinic) diagrams were shown to patients, in two clinics (the cardiology and shoulder and elbow clinics) patients were shown 2D images and in one clinic (the hip clinic) patients were shown 2D and/or 3D images. Consultations in the colorectal cancer clinic were much shorter than consultations in the other four clinics. During one clinic session (typically half a day) for example, two clinicians had a list of approximately thirty patients to see between them. This is in contrast to the hip clinic, in which two clinicians had a list of twelve patients to see between them. The consultations in the colorectal cancer clinic typically felt more rushed. More time was made available, however, for bad news consultations within the clinic.

1.3.3. MDTs

I observed two colorectal cancer MDTs and multiple MDTs with the hip clinic. This gave me a better understanding of how diagnosis and treatment plans are reached. Clinicians presented a background including information from their patient history and physical examinations about each patient to the rest of the team before medical images were viewed and discussed.

1.4. Chapter Summary

This chapter has outlined the epistemological position underpinning this research; introduced a selection of medical imaging techniques and provided the researcher's reflections of observations of clinical practice. The next chapter will review four bodies of relevant literature, to develop the rationale for the research undertaken for this thesis.

Chapter Two: Review of relevant literature

This chapter, divided into two parts, will discuss four relevant bodies of literature. The first part will present medical imaging from two different disciplinary perspectives. First, psychology literature examining visual search performance and attention will be reviewed. This body of work has frequently been applied to the interpretation of medical imaging by radiologists. Laboratory studies are a useful method of researching clinical questions and have been used to investigate if there are ways of improving clinical practice. Second, sociological perspectives of medical imaging will be outlined. This section will begin by illustrating the rise of visualisation within society and within medicine before debating the current presentation of medical imaging within society and concerns resulting from this presentation. The second part of this chapter will present the rationale for the current study, again drawing upon two disciplinary perspectives. First, the doctor patient relationship will be explored, with barriers to effective clinical communication and the current use of medical images within consultations considered. Finally, psychological theory of visual attention will be introduced to demonstrate how the use of images may be a beneficial aid to communication.

Due to the broad range of research spanning different disciplinary perspectives relevant to the topic, no formal systematic review was undertaken. A broad literature review was conducted which comprised four relevant bodies of literature, as described above. The literature review initially focused on two areas: “images in healthcare communication” and “sociological perspectives of medical imaging”. The scope of the review was broadened in light of the literature identified. For example, further review of the literature examining the doctor-patient relationship and doctor-patient communication was used to gain a better understanding and provide context to the images in healthcare communication literature. Theories of visual attention were then considered and this highlighted two areas of importance to this thesis, the first, visual search performance and research assessing the accuracy of image interpretation (as described in section 2.1) and the second, research examining attention capacity including cross modal attention and inattentional blindness. Literature included in the review included original research and review articles, theoretical textbooks and policy and public information documents. Searches were performed on Ovid MEDLINE, Google Scholar and for relevant articles, citation searches and reference lists were searched for further studies of interest.

Part One

2.1. Medical imaging and research on accuracy of image interpretation

Experimental psychology research aims to generate theories to further understanding of human behaviour, with relevance to everyday life (Goodwin, 2008). Psychology laboratory experiments can be categorised in to one of two types of research: basic experiments or applied experiments. These have been applied to a variety of everyday contexts including visual search performance. Research addressing visual search performance is of interest as it has highlighted difficulties that radiologists may face when searching for abnormalities while interpreting medical images.

Interpreting medical images is a specialist task that can be difficult, with miss error rates (when an abnormality is not detected) estimated to be approximately 30% (Krupinski, 2010). This can have a negative impact upon care resulting in misdiagnosis or delay in treatment initiation. Over-diagnosis when analysing medical images is also a concern. If the radiologist interprets an image to be abnormal when it is not, it could lead to unnecessary tests, procedures and anxiety for the patient (Joyce, 2008; Jørgensen *et al.*, 2011; Raab & Grzybicki, 2010).

Krupinski (2010) argues that errors in visual search performance, particularly miss errors, can be categorised into three different types of errors: search errors, recognition errors and decision errors. Abnormalities may not be detected due to search errors if the radiologist never directs their gaze to the specific area on the image in which the abnormality is located (Krupinski, 2010). Recognition errors occur when the target is not strong enough to be identified as suspicious even though the radiologist directs their gaze upon it (Krupinski, 2010). Finally, decision errors can occur when the radiologist directs their gaze upon the abnormality, the target is strong enough for the radiologist to notice it and examine it but the radiologist may incorrectly conclude that it is a normal structure (Krupinski, 2010).

Factors that can hinder visual search performance and result in the types of miss error described above have been identified through psychological experimental research examining visual attention and perception. These include inattentional blindness, low prevalence searches, change blindness and satisfaction of search (Drew *et al.*, 2013; Evans *et al.*, 2013; Russell & Kunar, 2012; Simons & Levin, 1997), which will each be discussed in turn. Before concluding, this section will discuss the sensitivity and specificity of imaging tests and the role of computer aided detection (CAD) which is argued to improve visual search performance.

2.1.1. Inattentional blindness

Inattentional blindness refers to the failure to recognise noticeable events or changes if they are unexpected and occur whilst a different task is being performed (Drew *et al.*, 2013). Within radiology, this is important as when interpreting images radiologists often look for a specific set of abnormalities that relate to the symptoms reported by the patient. There could however, be an additional abnormality that elicits no symptoms that the radiologist is not looking for and inattentional blindness could cause this to be missed. Psychology experiments have emphasised the extent to which unexpected findings can be missed within radiology. Potchen (2006) instructed radiologists to review a series of chest X-rays. The clavicle (collarbone) had been removed, however approximately 60% of the radiologists reviewing the case did not notice it was missing (Potchen, 2006). Drew et al, (2013) also demonstrated the presence of inattentional blindness within radiology by giving 24 radiologists chest CT images to examine and asking them to search for pulmonary nodules. Pulmonary nodules are small solid growths; smaller than lung masses and no greater than three centimetres in size (Mayo Clinic, 2014). The majority are benign but some may be early lung cancer or metastases. The radiologists were given five chest CT scans, which contained between 100 and 500 slices. In the fifth chest CT, a small picture of a gorilla was added to five of the images. The gorilla faded into and out of visibility and was 48 times the size of the average nodule presented within the images, making it clear to detect. Of the 24 radiologists, 20 did not report seeing the gorilla when scrolling through the images looking for nodules. Furthermore, 12 of the 20 radiologists did not report seeing the gorilla despite fixating on it. All the radiologists, however, did see the gorilla easily when shown a slice in which it appeared after the experiment (Drew *et al.*, 2013). This reinforces the view that focus on a specific task can cause unexpected information to be ignored. Inattentional blindness has also been demonstrated in a clinical setting. Lum *et al.,* (2005) found that clinicians missed an unexpected guidewire in CT scans, as they did not expect it to be there. This study is discussed further in section 2.4.

2.1.2. <u>Low prevalence targets</u>

Psychological experiments have suggested that low prevalence targets, such as uncommon cancers, are much harder to detect than those that occur more frequently, especially when searching for unknown targets or when the target could be one of multiple different targets (Russell & Kunar, 2012). The challenge of visual searches for low prevalence targets has also been replicated within a clinical context, through mammography screening (Evans *et al.*, 2013). Within mammography screening, the population tested are generally healthy and those that have the disease tend to be asymptomatic, with typically only one case of cancer for every 1000 mammograms (Evans *et al.*, 2013). Evans et al, (2013) compared the rate of false negative errors in high and low prevalence targets using 14 radiologists from a large teaching hospital, with a minimum of five years' experience in breast screening. One hundred mammograms each composed with a minimum of four images were used in the study. Fifty mammograms were positive (i.e. cancer present) and the remaining 50 were negative (i.e. no cancer present). The positive images differed in terms of tumours and levels of subjectively assessed difficulty. To examine errors in a low prevalence setting (prevalence of approximately 1%) the images were added in to the radiologists' normal caseload. Each mammogram was examined once by one radiologist. This was done over a period of nine months to prevent a false increase in prevalence (Evans *et al.*, 2013). In the low prevalence search 15 of the 50 cases of cancer were missed, a false negative error rate of 30%. The high prevalence search was conducted in a laboratory using the same images as the low prevalence search. Six of the 14 radiologists participated in the high prevalence search reviewing all 100 images. They missed six of the 50 cancers resulting in a false error rate of 12%, supporting the theory that low prevalence targets are more likely to be missed then targets of higher prevalence.

2.1.3. Change blindness

Change blindness: "the inability to detect changes to an object or scene" can also impair visual search performance within radiology (Simons & Levin, 1997. p261). Change blindness occurs when a change and a brief visual distraction, such as eye movements or blinking, happen simultaneously (O'Regan *et al.*, 1999). Basic experimental studies have used saccade contingent changes (changes introduced during eye movement) to demonstrate that even large changes can be extremely difficult to notice, particularly when the location of the change is unknown (Simons & Ambinder, 2005). Change blindness could occur when examining stacks of CT or MRI images as the exact location of abnormalities is rarely known.

Radiologists are required to detect extremely subtle changes within the tissues as they scroll through a series of images.

Change blindness occurs predominantly when the aspect of the scene that changes is of marginal interest rather than central interest to the viewer (O'Regan *et al.*, 1999). O'Regan et al., (1999) suggest that one example of when change blindness occurs is when mud splashes on to a car windscreen. Even if the mud splashes do not conceal changes occurring within the visual field, the viewer can still become blind to them. Using a basic experimental design, they used 48 pairs of pictures, one original and one modified to demonstrate this. The changes between the two pictures were categorised as either of marginal interest or central interest. The pictures were displayed for three seconds with an 80 milli-second 'mud-splash' at the moment of change. This was repeated for up to 40 seconds or until the participant could identify the change. The 'mud-splashes' in this experiment were six small black and white textured rectangles that did not cover the location of the change and did not disrupt the visual continuity at the moment of change (O'Regan *et al.*, 1999). Ten observers were asked to press a button as soon as they identified the change. Central interest changes were usually detected immediately. Marginal interest changes were not detected during the 40-second viewing period in 13 – 30% of cases. In the cases where marginal interest changes were identified it was not until the second or later viewings (O'Regan *et al.*, 1999). These findings suggest that only the aspects of the environment that the viewer encodes as interesting will be available for comparison (O'Regan *et al.*, 1999). Applied to radiology, these findings could indicate that if the radiologist does not consider certain tissues to be of importance they may not be available for comparison. This may cause later changes in tissues deemed unimportant to go unnoticed.

Applied experiments, using real world interactions, have also been used to demonstrate change blindness (Simons & Levin, 1998). A conversation was initiated by an experimenter with 15 un-expecting pedestrians walking on a university campus. They were aged between 20 and 65 and were walking alone or in pairs. The experimenter (first experimenter) was carrying a campus map and asked for directions to a nearby building. The pedestrian had a clear view of the first experimenter for approximately 20 meters as they were walking, before approach. After the first experimenter and pedestrian had been speaking for 10-15 seconds, a second and third experimenter rudely walked between them carrying a door. The door blocked the pedestrian's view for approximately one second. During this time, the third experimenter took the place of the first and the first experimenter walked away with the second experimenter and the door. The third experimenter held an identical map and continued to talk to the pedestrian after the door and other two experimenters had passed. The third and first experimenters wore different clothes to one another, differed in height by five centimetres and had easily distinguishable voices (Simons & Levin, 1998). After the experimenters with the door had passed, pedestrians tended to make eye contact before continuing to give directions. After pedestrians had given the directions, the experimenter (third experimenter) explained he was from the psychology department conducting an experiment to look at what people notice in the real world. Pedestrians were then asked if they noticed anything unusual when the door passed. The majority of pedestrians stated that the people carrying the door were rude. If the pedestrian did not report that the person they were now speaking to (third experimenter) was not same person who asked them for directions initially (first experimenter) they were then asked this directly. Seven of the 15 pedestrians reported noticing the change in experimenter. Those that noticed the change were all students and of a similar age to the experimenters. Those who did not notice the change were slightly older and were surprised to find that they had been speaking to two different people (Simons & Levin, 1998).

Applied psychology experiments have also been used in attempts to overcome the impact of change blindness in a clinical setting. Drew *et al.,* (2016) compared 23 radiologists' performance of interpreting clinical mammography images presented side by side to clinical mammography images viewed by 'toggling' back and forth between images. As described above, change blindness occurs when a change and a brief visual distraction happen simultaneously. Current and past mammography images are typically presented side by side. Drew *et al.,* (2016) argue that the eye movements between images presented side by side can create a brief visual distraction resulting in an increased likelihood that a change will be missed. Drew *et al.,* (2016) hypothesised that the likelihood of change blindness would be reduced if current and past mammography images were 'toggled' back and forth. As the images are alternated most of the contents would remain static so a change would immediately attract attention and a brief visual distraction would not be introduced. Each of the 23 radiologists interpreted 12 cases, 2 practice and 10 experimental. They were instructed to inspect each case as quickly as possible while still maintaining accuracy as they would in clinical practice. They were also instructed to close the case once they had reached a decision and rate the case on a scale of one to five, where one is a negative assessment and five is highly suspicious of breast cancer (Drew *et al.*, 2016). Drew *et al.,* (2016) found a six second benefit reaching a decision when the images were toggled in comparison to when they were viewed side by side. They also found a 5% improvement in diagnostic accuracy when the images were toggled. However, their study did not achieve a sufficient statistical power, so this result should be interpreted with caution (Drew *et al.*, 2016). This study illustrates how change blindness techniques can help radiologists read mammograms and potentially improve practices in a clinical setting.

2.1.4. Satisfaction of search

Miss errors could also result from satisfaction of search. This is when the radiologist fails to detect a subsequent abnormality within an image after an initial abnormality has been identified (Krupinski, 2010). Satisfaction of search occurs in two predominant scenarios. First, the radiologist may be more likely to terminate the search prematurely once they have detected one abnormality. If they had not found any abnormality, they may continue to review the image for a longer period of time (Krupinski, 2010). The second scenario in which satisfaction of search occurs is argued by Berbaum *et al.,* (1994) to be more common. After identifying one abnormality, radiologists continue their search of the images; however, their decision-making can become impaired. The identification of one abnormality may result in radiologists being less likely to conclude that a second suspicious tissue is abnormal (Berbaum *et al.*, 1994). Chest x-rays have been used to study satisfaction of search, with experiments showing abnormalities are missed when pulmonary nodules are added to the image (Berbaum *et al.*, 1990). Berbaum *et al.,* (1994) examined satisfaction of search using simulated trauma patients. Satisfaction of search is of particular concern when interpreting images of trauma patients as they often have numerous abnormalities of differing levels of severity. Two experiments were conducted four months, apart both containing 65 cases each made up of several images. Forty-six of the cases in experiment one included images with a subtle fracture, referred to as the target. In experiment two, the same cases were repeated but half of the cases had a more obvious fracture, referred to as a distractor, in place of one of the normal images. Sixteen radiologists interpreted the images and were told to report acute fractures or dislocations as soon as they were detected (Berbaum *et al.*, 1994). The accuracy of detecting the target abnormality was significantly reduced in cases where the distractor abnormality had been reported (Berbaum *et al.*, 1994). These findings demonstrate satisfaction of search within trauma imaging, as after an obvious abnormality was detected a second more subtle abnormality was less likely to be reported (Berbaum *et al.*, 1994). The detection of one abnormality may lead to a reduced chance of detecting subsequent abnormalities because after the first abnormality is detected the radiologist may feel satisfied that they have accounted for the patient's symptoms.

2.1.5. Sensitivity, specificity and computer aided detection

CAD has been implemented within radiology departments to assist radiologists with image interpretation (Drew *et al.*, 2012). Based on the digital data, CAD uses algorithms to highlight statistical abnormalities within images. This encourages radiologists to spend additional time evaluating the highlighted areas, with the aim to help radiologists more easily detect cancers. CAD aims to increase sensitivity (the rate of true positives) without impacting upon specificity (the rate of true negatives). The combination of the radiologist's ability to detect visual abnormalities and the computer's ability to detect statistical abnormalities is believed to reduce miss errors (Drew *et al.*, 2012).

CAD has been used to improve the sensitivity of mammography screening. Freer & Ulissey (2001) compared the interpretation of 12,860 mammograms over a period of 12 months, first without CAD and then with CAD. CAD was found to increase recall for further investigation, with 830 patients recalled when the mammograms were interpreted without CAD and a further 156 patients recalled when CAD was used to aid interpretation (Freer & Ulissey, 2001). CAD also increased malignancy detection. Without CAD 41 malignancies were detected; this was a detection rate of 3.2 cancers for every 1000 women. An additional eight malignancies were detected as a result of using CAD, improving the detection rate to 3.8 cancers for 1000 every women (Freer & Ulissey, 2001). Of the eight additional malignancies detected, five were stage 0 and three were stage 1, suggesting that CAD can aid the detection of early stage malignancies (Freer & Ulissey, 2001).

Although there is some evidence to suggest the introduction of CAD can result in increased detection rates as demonstrated by Freer and Ulissey (2001), the benefits of CAD are contested (Drew *et al.*, 2012). Improvements are argued to be modest with the slight increase in detection rates accompanied by an increased rate of false positive results (Drew *et al.*, 2012).

A second study looking at the influence of CAD on mammography screening across 43 breast screening clinics in the United States found that CAD did not increase sensitivity but did impact upon the specificity of the test (Fenton *et al.*, 2007). Fenton et al, (2007) compared the performance of mammography screening with and without CAD using data from 222,135 women who underwent screening between 1998 and 2002. Specificity decreased from 90.2% to 87.2% as a result of using CAD, meaning there were more false positives when CAD was used (Fenton *et al.*, 2007). There was, however, no significant change in cancer detection rate with 4.15 cases of cancer detected per 1000 women before the introduction of CAD and 4.20 cases of cancer detected after implementation (Fenton *et al.*, 2007).

This increase in false positives could be due to a reliance on CAD as it takes an element of decision-making away from the radiologist. Reliance could also be problematic in cases where CAD fails to highlight a suspicious area. It is possible that the radiologist will base their decisions upon this and conclude a suspicious looking tissue in an area not highlighted to be normal (Alberdi *et al.*, 2004; Taplin *et al.*, 2006).

Medical imaging can result in overtreatment - patients receiving further tests or treatment when it is not necessary, particularly within mammography (Freer & Ulissey, 2001) and cardiac imaging (R. Wellings, personal communication, November 13th 2013).

Overtreatment occurs when a test has low specificity. This was demonstrated by Freer and Ulissey's (2001) prospective study examining the use of CAD within mammography screening, where 986 patients were recalled for further investigation with only 49 incidences of cancer. Overtreatment can reduce the number of Type II errors (false negatives) identified by the test. CT angiogram, for example, has a high rate of Type I errors (false positives) as it is of greater detriment to achieve false negative results than false positive results. Overtreatment, although minimal, therefore ensures that every patient who is not treated and receives a negative result truly does not have the disease (R. Wellings, personal communication, November 13th 2013). Within other specialities, oncology for example, overtreatment is a greater concern as treatments can be aggressive and have severe side effects (Loeb *et al.*, 2014).

2.2. Medical imaging from a sociological perspective

The previous section aimed to highlight some of the difficulties radiologists can face when interpreting medical images and demonstrate the complexity and uncertainty inherent to medical image interpretation. Similarly, sociological perspectives of medical imaging also raise concerns. Sociologists have commented on the dominance of visualisation, both within society and within medicine through medical imaging tests. This section will provide a brief overview of visualisation within society and medicine. This will be followed by an introduction to the work of Professor Kelly Joyce, who has extensively examined the presentation of medical imaging technologies, particularly MRI, within society. The section will conclude by presenting some important consequences that may arise from the dominance of medical imaging.

2.2.1. Visualisation in society and medicine

The rise of medical imaging, particularly MRI which is often considered the gold standard method, was accompanied by a general turn towards visualisation in society. The dominance of images within society through photography, television and video has contributed to the association of sight with truth (Joyce, 2008). Life is becoming increasingly represented through images in both the private and the public sphere. The use of family pictures and personal videos continues to grow, with images portrayed as depicting accurate and truthful stories of events or social relations (Joyce, 2005). Although these images can provide detail about a given event or person, there remains a large amount of information that a single image or a series of images is unable to reveal. They are only able to offer one account or snapshot without giving the viewer the entire context (Joyce, 2008). Within the public sphere, images are widespread, reinforcing the cultural ideology that knowledge is best obtained through sight. Television, newspapers and advertising campaigns use images extensively to present messages and information, with the image being viewed as a particularly persuasive tool (Joyce, 2008).

Recent technological developments have allowed the viewing experience to be further enhanced. With the introduction of 3D cinema and 3D home televisions, a greater sense of immersion within the images has been achieved. 3D images and video are becoming increasingly common within everyday life creating a virtual reality and providing the viewer with depth perception and a greater amount of information than ever before (Roberts, 2012).

Within medicine, visualisation has long been a priority. Hippocrates (460-377BC) emphasised the importance of observation throughout his teachings and practice. Hippocratic Medicine regarded wound observation and animal dissections, although rare, as vital to gain first-hand knowledge of the inner body (Porter, 1997). During the Renaissance (1300 – mid 17th century) the focus on observation became prominent, with the aim to improve knowledge of anatomy and physiology. Dissection became commonplace in medical education and students were able to learn through observing animal dissections and the dissections of hung criminals, which were performed as lectures (Waddington, 2011). In the late 16th/ 17th century dissections became public events, serving education, social and religious purpose (Waddington, 2011).

During the Enlightenment (Late 17th / 18th Century), the association between sight and knowledge was furthered. Emphasis was placed upon observing the patient's symptoms as a way to access knowledge and understanding of their disease (Waddington, 2011). Improvements to microscopes allowed the body to be visualised in detail, moving the focus from understanding the body as a whole to understanding the structures within specific areas of the body. This localised approach to medicine has been maintained by continuous developments in medical technology. In the 19th Century, surgical and diagnostic tools, such as the introduction of gastroscopy and X-ray (as discussed in Chapter One), advanced rapidly. These improvements furthered the notion that through visualisation an objective diagnosis can be achieved, rendering information gleaned from the patient's account as unreliable (Porter, 1997). The expanding utility of diagnostic tools, which focused on localised health problems, contributed to the reduced focus on understanding the patient as a whole and offering a wholesome approach to care. Robert Volz (1806- 82), a German physician, argued that as a result of these developments the 'sick person has become a thing' and no longer viewed as a whole (Porter, 1997, p.311). The importance of viewing the patient as a whole has become of interest recently and is now a focus within healthcare (this will be further discussed in the following section) (Levenstein *et al.*, 1986).

Visualisation and the use of medical imaging have become increasingly central to pregnancy. Images, traditionally generated for medical purposes to monitor the development of the foetus, have become socially important and are argued to increase parental bonding. Expectant parents eagerly await their Ultrasound scan and the opportunity it provides to see their foetus. This reinforces the association between sight with knowledge and truth as it is only when the foetus is seen that the baby feels real (Roberts, 2012). The use of 3D and 4D technology within ultrasound allows facial features and movements to be visualised more clearly. The image can be extremely emotive, creating a sense of personhood of the foetus. 3D and 4D foetal images are becoming increasingly used in anti-abortion campaigns, particularly those that aim to reduce the legal gestational age for abortion from 24 weeks to 12 weeks (Roberts, 2012). The images, although highly emotive, provide no new information about the development of the foetus during pregnancy, suggesting that there is a difference between seeing and knowing, with greater value placed upon seeing information (Roberts, 2012). The focus on foetal ultrasound and the image of the baby as a bonding tool can be of benefit, as bonding is likely to ensure that mothers comply with medical advice and early bonding can reduce abortion rates (Roberts, 2012). The reliance on technology and the clinical environment to promote bonding, however, could result in other forms of important bonding such as massage, singing and talking to the foetus, becoming less utilised (Roberts, 2012).

Similar to 3D foetal ultrasound, full body CT and MRI scans are available privately. Often referred to as 'health MOT' scans, they are advertised to healthy adults to detect early signs of disease or asymptomatic conditions. A full body MRI costs approximately £1500 with optional extras including breast mammography, virtual colonoscopy or a CT scan of the lungs at an additional charge (PreScan, 2014). Clients are given their images to take home on a disc. Numerous professional and governing bodies including: the American College of Radiologists, the US Food and Drug Administration (FDA) and the Royal College of Radiologists, have raised concerns over full body scans. They warn that the benefits of 'health MOT' scans are unclear and they may not outweigh the potential harms (American College of Radiologists, 2002; Royal College of Radiologists, 2014; US Food and Drug Administration, 2014; Wilson, 2010). Three potential harms have been emphasised. The first of which is the exposure to radiation (Committee on Medical Aspects of Radiation in the Environment, 2007; US Food and Drug Administration, 2014). Within radiology departments, the risk of exposing patients to radiation is balanced against the benefits of detecting a specific condition (as discussed in Chapter One). Exposing asymptomatic adults to ionising radiation for a CT scan when there is no clear benefit is argued to be harmful. A second concern is the risk of over-diagnosis/overtreatment (as discussed in the section above) (American College of Radiologists, 2002; Committee on Medical Aspects of Radiation in the Environment, 2007; Royal College of Radiologists, 2014). This could be the result of an error (such as those previously discussed) or it could result from the detection of a benign abnormality such as a benign tumour. Benign tumours may never present as a disease; they may regress naturally or they may grow so slowly that the patient dies from another cause before they have the disease. Overtreatment can lead to unnecessary procedures, which can be invasive and can have potential risks themselves (Committee on Medical Aspects of Radiation in the Environment, 2007; Wilson, 2010). Overtreatment could also cause anxiety and impact upon a patient's quality of life (QOL) (Wilson, 2010). A final concern of 'health MOT' scans is the false reassurance that a negative result can provide (Committee on Medical Aspects of Radiation in the Environment, 2007).

2.2.2. The perception of medical images as truthful, authoritative and agentic

The perception of medical images, particularly MRI, in society has been studied extensively by Joyce (2005; 2008). Joyce argues that MRI is depicted through the media, by medical professionals and by scientists to reveal the truth about the body and to have agency and authority. She explains that MRI is described using three tropes: MRI as transparent knowledge, MRI as progress and MRI as an agent.

The images produced from the MRI data are treated as though they provide a window into the human body, revealing the truth and providing a definitive diagnosis (Blaxter, 2009; Joyce, 2008). The machine and the image it generates are depicted as having agency as they are described to reveal information about health status and reach a diagnosis without intervention from humans. The information provided from the image is also presented to be more accurate and valuable than the patient's account or information obtained through other tests or physical examinations, making MRI appear to be authoritative.

The perception of images as able to reveal the truth may result in uncritical acceptance of information provided by the image, without evaluating it in the context of other test results or knowledge. Blaxter's (2009) case study, of one patient's experience of medical imaging, revealed that an old slipped disk that the patient had previously suffered from several years prior to the scan still appeared on the image. This caused the clinicians to focus on the slipped disk and ignore the real cause of the patient's back pain, which was later determined by an osteopath and confirmed by the GP to be polymyalgia, a condition that is not diagnosed by imaging (Blaxter, 2009).

The notion that imaging can access the truth could also increase confusion for patients whose symptoms remain unexplained and who do not receive a diagnosis after imaging tests. Talcott Parsons' notion of the sick role emphasises the need for diagnoses to legitimise illness (Parsons, 1951). Patients who are unable to obtain a diagnosis are left in a vulnerable and frustrating position (Corbin & Strauss, 1985). The belief that MRI, or other imaging tests, can access the truth about the body and the presence of disease could potentially add to the patient's distress as the belief appears to suggest that if the imaging test cannot detect the disease, then the disease cannot be present.

The belief that MRI is both an authoritative tool and an agent devalues the work of the doctor suggesting that the machine can better access accurate information about the patient's health status. This is a concern as information that is of great importance to both diagnosis and treatment, such as patient history for example, can be accessed most effectively through doctor-patient communication. Although medical imaging results make a substantial contribution to diagnosis, they can rarely reveal the patients' health status or confirm the presence of disease alone. Without interpretation by the radiologist and the context gained through patient histories and symptoms, the image is unable to reveal adequate information about the patient's health status. In order to achieve an accurate diagnosis the results from imaging tests are evaluated in relation to other forms of knowledge, gained through patient histories and symptoms or physical examinations or other clinical tests (Joyce, 2005).

The depiction of medical images as the truth, authoritative and agentic could also undermine the work of both the radiographer in generating the images and radiologists in interpreting them. The expertise of the radiologist along with the imaging technology and the radiographer who takes the image all contribute to the diagnostic process (Joyce, 2008).

Medical images are frequently described to be objective and are trusted to provide an accurate and truthful diagnosis. However, medical imaging tests involve a much greater amount of subjectivity and uncertainty than is often portrayed, with subjectivity introduced during image generation, interpretation and report writing (Joyce, 2008). The interpretation of images requires extensive expertise and decision-making from the radiologist in order to identify abnormalities or reach a diagnosis. A radiologist's decision-making when interpreting images may be influenced by their experience. For example, if they are aware that the prevalence of a particular disease is extremely low, they may be less likely to conclude that an abnormality is an indicator of that disease. When measuring features within an image, radiologists' perceptions of where the measurement should begin and end may also differ. Written reports of the imaging results provided by radiologists to referring clinicians could also lead to different conclusions being drawn, depending on the experience of the clinician, the clarity of the report and the vocabulary (Joyce, 2008).

Blaxter (2009) highlights the subjective nature of medical imaging through a case study, aimed at examining the experience of diagnosis and treatment of a patient diagnosed with stage 111b small cell lung cancer, which had spread to the lymph nodes. The initial scan taken was interpreted as showing no abnormalities until it was reviewed again seven months later. After a second scan indicated an abnormality and the patient was diagnosed, the scan taken seven months earlier was thought to show a tumour. This reinforces the influence of knowledge on the interpretation of images. With hindsight, the tumour became more visible to the radiologist within this case study (Blaxter, 2009). Knowledge such as the radiologist's knowledge of the patient's symptoms or family history of the disease or suspicion of disease presence could also influence the radiologist's interpretation (Joyce, 2008).

2.2.3. Concerns arising from the perception of medical images as truthful, authoritative and agentic

The depiction of medical images as truthful, authoritative and agentic could influence the public's perception and understanding of both the images and the technology used to generate them, as well as influencing practices within radiology departments and clinical consultations. Several specific concerns have been raised. These include reliance on imaging resulting in either overuse of imaging (Gelb *et al.*, 1996; Joyce, 2008; Roberts, 2012) or disregard for other forms of information (Blaxter, 2009; Reventlow *et al.*, 2006; Roberts, 2012); passivity on the part of the patient (Griffiths et al., 2010); impairment to the doctor patient relationship (Gunderman, 2005; The *et al.*, 2000) and fragmentation of the patient (Gunderman, 2005; Reventlow *et al.*, 2006; The *et al.*, 2003). These concerns will each be discussed in turn.

2.2.3.1. Overuse of imaging

Patient demand for medical imaging is increasing and the perception of medical imaging as the most accurate and scientific way to gain knowledge about a condition or to provide a diagnosis may lead patients to feel they require imaging tests even when they are not necessary (Gelb et al, 1996; Roberts, 2012). Clinicians may also request more medical imaging tests as a result of the association between images and the truth and due to increased revenue generated or fear of litigation (Joyce, 2005; Roberts, 2012). The use of MRI for patients with knee disorders, specifically anterior cruciate ligament injuries and isolated meniscal legions, was studied by Gelb et al., (1996). They concluded that MRI was overused in this population of patients, with information gained through the MRI contributing to diagnosis in only three of 72 cases and treatment planning in 14 of 72 cases. Physical examinations provided greater predictive accuracy than the MRI for these two conditions and were more cost effective (Gelb et al., 1996). This finding challenges the notion that MRI, along with other medical imaging techniques, are superior to other methods of diagnosis, such as patient histories and physical examinations.

2.2.3.2. Disregard for other forms of information

The belief that medical images are authoritative and capable of providing superior information could result in disregard for other forms of information (Blaxter, 2009; Gelb et al., 1996; Joyce, 2005), including information from the patient such as symptoms and patient histories as well as information gleaned from physical examinations. Roberts (2006) and Reventlow (2012) argue that health professionals alone cannot determine an individual's health status. Individuals should be encouraged to evaluate their own health even when there is a conflict between the body's sensations and information gleaned from the images.

Roberts (2012) discussed this conflict between the information provided by the body and the information provided by an ultrasound scan in pregnancy. The date of conception and expected due date calculated from the date of menstruation may differ from the date calculated from the scan results creating a tension between the patient and their imaging results.

In Blaxter's (2009) case study, as described above, the patient reported feeling that the symptoms she raised were considered to be of lower status than the information gleaned from the imaging tests. The patient reported symptoms related to the thyroid, which indicated spread to the lymph nodes. These symptoms were of great importance to the final diagnosis; however, they were initially ignored due to a greater concern of potential bowel metastasis, which were indicated on the imaging results. The thyroid symptoms were not acted upon until 77 days after the patient first reported them, resulting in a change in diagnosis from stage 1/11 to stage 111b small cell lung cancer.

2.2.3.3. Passivity on part of the patient

Sociologists argue that the reliance on medical imaging may result in passivity on the part of the patient, with patients feeling unable to evaluate their symptoms and health status (Griffiths *et al.*, 2010; Reventlow *et al.*, 2006). As a result of this, patients may ignore vital symptoms concluding them to be insignificant or visit their clinician when there are few symptoms to warrant a visit (Gunderman, 2005). Griffiths et al (2010) examined patients' experience of breast cancer screening. They found that mammography screening provided a sense of reassurance to women who were found to have no abnormalities. They argue, however, that this reassurance is false. Women were found to place greater trust in mammography screening than their own ability to perform breast self-examination and their own knowledge of their body and what is normal for them. Faith in their screening result may lead women to ignore breast self-examination, believing to an extent that they now have the all clear until their next screening appointment in three years' time. This is problematic, as early detection of breast cancer requires ongoing self-examination, which leads to a greater detection of early stage breast cancers than mammography screening. The mammography test reveals only that there are no suspected abnormalities now, but it is recommended that women should regularly partake in breast self-examination in the years between screenings (Griffiths et al., 2010).

Reventlow *et al*., (2006) observed that after receiving results from a bone scan for possible osteoporosis patients began to interpret their own bodily sensations differently and changed their behaviour. Patients with low bone mass, along with risk factors for osteoporosis including low body weight, physical inactivity, smoking, family history and history of fractures, are more likely to suffer with fractures in later life. Patients' perceptions of their bodies and their sense of fragility changed after receiving their results even though bone scans cannot predict which patients will suffer from fractures (Reventlow *et al.*, 2006). The results, reflecting their bone calcium content, were presented in pictorial and numerical form. Patients' perception of the pain that they had previously experience altered and patients began to attribute this pain to osteoporosis (Reventlow *et al.*, 2006). They also expressed an increased sense of fragility and became more cautious about what they were able to do. Although aware that exercise was required to strengthen their bones, patients were fearful of injury and believed that they could participate in fewer activities than they were previously partaking in (Reventlow *et al.*, 2006).

2.2.3.4. Impairment of the clinician – patient relationship

Reliance on medical imaging could also impair the doctor patient relationship as well as communication within clinical consultations. If clinicians attribute too great a value to the information gained from the medical imaging tests they could begin to ignore patient histories and symptoms. Interactions between patients and clinicians may also reduce if medical imaging takes precedence over physical examinations and understanding the patients' story (Gunderman, 2005). Gunderman (2005) argues that touch and listening create human bonds and relationships and a focus on the image over the patient could impair this. The emphasis on visualising the disease could undermine the practice of viewing the patient as a whole, which is important when assessing the suitability of different treatments for specific patients. Having an understanding of the patient's mental wellbeing, social support and lifestyle are crucial as they can have a substantial impact upon patient outcomes and can influence how well a patient may be able to comply with recommendations (Gunderman, 2005).

Medical images can also be used as a means of persuading patients that they are seriously ill (The *et al.,* 2003). Lung cancer patients, for example, often do not feel seriously unwell at the point of the diagnosis, with symptoms usually imitating flu symptoms. Images can therefore be beneficial in alerting these patients to the severity of their condition and force them to re - evaluate their health status, with patients accepting their diagnosis only after seeing that it is true (The *et al.,* 2003). The image can be a valuable persuasive tool throughout the patients' journey and can demonstrate to the patient whether the treatment is working. During chemotherapy for example, patients often feel extremely ill and weaker than they did prior to treatment initiation. The use of images at this stage can convince patients that the treatment is effective and can be used to encourage them to continue (The *et al.,* 2003). Although from a medical perspective the use of images as a persuasive tool is beneficial, from a sociological perspective this practice raises concerns. Patients could feel unable to evaluate their own health status if images are used as proof that the medical professional's view is correct and the patient's view is incorrect (The *et al.,* 2003). The *et al.,* (2003) also found that patients developed a greater sense of trust in the images than they held for their own bodily sensations and symptoms, with one patient continuing to ask what his image showed as he were dying. The *et al.,* (2003) argued that the belief that images could still provide superior and contradictory knowledge while the patient was dying suggests that the images provide patients with a false sense of optimism and may prevent them from coming to terms with their prognosis. False optimism was also evident during stages of remission with patients describing "being cured" even though their prognosis was poor. (The *et al.,* 2003, p.117) They still felt sick at this point and had not yet recovered from chemotherapy but described themselves as cured, as their images no longer showed they had a tumour (The *et al.,* 2003).

2.2.3.5. Fragmentation of patients

The focus on medical imaging as the most reliable method to determine an individual's health status and the practice of viewing patients as individual parts has been argued to contribute to a sense of fragmentation or alienation experienced by patients (Blaxter, 2009; Griffiths *et al.*, 2010; Gunderman, 2005; Roberts, 2012). The processes patients undergo with the X-ray department have also been thought to increase this sense of fragmentation further. Frank (1992) notes that much diagnostic work takes place away from the patient and argues that “for diagnostic and even treatment purposes the image on the screen becomes the ‘true’ patient” (Frank, 1992 p.83).

Gunderman (2005) argues that a sense fragmentation may cause patients to lose confidence in their own ability to detect symptoms of disease, which can be important for early diagnosis. When this ability is undermined, patients may be less likely to report vital symptoms of disease (Gunderman, 2005). Furthermore, the practice of viewing patients as a set of individual parts could lead to important factors being missed during diagnosis or treatment planning.

2.2.3.6. Images as a powerful resource

Blaxter (2009) argues that medical images could be a powerful resource for patients, despite the concerns outlined above. Seeing their own images with an explanation may reduce the sense of fragmentation that results from the process of undergoing imaging tests. In the case study previously described, Blaxter (2009) found that images could empower patients. The imaging tests enabled the patient to feel as though she had an active role and was participating in her diagnosis or treatment evaluation. Blaxter (2009) also reports that the image produced by the tests felt more real than the words spoken during oral discussions with her doctor. The patient gained a sense of agency from the imaging tests, desiring to present her body in the best light, taking responsibility to remain as still as possible throughout the exam and aiming to receive better results than those of her previous test (Blaxter, 2009). Similarly, The *et al.,* (2003) found patients engaged with their imaging results, speaking about their images as a measure of how successfully they had been in responding to treatment. This reinforces the view that the imaging results can become a powerful resource for patients.

2.3. The clinician – patient relationship

The relationship between healthcare professionals and their patients has long been studied, interesting researchers from a broad range of disciplines and epistemological standpoints. The topic has been studied from the perspective of health psychology, medical sociology and medical education, adopting critical realist, positivist and interpretivist frameworks (De Maio, 2010). This has created a complex body of research (De Maio, 2010). This section will begin by presenting the three models of the clinician – patient relationship during medical interactions as proposed by Szaz and Hollander (1956). This section will then move on to discuss the following topics: the patient centred method of interactions, trust within the clinician - patient relationship, clinician – patient communication, shared decision-making and decision aids and the use of images within health care communication.

2.3.1. Models of clinician – patient interaction

Erving Goffman (1983) proposed that society largely takes place through group or individual interactions with one another (Goffman, 1983). Everyday interactions allow roles to be defined and power to be asserted or negotiated. The assertion and negotiation of power is dominant in medical interactions, with previous research seeking to understand how medical professionals maintain power within the relationship and how and when patients may attempt to challenge it (De Maio, 2010).

The prevalence of non-communicable diseases; the most common four being cardiovascular diseases, cancers, respiratory diseases and diabetes (World Health Organisation, 2015), are rising and are expected to continue to rise (Kings Fund, 2016). Premature death caused by non-communicable diseases has reduced as a result of improvement to treatment and early diagnosis, increasing the number of people living with and managing such conditions (Kings Fund, 2016). Musculoskeletal problems are also predicted to continue rising due to lifestyle factors such as obesity and physical inactivity and as a result of the aging population (Kings

Fund, 2016). As the prevalence of chronic non-communicable conditions and co morbidities rise, the relationship between clinician and patient will become increasingly important. Non-communicable, chronic disease can require complex long-term management, requiring a strong relationship to be built between the clinician and the patient enabling the patient to be actively involved in disease management and decision-making (Department of Health, 2001; Holman & Lovig, 2000).

Three models of medical interactions have been identified, each displaying different balances of power between the clinician and the patient (Szasz & Hollander, 1956). These three types of interaction have been labelled by Szasz and Hollander (1956) as activity - passivity, guidance co-operation and mutual participation. Activity - passivity refers to an interaction in which the medical professional has complete control of the agenda and decision-making (Szasz & Hollander, 1956). This type of interaction occurs predominantly in emergency medicine, as in life threatening situations it is less important and practical for the patient to understand or be involved in the decision-making. Although activity - passivity is appropriate within life-threatening situations, its use is discouraged in other interactions (Fox, 1993 as cited in De Maio, 2010). Guidance co-operation refers to interactions in which the patient takes a more active role. They are however expected to comply with the advice and instructions of the medical professional. Talcott Parsons' 'The Sick Role' describes guidance co-operation interactions. 'Sickness' is only legitimised, according to Parsons, if patients seek expert help and cooperate with the doctor (Parsons, 1951). Mutual participation, the final type of interaction, is widely favoured. The patient is a full participant; they are well informed and involved in the decision-making (Szasz & Hollander, 1956). This is similar to the patient centred approach, which is discussed below.

2.3.2. Patient centred consultations

Clinical consultations adopting a patient centred approach aim to address bio-psychosocial concerns relating to the patient and their condition, providing a more holistic approach than the traditional medical model (Levenstein *et al.*, 1986).

Although widely discussed within healthcare literature, to date there is no universally agreed, concrete definition as to what the approach entails (Mead & Bower, 2000a). Most descriptions include similar aims and components. Levenstein et al., (1986) describes the aim of the patient centred approach to enable the doctor to know the individual patient and for the agendas of both the clinician and the patient to be addressed through the consultation. These two aims are important because all patients, even those with the same disease, have a different experience and have different expectations or agendas when attending a consultation (Levenstein *et al.*, 1986). Components of the approach include a good interpersonal relationship; effective information exchange and the involvement of the patient in decision-making (Arora, 2003).

A patient centred consultation is achieved when the doctor acknowledges the patients expectation or agenda; allows them to speak as much as possible without interrupting and asks open as opposed to closed questions (Arora, 2003; Levenstein *et al.*, 1986; Rosenblum, 1994). This not only enables the doctor to establish a rapport with the patient but also helps the doctor to better understand the patient as person and aids the doctor's ability to tailor a treatment plan that will be most appropriate for the patient's subjective experience (Arora, 2003). Being receptive to cues such as a statement that appears out of context or repetition of a previously discussed topic will help the doctor to unveil the patients concerns. This is important, as existing research has indicated that patients with more concerns tend to have poorer outcomes (Maguire, 1999). Maguire, (1999) found greater number and severity of concerns predicted psychological distress, anxiety and depression in cancer patients.

Additionally, if the doctor addresses and provides answers to the patient's concerns during the first consultation they are likely to report better psychological adjustment at follow up (Butow *et al.*, 1995). The detriment of 'cutting off' a patient has also been emphasised (Levenstein *et al.*, 1986). Cutting off can refer to the doctor interrupting the patient, changing the subject or failing to acknowledge a patient's concern by dismissing their questions or opinions and refocusing the interaction back to their own agenda. These can lead to the patient becoming frustrated; reporting lower satisfaction and can lead to the doctor missing vital information that may aid their understanding of the patient's ability to adhere to recommended treatments or suitability for certain treatments (Levenstein *et al.*, 1986).

The patient centred approach has been associated with improved outcomes including disease related outcomes such as lower blood sugar and blood pressure (Kaplan *et al.*, 1989) and improvements in quality of life (Arora, 2003; Epstein *et al.*, 2010). Further, the approach has been associated with greater compliance to recommended treatments and better disease management (Arora, 2003; Kaplan *et al.*, 1989). Patients also report a greater sense of satisfaction, wellbeing and enablement as a result of patient centred approaches (Ishikawa *et al.*, 2002; Little *et al.*, 2001; Paasche-Orlow & Roter, 2003; Pawlikowska *et al.*, 2012). Satisfaction however has been found to be more closely linked to patient centredness in general practice consultations than in internal medicine, indicating that consideration of the type of consultation is also important (Paasche-Orlow & Roter, 2003).

The patient centred approach, although predominantly used in general practice (Neal *et al.*, 2006; Pawlikowska *et al.*, 2012), is applicable to consultations within other specialities (Roter and Larson 2002) with aspects widely implemented and encouraged in consultations for oncology (Ford *et al.*, 1996; Ishikawa *et al.*, 2002) and family planning (Abdel-Tawab & Roter, 2002) for example. Within oncology, consultations are often accompanied by increased emotional concerns and thus a patient centred approach is particularly valuable. (Arora, 2003). Patient centredness, however, may not be appropriate within all specialties. Levinson, Hudak & Tricco, (2013) argue that this approach may not be suitable for consultations about surgery. This will be discussed further in Chapter Four.

Several instruments have been devised to evaluate clinician - patient interactions, which seek to identify behaviours that are characterised by the patient centred approach. This is achieved by observing or video-recording consultations or surveying patients after their consultations. One of the most frequently used instruments is the Roter Interaction Analysis System (RIAS). RIAS will be described in Chapter Four. Other models include The Henbest and Steward Method and the Medical Interaction Process System (MIPS) (Mead & Bower, 2000b).

2.3.3. Trust in the clinician - patient relationship

Trust, a crucial element of the clinician – patient relationship, is most simply defined as acceptance of the truth of a statement without evidence or investigation (Oxford English Dictionary, 2014). Trust is characterised by a state of vulnerability. It is often thought of as fragile as it can be difficult to gain or regain even though it is easily lost (Mechanic & Meyer, 2000). Trust is fundamental for effective interpersonal relationships, including the relationship between clinician and patient. During injury or illness, patients experience a period of increased vulnerability and are reliant on the clinician for help. They are often required to place trust in someone that they may not have had time to build a relationship with (Mechanic & Meyer, 2000). Existing research has sought to understand the factors that increase patients' trust in their clinicians and why trust is important (Mechanic & Meyer, 2000). However, it is a complex concept, which is difficult to measure.

Patients have trust in their clinician when they believe that they are advocating for them and working in their best interests (Mechanic & Meyer, 2000). This is of particular importance when patients have little trust in the health service as a whole. In these circumstances, patients trust their clinician to fight for the best treatment possible for them against competing demands and pressures to reduce costs. Trust in healthcare systems appears to have eroded in both the UK and internationally, however patient trust in medical professionals and their own doctor remains strong (Blendon *et al.*, 1993; Calnan & Sandford, 2004).

Technical competence is an important factor in gaining patients' trust (Mechanic & Meyer, 2000). Clinicians must thoroughly investigate the patient's condition and provide an effective and appropriate treatment. They must also be honest with the patient and communicate with them completely and clearly, allowing the patient to access all the information they require (Mechanic & Meyer, 2000). Additionally, the patient centred approach has also been associated with trust (Calnan & Sandford, 2004; Fiscella *et al.*, 2004). Understanding the patient's individual experience and compassion are also traits that foster trust from patients (Mechanic & Meyer, 2000). These could be of particular benefit to encouraging disclosure. Patients may be more likely to disclose information to their clinician if they feel understood and cared for (Mechanic & Meyer, 2000).

Trust has been positively associated with increased patient satisfaction, adherence to treatment and self-reported health improvement (Hall *et al.*, 2002b; Safran *et al.*, 1988; Thom *et al.*, 1999). Safran et al., (1988) do not suggest causality but their findings do emphasise the importance of trust within the clinician-patient relationship, acknowledging its contribution to several key health outcomes. Trust has also been linked to an increased level of engagement with medical recommendations and an increased willingness to disclose information and seek advice (Hall *et al.*, 2002a; Rowe & Calnan, 2006; Safran *et al.*, 1988). These outcomes support the importance of trust in clinician – patient relationship.

2.3.4. <u>Clinician – patient communication</u>

During clinical consultations, patients are often given large amounts of information, which can relate to their diagnosis, prognosis and treatment options or to changes in lifestyle, behaviour or instructions about medications that they are expected to follow (Selic *et al.*, 2011). They are often required to recall and comprehend the information they are provided with and use it to make decisions about their care. Their ability to do this can be impaired by healthcare professionals' communication style and by social and psychological factors (Kessels, 2003; McCarthy *et al.*, 2012; Selic *et al.*, 2011; Watson & McKinstry, 2009).

Research has indicated that patients often struggle to recall and comprehend information that they have been given during consultations (Selic *et al.,* 2011). Information relating to prognosis, treatment options and instructions have been found to be especially difficult (Ley, 1979; Marty *et al.*, 2013).

Studies examining patient understanding in cancer care found that many patients do not understand their disease status. They often overestimate their life expectancy and chance of cure. Additionally, some patients do not understand the purpose of their treatment. Several studies have found patients being treated palliatively, believed that they are being treated with curative intent (Hagerty *et al.*, 2005; Mackillop *et al.*, 1988; Quirt *et al.*, 1997). This could lead to false optimism about recovery and could cause patients and their family members to feel unprepared for the imminent death (The *et al.*, 2000). False optimism could also result in patients failing to make appropriate arrangements or appropriate decisions about their treatment and care (The et al., 2000). Furthermore, Mackillop et al (1988) found five of 52 patients believed they were being treated palliatively when they were being treated with curative intent. This could lead to avoidable distress for patients and their families and could alter their decisions about treatment. Lack of patient understanding is not limited to cancer care. Fossum *et al.,* (1998) found almost half of patients attending an orthopaedic outpatient clinic in Stockholm did not understand what the clinician did or said (Fossum *et al.*, 1998).

Patients are frequently given more information than they are able to process and previous studies have demonstrated that recall is improved when patients are given fewer instructions (Selic *et al.*, 2011). Selic *et al.,* 2011 recommend that only one or two instructions should be given to a patient within a consultation, arguing that any more instructions could leave patients unable to recall information and subsequently unable to adhere to any of the instructions given. They also propose that attending a follow up appointment within two weeks of the initial appointment could be beneficial if the patient is to receive a large amount of information or several instructions. Instructions can be broken down so that they are not all given to patients in one consultation, aiding recall and allowing the clinician to reiterate the information previously provided (Selic *et al.*, 2011).

Providing patients with information specific to them has also been found to be beneficial (Selic *et al.*, 2011). Hagerty *et al's.,* (2005) systematic review revealed health care professionals generally give broad generalisations as the specific details or time frames that patients want cannot always be known or can be difficult to communicate. For example, doctors are often reluctant to provide patients with an estimation of life expectancy even though they often ask for it (Hagerty *et al.*, 2005).

The type of information communicated also influences recall and comprehension of medical information. Marty *et al.,* (2012) found that only 43% of patients left the emergency department at the time of their study with the correct understanding of their diagnosis, planned examinations and follow up. Patients particularly struggled to recall information about planned examinations and the medication they were given, including information relating to potential side effects, the duration for which they were to take it and its use.

Ley (1979) argues that primacy effects as well as the perceived importance of the information provided may impact upon recall. Primacy effects refer to the tendency to recall information that has been presented first at the expense of information presented later (Petty *et al.*, 2001). Within clinical consultations, it is important to be aware of this effect as clinicians typically present information relating to diagnoses to patients first and provide instructions and advice later on during the consultation. This can result in patients failing to adhere to treatments or advice, as they are more likely to remember the diagnosis than the instructions. Ley (1979) also suggests that the extent to which the patient perceives the information as important influences recall. Using healthy laymen to evaluate the importance of medical statements, Ley (1969, as cited in Ley 1979) found that diagnostic information was considered to be of most importance whilst statements providing instructions and advice were considered less important. If patients receive more information than they are able to recall, it is likely that they will remember the information to which they attributed the greatest importance (Ley, 1979). Reframing the way in which information is presented to patients to place a greater emphasis on instructions could influence the type of information that patients regard to be most important and potentially improve recall of this type of information.

Medical information is often explained to patients in unfamiliar or medical language that they may struggle to understand (Farrell *et al.*, 2008; Shaw *et al.*, 2009; Wiener *et al.*, 2013). Research has shown that using simple language when communicating with patients can improve recall and understanding of information (Watson & McKinstry, 2009). Better recall of medical information is also evident in patients with high school or college education, whilst those with lower literacy are more likely to struggle to recall and comprehend the information they are given (McCarthy *et al.,* 2012; Selic et al., 2011). It is of particular importance that individuals with lower literacy levels understand the information they are given by their clinician during clinical consultations as they are less likely to seek further health information independently or read and comprehend information leaflets provided (McCarthy *et al.,* 2012). Clinicians could seek to gain an awareness of patients' literacy levels in order to ensure that they can benefit from written materials. This can also allow clinicians to tailor information and communicate it to patients with lower literacy in a way in which they can benefit.

Older patients are typically less able to recall medical information successfully (Kessels, 2003; McCarthy *et al.,* 2012; & Watson & McKinstry, 2009). This is to be expected as a large proportion of individuals experience impairment to their episodic memory, particularly the coding of new information, with age (Small *et al.*, 1994). Health care practitioners should consider this when presenting information to older patients and seek to develop a strategy with the patient to enable better recall of the instructions given (Rice & Okun, 1994). Rice and Okun (1994) found that recall of medical information by older people improved when the information presented confirmed rather than conflicted with the patient's own beliefs. This suggests effective communication with older patients is particularly important when the information being presented within the consultation is likely to conflict with the patient's existing beliefs.

Psychological factors such as anxiety or preoccupation with symptoms can also play a role in influencing whether patients understand their diagnosis and treatment options. Patients can become preoccupied with their symptoms, particularly when they are difficult to manage or have a big impact upon quality of life (Houts *et al.,* 2006). The focus on alleviating symptoms could also cause patients to prioritise information relating to their symptoms rather than their diagnosis, prognosis or planned treatments. Patients appear to be better equipped to process information when they have moderate levels of anxiety rather than high or low levels (Kessels, 2003; Shapiro *et al.*, 1992). Information leaflets can be provided to patients in attempt to overcome the impact that high levels of anxiety can have on recall and comprehension (Kenny *et al.*, 1998). This can be helpful as it gives patients the opportunity to review the information in their own time after they have begun to adjust to the initial shock that a diagnosis can cause. Although written information can be advantageous to some it is also problematic for those with lower levels of literacy who may not be able to comprehend sufficient information without the support from a medical expert who can explain the relevant material (as previously explained) (Kenny *et al.*, 1998).

Strong communication between clinicians and patients is of particular importance when patients are encouraged to take an active role in decision-making, requiring patients to be able to recall, comprehend and evaluate the information they are given.

2.3.5. Shared decision-making

Participation by patients in health care decisions, often referred to as shared decision-making, is widely encouraged, especially in chronic illnesses where patients often become experts in their condition (Coulter & Collins, 2011; Department of Health, 2012b). Clinicians are expected to educate patients, providing them with information about all appropriate options in order to help them make an informed decision (Coulter *et al.*, 2008). This is reflected through the NHS mantra "no decision about me without me" (Department of Health, 2012b).

Patient participation in clinical discussions has been found to result in greater patient satisfaction and better clinical outcomes (Stevenson *et al.*, 2004). Additionally, patients with breast cancer who were involved in decision-making about their treatment experienced reduced anxiety and depression and improved quality of life compared to patients who were not given a choice or who were heavily encouraged to select a specific option (Fallowfield & Jenkins, 1999; Morris & Ingham, 1988; Street & Voigt, 1997).

In contrast, Gattellari *et al.,* (2001) argues that not all patients will benefit from participating in decision-making. Patients who receive their optimal level of participation will experience a decrease in anxiety and depression in comparison to those who are given either more or less input than they believe to be desirable (Gattellari *et al.*, 2001). Therefore, the consultation and input into decision-making should be tailored for each individual patient's needs.

The emphasis on shared decision-making has been the subject of debate. Patient preference remains unclear with contradictory evidence both in favour of patient participation in decision-making and against (Chewning *et al.*, 2012; Degner & Sloan, 1992; Leydon *et al.*, 2000). Surveys of 436 newly diagnosed cancer patients and 482 members of the public revealed that although the majority of the public believed that they would want to make their own treatment decisions should they develop cancer, the majority of cancer patients wanted their clinician to make the decisions on their behalf (Degner & Sloan, 1992).

Some patients, particularly older patients, avoid taking an active role in decision-making; preferring to do as their clinician tells them (Leydon *et al.*, 2000). Older patients would be more familiar with traditional activity–passivity interactions and may feel they lack the knowledge or expertise to participate. Faith in the clinician and the desire to be a good patient by listening and adhering to instructions are further factors identified by cancer patients for their adoption of a passive, more traditional role (Leydon *et al.*, 2000). Furthermore, when faced with a serious diagnosis such as cancer, some patients prefer to know as little as possible in order to cope which can prevent them from participating in decision-making (Leydon *et al.*, 2000). Research has tended to focus on cancer patients, who are a specific group whose preferences may not reflect those of patients in general (Degner & Sloan, 1992). Cancer patients often suffer severe disruption to their lifestyle, experience changes in body image and are subjected to high levels of toxicity (Degner & Sloan, 1992).

Patients suffering from conditions that cause less disruption or are not life threatening may be better placed to participate in decision-making (Degner & Sloan, 1992).

2.3.6. Decision aids

To aid patient participation in decision-making a variety of decision aids such as pamphlets, decision boards and videos have been introduced (O'Connor *et al.*, 2009). Decision aids convey information designed to aid patients in making their own treatment choices based upon the value they place on the benefits and harms. They provide information about available treatment options and their advantages and disadvantages (O'Connor *et al.,* 2009; Tiedje *et al.,* 2013). They differ from other healthcare literature such as information leaflets that are designed to inform patients about treatments rather than help them make a decision (O'Connor *et al.,* 2009). Decision aids are used by patients facing a range of decisions with different conditions including cancer, diabetes, hypertension and osteoporosis (Lalonde *et al.*, 2006; Montgomery *et al.*, 2003; O'Connor *et al.*, 2009; Tiedje *et al.*, 2013). In addition to treatment options, decision aids can be used to aid a wide variety of decisions such as participation in genetic testing or participation in screening programmes such as colorectal cancer screening, PSA screening and prenatal screening. They can also be used to aid decision-making for parents considering male newborn circumcision or infant vaccination (O'Connor *et al.,* 2009). The use of decision aids has increased rapidly since 1999, particularly in Australia, Europe and North America.

The International Patient Decision Aids Standards (IPDAS) Collaboration agreed criteria for evaluating decision aids to ensure they are of high quality (O'Connor *et al.,* 2009). The IPDAS state that a decision aid is good if the option the patient selects is matched with the aspects that they deem most important (O'Connor *et al.,* 2009).

Overall, evidence to support the use of decision aids is strong. A systematic review of randomised control trials comparing patients who receive decision aids to those receiving standard care was conducted using 55 trials from seven different countries. The review found that patients with decision aids have greater knowledge of their treatment options. It also found the use of decision aids reduced the number of patients who were either passive in decision-making or remained undecided as to which treatment was best for them (O'Connor *et al.,* 2009).

In contrast, some studies have drawn more cautious conclusions (Lalonde *et al.*, 2006; Tiedje *et al.*, 2013). Lalonde *et al.,* (2006) found the proportion of patients with high decisional conflict decreased after use of a decision aid. However, the decision aid had no impact on their knowledge of cardiovascular disease (Lalonde *et al.*, 2006). This could be considered concerning as in order for patients to make a good decision they must have good knowledge of their condition.

Tiedje *et al.,* (2013) also question the impact of decision aids on decision-making. They found that decision aids used during primary care consultations about medications for type two diabetes were considered by patients and clinicians to be best used as a tool for facilitating discussions or presenting information to patients. The decision aids were not believed to influence roles within decision-making or engender shared decision-making (Tiedje, *et al.,* 2013). However due to limitations of Tiedje *et al's.,* (2013) study design (i.e. not all their participants were required to make a decision and the majority of participants reported no or only a vague memory of the decision aid) their results may not reflect how patients who are participating in decisions feel about decision aids. Further investigation exploring patients' experience of using decision aids could aid understanding of their efficacy and how they can be incorporated into consultations.

2.3.7. Images in health care communication

Pictures (Houts et al., 2006; Vilallonga *et al.*, 2012), photographs (Gibbons *et al.,* 2005) and more recently medical images, including CT and ultrasound images (Carlin *et al.,* 2014;

Shahab *et al.,* 2007; Weiner *et al.,* 2013) have been found to aid patients' understanding of medical information and increase patient satisfaction. This section will first discuss the use of pictures, followed by a discussion of patient specific images including photographs and 2D images. The section will conclude by presenting the use of 3D images.

In 2006, an international review found that recall and understanding of written medical information improved when the information was accompanied with pictures compared to text alone (Houts *et al.,* 2006). Written information examined in the review included discharge instructions, brochures on cervical cancer prevention and medication instructions. Houts *et al.,* (2006) also found that patients with low literacy were especially likely to benefit from the incorporation of images into written medical information.

Vilallonga *et al.,* (2012) examined the use of images within outpatient surgical consultations about the following conditions: inguinal hernia, gallstones, inflammation of the gall bladder, gallstones in the bile duct and thyroid cancer. Images used within the study were diagram style pictures presented to patients on a computer. Over a period of 8 months, 183 patients were randomised to one of two conditions. In condition one patients (n=83) were shown images during their consultation and in the condition two patients (n=100) received a verbal explanation only. All patients completed a questionnaire after their consultation, asking them to rate their level of satisfaction with the explanation they received as either very bad, poor, regular, well, very good or excellent. Overall, over 80% of patients were satisfied with the explanation that they received (ratings of well, very good and excellent). 37.4% of patients within the image condition rated the explanation as excellent compared to 15% in the no image condition. Furthermore, 90% of all patients (93 out of 100 in the no image condition and 78 out of 83 in the image condition) reported that they believe the use of images can improve consultations (Vilallonga *et al.,* 2012).

Additionally, images are becoming increasingly used in public health campaigns such as the Department of Health's Mutation Health Harms advert, which depicts a tumour growing from a cigarette in order to reinforce fundamental health messages (Department of Health, 2012a).

Patient specific 2D images have been found to aid patient understanding (Carlin *et al.,* 2014; Wiener *et al.,* 2013), provide reassurance to patients and increase intention to partake in positive health behaviour change (Shahab *et al.,* 2007; Gibbons *et al.,* 2005; Mahler *et al.,* 2010). However, research has also suggested they can lead to anxiety (Carlin *et al.,* 2014; Ogden *et al.,* 2009) or false optimism about recovery (The *et al.*, 2003).

A systematic review has found that patient specific images (including UV photographs of skin damage, ultrasonography images of arteries and CT images) may be beneficial to promoting positive health behaviours such as sunscreen use. They may also increase intention to change negative health behaviours such as smoking, sunbathing and the use of tanning booths (Gibbons *et al.*, 2005; Hollands *et al.*, 2010; Mahler *et al.*, 2010; Shahab *et al.*, 2007).

Carlin *et al.,* (2014) found that patients who viewed X-rays, MRI or CT images reported better understanding of their diagnosis and felt that the image validated their emotional response to their injury. They also found that patients with skeletal injuries had a greater desire to see their images (Carlin *et al*., 2014).

Weiner *et al*., (2013) found that patients who viewed their chest CT images during their consultations about intermediate pulmonary nodules found them helpful. Patients tended to assume the nodules were cancer and therefore effective communication and reassurance was required, particularly when patients were recommended surveillance over biopsy as the treatment plan. Patients reported seeing the nodule on their CT scan or having a hand drawn sketch of the lung with nodule to be helpful. This helped them gain an understanding of the size of the nodule in relation to the size of the lung and could help them to understand that the nodule was too small for biopsy or treatment. Patients reported that being given the measurements of the nodule, two millimetres for example was unhelpful as it was meaningless to them without being able to understand its size in relation to the size of the lung (Weiner *et al.,* 2013).

In contrast, Carlin *at al.,* (2014) and Ogden *et al.,* (2009) found that viewing their own medical images could result in patients feeling anxious. Ogden *et al.,* (2009) compared the experience of women viewing the screen during a hysteroscopy procedure to those who did not view the screen while Carlin *et al.,* (2014) interviewed patients who were shown 2D images during a clinical consultation. Although Carlin *et al.,* (2014) found patients who viewed their images reported feeling anxious they did not compare patients who viewed their images with patients who did not. It could therefore be possible that patients who did not view their own medical imaging results were as or more anxious after their consultation.

Existing studies have tended to include mostly older patients (mean age > 60 years) (Carlin *et al.*, 2014; Shahab *et al.*, 2007; Wiener *et al.*, 2013) Therefore, little is known of the effect of viewing images on a broader age range.

To date limited research has explored the practice of sharing 3D images with patients. One area where the use of 3D images has been studied is ultrasound in pregnancy.

Expectant mothers undergoing 3D ultrasound images describe the experience positively using terms such as “amazing” (Ji *et al.*, 2005). Seeing the foetus through ultrasound images (2D, 3D and 4D) has been suggested to promote bonding (Ji *et al.*, 2005; Roberts, 2012). Ji *et al.,* (2005), for example, found 70% of 50 mothers undergoing 3D ultrasound felt they knew the baby immediately after birth compared to 56% of mothers undergoing 2D ultrasound. Visualising the foetus is also argued to encourage positive health behaviours, such as reduced alcohol intake during pregnancy, as bonding is believed to create a desire to protect the foetus (Waldenström *et al.*, 1988). The importance of ultrasound images as a bonding tool is contested. Roberts (2012) argues that women may not wish to bond with their foetus at such an early stage, especially if they have previously experienced miscarriage. Roberts (2012) also insists that bonding can be achieved without medical intervention through massage, singing or talking to the foetus.

Expectant mothers in routine antenatal consultations, such as the dating scan at 12 weeks, are a unique group of patients. They will not receive a diagnosis, be expected to undergo treatment or make treatment decisions. Therefore, research with expectant mothers has not focused on the impact of the images on recall or comprehension of information relating to diagnosis, prognosis or treatment options and the findings from these consultations may differ to other clinician – patient interactions.

3D images have also been used during the preoperative consent process (Morris & Van Wijhe, 2010). Morris and Van Wijhe (2010) found that patients with cholesteatoma (abnormal skin cell growth in the middle ear) reported better understanding of their condition when they were shown 3D images during the consent process.

Research has shown that the use of pictures, 2D images and potentially 3D images may be helpful when shown to patients either alongside medical information delivered verbally or in writing. Research exploring the benefits of showing 3D images to patients, however, remains limited.

2.4. Psychological theories of attention

In order to process a medical image, patients must be able to attend to it. There are several theories from the attentional literature that predict different outcomes for whether presenting patients with a medical image would be helpful in terms of them being able to better understand their diagnosis or harmful in terms of overwhelming patients with too much information. The term 'attention' refers to a cognitive process that enhances some information or stimuli at the expense of others. This enables individuals to select the most relevant information and ignore information that is irrelevant to them (Chun & Wolfe, 2001).

Research into attention increased after World War II because of the observation that pilots were struggling to use information when it was presented from several sources concurrently (Styles, 2006). This observation highlighted the limitations of information processing in humans and our inability to process multiple stimuli from multiple sources. This section will firstly consider the limited capacity of human attention and will then discuss how attention varies across modalities.

2.4.1. Human attention

At any given time, the human senses are being bombarded with multiple sources of information. The human cognitive system uses attentional mechanisms to filter out irrelevant information in favour of processing more important information for the current goal (Styles, 2006). These mechanisms prevent the cognitive system from being overwhelmed by information processing. Attention allows our limited cognitive resources to be allocated to a certain stimuli that the individual wishes to focus on (Styles, 2006). When attention is focused, much of the environment is ignored without conscious awareness (Drew *et al.*, 2013). An example of this can be seen in cases of inattentional blindness (as previously described). Simons and Chabris (2011) demonstrate this effectively through an experiment where participants failed to notice highly salient events when they were concentrating on other things. In their study, participants were instructed to watch a video in which six players, three wearing black shirts and three wearing white were passing two basketballs. Participants were asked to count the number of passes made by the players in the white shirts. During the video, a man dressed in a gorilla costume slowly walked through the players, stopping in the middle to thump his chest before continuing to walk to the other side. Only 50% of the participants reported seeing the gorilla after watching the video. Simons and Chabris (2011) concluded that by focusing attention on counting the passes, important changes within the video were completely ignored (Simons & Chabris, 1999). Inattentional blindness has also been demonstrated in a clinical setting where multiple clinicians including radiologists failed to notice a guidewire that had been left in a patient's chest (Lum *et al.*, 2005). The guidewire was clearly visible on a chest CT and three x-rays but due to the radiologists' inattention of the unexpected item it was five days before it was detected and removed. Clearly, this example suggests that medical images used in clinical consultations are susceptible to limitations of attention and could result in both clinicians and patients missing information.

In order to understand how patients may process information shown to them on medical images it is important to understand how people control their attention. Individuals can be easily distracted by new and changing stimuli within the environment and attention can be altered automatically to focus on the novel stimuli (Styles, 2006). From an evolutionary perspective, this is beneficial, as the ability to detect potential dangers through sight, sound or smell is imperative for self-preservation and survival (Styles, 2006). In a clinical context, patients may allocate their attention to the information provided to them during their consultation. However, they may be unable to maintain their attention throughout their entire consultation, particularly if there are interruptions during the conversation. Furthermore, some research has suggested that there is a dual-task deficit of conversing and attention, where the act of conversation impairs attentional processing (Kunar *et al.,* 2008) and vice versa (Becic *et al.*, 2010). This has implications for clinical practice, as it is important to determine whether the act of having patients attend to an image interferes with what they understand from the doctor-patient dialogue.

Several theories have been proposed to explain how the active allocation of attention to stimuli occurs. The main argument between the different theories is the time at which the selection of relevant stimuli occurs (Chun & Wolfe, 2001). Early selection theory claims that active selection of relevant stimuli occurs early on in the cognitive system, with the information that is deemed irrelevant and therefore not allocated attention not processed beyond its initial characteristics (Broadbent, 1958). Late selection theory, on the other hand, argues that active selection does not occur until all the information is processed, analysed and categorised and it is only at this point that irrelevant information is discarded (Deutsch & Deutsch, 1963). Attenuation theory appears to offer a compromise of the two positions (Treisman, 1964). Attenuation theory suggests that depending on task demands there is an attenuation of irrelevant information. The information is processed but not to the same extent as the information that is attended to (Chun & Wolfe, 2001). More recent research suggests that attentional processing depends on the perceptual load of a task (Lavie, 1995). If the perceptual load of a task is low (denoting an easy task) then there is more attention available to process other available information. In contrast if the perceptual load of a task is high (denoting a more difficult task) then there is less attention available to process other information. This is an important point to consider when showing medical images to patients alongside a consultation. If showing patients a complex image results in a high perceptual load then they may have fewer cognitive resources left to pay attention to the spoken part of the diagnosis in comparison to a condition when no image was shown.

In contrast, showing participants a medical image may help them attend better to the diagnosis. Attention can be allocated to a variety of tasks, including visual, auditory and tactile tasks. Existing research examining the limitations of human attention has observed that, although it is difficult to attend to two stimuli presented to the same modality, if stimuli are presented in different modalities there should be little attentional impairment (Wickens, 1980). That is, although people will find it difficult to process two simultaneous visual stimuli, they would be able to allocate attention to both a visual task and an auditory task at the same time without difficulty (Styles, 2006). This could be the case within a clinical consultation. Patients can look at visual stimuli, such as an image, while they are participating in a conversation with their clinician without any attentional impairment.

2.4.2. Cross modal attention

Existing research has suggested that when attending to multiple signals detected by the different senses, one sense becomes dominant. The way the senses interact with one another is known as cross modal attention. Vision is believed to be the dominant sense in the majority of contexts and can modify the way in which information detected by the other senses is perceived. Additionally, information from two or more different senses can become merged. This can result in either an inaccurate representation of the sensory information or a representation of the information that is more accurate (Styles, 2006). McGurk and MacDonald (1976) examined cross modal attention, specifically the merging of auditory and visual information by looking at lip reading. They found that when a video of someone saying ‘ba’ was synchronised with a voice saying ‘ga’, the vast majority of participants (98% of adults and 80% of preschool children) reported hearing neither of these two sounds but instead heard ‘da’ (McGurk & MacDonald, 1976). These findings support the theory that the processing of auditory and visual information can be integrated.

Psychological studies and illusions have shown the dominance of visual over tactile and auditory stimuli. The rubber hand illusion, first described by Botvinick and Cohen (1998), is a commonly referred to example which demonstrates this effect between visual and tactile stimuli (Botvinick & Cohen, 1998). Within this experiment the participant’s hand, hidden under the table, is stroked simultaneously with a rubber hand on the table in front of them. Although participants are aware that the rubber hand is not in fact theirs the illusion results in them inaccurately judging the location of their own hand, believing that it is closer to the rubber hand than it actually is (Ijsselsteijn *et al.*, 2006). The ‘rubber hand illusion’ experiment has been replicated and extended, with recent experiments using a virtual hand in place of the rubber hand (Ma & Hommel, 2013). When the rubber or virtual hand is attacked or injured a strong affective response is found in participants, as measured by skin conductance response (Armel & Ramachandran, 2003; Ma & Hommel, 2013). The ventriloquists dummy is an illusion demonstrating how auditory stimuli can be modified by the dominant visual stimuli (Styles, 2006). A ventriloquist’s dummy appears to be talking as the audience can see its lips move in synchrony with the words of the ventriloquist, whose lips appear closed. From the audience’s perspective, the sound appears to be coming from the dummy even though they are aware that this is not possible (Styles, 2006). These experiments suggest that visual information has more attentional weight compared to tactile or auditory information. If this is the case, then giving people visual information in terms of showing them an image during a clinical setting may help people attend and understand their diagnosis.

2.4.3. Examples of applied research questions tested in the laboratory

Current understanding of attention has developed as a result of numerous experimental studies (Styles, 2006). Many applied research questions can be tested using an experimental design in a laboratory and there are many benefits of being able to do so. For example, using an experimental design allows for stricter control over extraneous variables and allows researchers to recruit more participants than an applied setting, achieving greater statistical power. Laboratory experiments can be categorised in to two types: basic experiments or applied experiments, which will now be discussed in turn.

Basic experiments are used to generate theories that are applicable to everyday contexts using conditions that are easy to manipulate, control and measure (Goodwin, 2008). Findings from basic laboratory experiments into human attention have been applied to driving (Kunar *et al.,* 2008). Kunar *et al.,* (2008) studied participants’ ability to complete a multiple object tracking task (MOT) while listening to differing forms of auditory stimuli (participation in a telephone conversation or listening to an auditory narrative) or no auditory stimuli. In each condition, participants were required to follow four of eight grey disks. The eight disks moved in unpredictable, random trajectories over the computer screen but never occluded one another. Participation in the telephone conversation used hands-free to prevent performance deficits as a result of motor interference. Within the narrative condition, participants listened to the passage via a headset. They were instructed to pay attention because they would be asked questions about the passage at the end of the experiments. MOT performance was disrupted when participants participated in the telephone conversation condition but no effect was found as a result of listening to the narrative (Kunar *et al.*, 2008). The experiment was then repeated with additional conditions. The additional conditions each had different auditory stimuli. In one condition, participants were required to repeat words that they were given and in another condition, participants were required to generate a new word in response to the given words. MOT performance was disrupted in the word generation but not the word repetition condition. The findings of this experiment indicate that it is word generation that disrupts performance of sustained visual tasks, such as driving, rather than listening or speaking. These findings reinforce the dangers associated with conducting telephone conversations whilst driving. They demonstrate that it is not possible to sustain visual attention, which is essential for drivers in order to be aware of the changing environment around them, during a conversation. The findings also suggest that listening to the radio or singing along to music is likely to be okay. They do however raise questions about the possible dangers of participation in conversations with passengers whilst driving as this too requires word generation and so therefore may disrupt performance of visual tasks. Finally, these findings also support the theory of cross modal links between visual and auditory attention, with interference resulting from generation of speech rather than an inability to process auditory and visual stimuli simultaneously (Kunar *et al.*, 2008).

Applied experiments have also been used to study the dangers of telephone conversations whilst driving, drawing upon methods used in basic experiments (Strayer *et al.*, 2004). Strayer *et al.,* (2004) used a simulated driving task to compare the effect of telephone conversations on the amount of visual information seen and recalled. The stimulator used a steering wheel, dashboard and brake pedals and displayed realistic scenes and traffic conditions. The experiment had two conditions. In the first condition, participants completed the driving task alone and in the second condition, they participated in a hands free telephone conversation with the research assistant whilst completing the simulated driving. Sixty objects that could occur within a driving scene were used within the experiments. These included objects such as pedestrians or trucks. Within each condition, 30 of the 60 objects were displayed in the scene. Counterbalancing was used to ensure that the different objects appeared in an equal number of experiments and in different orders. After the experiment, participants' ability to recall the objects that they had seen whilst driving was assessed. This was done by presenting the 60 possible objects in pairs – one that had been displayed and one that had not. Eye tracking data was also collected to determine whether the participants directed their gaze at the objects. No significant difference was found in eye tracking between the two conditions. Recall of the objects seen during the simulated driving was better when participants were completing the driving condition alone in comparison to when they were completing the driving condition and talking to the research assistant. These findings suggest that drivers may fail to see objects within the environment when participating in a telephone conversation, even when they direct their gaze upon the object. Strayer *et al.,* (2004) conclude that this is due to their attention being directed elsewhere.

Findings from both basic and applied experiments such as these not only have real world applications such as driving safety, they also further understanding of theory. These two studies contribute to the large body of work examining human attention with findings supporting theories of limited attention and processing ability, as they again demonstrate that we are unable to attend to and process all the information available to us at a given time. The findings also raise questions about cross modal attention and our ability to attend to more than one mode of stimuli at a given time.

2.5. Chapter Summary

This chapter has outlined four bodies of literature. The first two sections of this chapter highlighted the discrepancy between the public and media's perspectives of medical images and the reality. The first section discussed the uncertainty associated with interpreting medical images by outlining psychological literature examining visual search performance and errors in image interpretation. This is in contrast to the second section, which presented the perspective of medical images as truthful and authoritative. Consequences of this perception, such as the overuse of imaging tests, were also discussed. This perspective is revisited throughout the thesis and in part, forms the rationale for one aspect of experiment two conducted in study four, as described in Chapter Six.

The final two sections of this chapter presented two areas of research, which formed the rationale for this research project. Communication in healthcare literature and psychology literature addressing visual and auditory attention suggest that it is worth studying the use of 3D images within consultations in order to understand if they can be helpful to patients. Communication in healthcare literature has highlighted the need to improve clinical communication and increase patient understanding. The potential for patients to benefit from viewing images (including pictures, diagrams and 2D images) during a clinical consultation has also been raised, with reported benefits including increased patient understanding and satisfaction. Study one (Chapter Three) seeks to build upon these findings by exploring patients experience of viewing their own 3D image during a clinical consultation. Psychological literature has emphasised the ease at which individuals are distracted from sensory information, including auditory stimuli. The suggestion that vision is the dominant sense suggests that benefit could be gained from presenting information to patients in this form. The combination of auditory stimuli from the conversation with the doctor and the use of an image may improve the patient's attention to the message that is being communicated. The image may aid the patient to maintain focus. In contrast, the image could further distract the patient from the auditory message or lead to it being inaccurately assimilated. This will be explored in an experimental study (Chapter Six) which will compare participants' experience of hearing a diagnosis with and without an image.

This review of the literature suggests that an exploratory study could be useful to understand the impact of the image when presented alongside auditory information.

Part Two

Chapter Three: Understanding the experience of viewing a 3D image within a clinical consultation: an orthopaedic clinic case study

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3.1. Background literature summary

Existing research has indicated that some patients struggle to comprehend and recall medical information (Kessels, 2003; Marty *et al.*, 2013; McCarthy *et al.*, 2012). Pictures (Houts *et al.,* 2006; Vilallonga *et al.,* 2012), photographs (Gibbons *et al.,* 2005) and medical images including 2D CT and ultrasound images (Carlin *et al.,* 2014; Shahab et al., 2007; Wiener et al., 2013) have been reported to be helpful in aiding patients' understanding of medical information and promoting behaviour change. Other benefits of presenting patients with their own medical imaging results reported in the literature are the ability for patients to visualise their problem (Wiener *et al.*, 2013) and providing reassurance to patients (Carlin *et al.,* 2014). Disadvantages of showing patients their own medical imaging results have also been reported. They may result in false optimism (The *et al.,* 2000) or anxiety (Carlin *et al.,* 2014; Ogden *et al.,* 2009). Existing studies have included older patients (mean age > 60 years) with the effect of viewing images on a larger age range relatively unknown (Carlin *et al.,* 2014; Shahab *et al.,* 2007; Wiener *et al.,* 2013).

3D images are available for use in clinical practice. Although their use within the UK is fairly limited, they are shown to patients within clinical consultations about certain health conditions. They are relatively easy to interpret and could benefit lay people.

In medicine, the improvements to medical imaging are considered to benefit diagnosis and treatment planning. However, from a sociological perspective the portrayal of medical imaging can be problematic. Based upon observation of the way in which MRI is presented by the media, scientists and medical professionals, Joyce (2005) argues that medical images are often portrayed to depict the truth, to have agency and to be authoritative. Several specific concerns resulting from this portrayal have been raised including overuse of imaging (Gelb et al., 1996; Joyce, 2005; Roberts, 2012); disregard for other forms of information (Blaxter, 2009; Reventlow et al., 2006; Roberts, 2012); passivity on part of the patient (Griffiths *et al.*, 2010); impairment to the doctor patient relationship (Gunderman, 2005; The *et al.*, 2003) and fragmentation of the patient (Blaxter, 2009).

This study explored whether 3D images may be of benefit to patients when shown by their clinician during a clinical consultation. A full discussion of the relevant published literature can be found in Chapter Two.

3.1.1. Research questions

Using an orthopaedic tertiary care outpatient clinic as a case study, study one addressed the following questions:

1) How are 3D images used within the case study clinic?
2) From the perspective of the patient, clinician and an observer, what is the impact of the patient's own 3D image when viewed during a clinical consultation on:
   - Clinical communication?
   - The patient's understanding of their illness?
   - The patient's trust in their diagnosis and clinician?
   - The patient's role in treatment decision-making?

3.2. The case study clinic

Patients and their clinicians were recruited from a tertiary care orthopaedic hip clinic in the West Midlands. The clinic sees patients up to the age of sixty with a variety of hip complaints with the aim of preserving their native hip. One of the main conditions patients attending the clinic are diagnosed with is FAI. FAI is a condition in which the shape of the hip joint is abnormal. The abnormalities are categorised as either CAM or pincer deformities or both. CAM deformities describe additional bone on the femoral head neck-junction whilst a pincer deformity refers to additional bone around the acetabulum. The additional bone limits the range of movement that a patient can make before the acetabulum (hip joint socket) impinges with the femoral head-neck bone (ball). This can cause damage to the cartilage and labarum within the joint as well as pain during certain movements or at rest (Royal Berkshire NHS Foundation Trust, 2011).

Athletic or active individuals may be more likely to suffer from FAI due to the way in which they use their hips. The range of movement required to participate in activities such as football, aerobics and dancing can cause earlier impingement (Oxford University Hospitals NHS Foundation Trust, 2016). Treatments for FAI include, adjustments to lifestyle, physiotherapy, hip arthroscopy (a key hole operation to alter the shape of the bone) and total hip replacement.

Patients attending the case study clinic usually have two clinic appointments on the same day. During the first appointment, which is in the morning, patients see a clinician (either a doctor nearing completion of their specialist training in orthopaedics or a physiotherapist) who takes a patient history and conducts a physical examination. Patients also have their imaging tests in the morning before returning to the clinic in the afternoon. The clinic team meet with a consultant radiologist prior to the afternoon consultations to discuss each patient and their imaging results. During the afternoon consultations patients tend to see the clinician they saw in the morning again along with one of the clinic's two consultants. Patients are often shown their medical imaging results during this consultation and diagnosis and treatment are discussed.

Within the case study clinic, clinicians use 3D images to gain greater visualisation of the shape of the bone. They are also shown to patients.

3.2.1. Clinic selection

Further clinics to study were sought. These included additional orthopaedic clinics (specifically two knee clinics and a shoulder and elbow clinic), a colorectal cancer clinic and a cardiology clinic. Clinicians, particularly the consultant within the colorectal cancer clinic, were interested in using 3D images and were already using 2D images and diagrams during some consultations. 3D images were not always available or appropriate for use in the clinics considered. Within one of the knee clinics and the shoulder and elbow clinic, this was because patients often had CT scans after their consultation and so it would not be possible for a 3D image to be available at the time of the consultation. Within the colorectal cancer clinic, this was because the majority of patients did not have the correct type of CT scan (i.e. with gas in the bowel) to allow a 3D image to be produced. Within the second knee clinic the room layout did not lend itself to sharing images with patients, as computers were not located in the immediate area where the consultations took place. Additionally, only a few patients had CT scans before their clinic appointment, which would make recruitment difficult. The cardiology clinic was also deemed inappropriate for this study, as many patients attending the clinic were not given a diagnosis and required no treatment. This would make recruitment difficult with many patients invited to participate becoming ineligible once the clinical team had reviewed their results.

3.3. Statement of methods and justification for the study design

This study adopted a qualitative approach, using individual, semi structured interviews with patients and clinicians, non-participant observations and video-recorded consultations. As the impact on patients of viewing their own 3D images within clinical consultations is relatively unknown, with little prior research exploring this practice to date, an exploratory study was required. Qualitative data collection methods such as interviews and observations are widely used in exploratory research (Bryman, 2012).

Interviewing patients and clinicians provided two accounts of the consultation allowing insight from both parties participating in the interaction. Consultations were also observed by the researcher and video-recorded. Data collected from the video-recordings enabled confirmation of some of the themes raised by patients and clinicians at interview. Data collected through the non-participant observations was used to inform the interviews. Using different data sources enabled triangulation of data and increased confidence in the conclusions drawn from the data (Flick, 2004).

The rationale for selecting each method will now be discussed in turn starting with non-participant observation, followed by interviews and then video-recordings.

3.3.1. Non-participant observation

Non-participant observation, an ethnographic method, is used to understand "the social meaning and activities of people in a given field or setting" (Brewer, 2000, p.11). Behaviours and interactions are observed within naturally occurring settings which allows the research to understand how the field is experienced (Murchison, 2010). Non-participant observation can allow access to details that those within the field may not find noteworthy or that those within the field may be unaware of (Gobo, 2008). Non-participant observation can also overcome what Mays and Pope (1995) describe as "the discrepancy between what people say and what they actually do" (Mays & Pope, 1995, p.183). Individual accounts of their own behaviour are often inherently biased with individuals wishing to present themselves in the best possible light. In this study for example, clinicians may believe that the researcher considers sharing medical images with patients to be good practice, which could lead to them exaggerating their use of medical images at interview. Observing consultations, in contrast, allows the researcher to learn exactly how and to what extent images are used in the consultation. Furthermore, unlike other data collection methods, such as interviews, observation is not reliant on participants' memory of an event and could therefore capture more details than participants are able to recall (Mays & Pope, 1995).

Non-participant observation allowed understanding of how 3D images are used within the consultations and informed interviews. During the consultation, observation notes were made. They focused on: how and when the images were used; the patients' initial reaction to viewing the image and their subsequent behaviour and language and how the clinician spoke about the image. This provided access to details that patients and clinicians might have been unaware. All but one of the consultations were observed and so the interviews commenced with the shared knowledge that the researcher was present. This allowed questions to be tailored to ensure they were relevant. Non-participant observation also allowed the researcher to begin developing a rapport with the participants as they became more familiar with the researcher before their interview.

3.3.2. Interviews

Qualitative interviews are used to gain an in depth understanding of the interviewee's perspective on a phenomenon of interest as they allow the interviewee to talk freely without their ideas being confined (Fontana & Frey, 2008). They are widely used in exploratory research. As little is known about patients' experience of viewing their own 3D images an exploratory study is required, where interviewees have the opportunity to describe their experience using their own words as opposed to fitting their ideas into predefined categories. Face to face, semi-structured, individual interviews were deemed most appropriate for this study.

Face to face interviews were sought, where possible, as they can help the interviewer build rapport with interviewees. They can also allow the interviewer to view facial expressions and gestures that may reveal further information about the interviewees' experience (Bryman, 2012). A final benefit of face to face interviewing is the ability for the interviewer to detect signs of the interviewee becoming distressed more easily (Bryman, 2012). As this research is exploring a relatively sensitive topic, this is important and will allow the researcher to adapt the questions or offer more reassurance or comfort to the interviewee.

Semi-structured interviews were selected as the most appropriate method of interviewing for this study to ensure that the research questions were addressed within the interview and to allow flexibility to explore issues raised by the interviewees. During semi-structured interviews, the researcher asks open-ended questions to gain a rich insight into interviewees' experience and opinions (Bryman, 2012). In semi-structured interviews an interview guide, which contains a brief list of specific topics to be covered reflecting the research questions, is used (Fontana & Frey, 2008). Semi-structured interview guides are flexible; the structure can be altered if required and additional questions can be added in response to the interviewee's views. This allows exploration of ideas which participants find particularly meaningful (Fontana & Frey, 2008). Furthermore, in order to address all of the research questions in this study, several questions may need to be asked. It is unlikely that the response to one or two broad questions will sufficiently answer all of the research questions. The researcher will also be eager to gain an understanding of other ways that the interviewee feels 3D images impact upon them, either positively or negatively, that had not been foreseen and hence not included in the interview questions.

Individual interviews were selected over group interviews due to the nature of the topic to be discussed at interview. This research is seeking to understand the interviewee's individual account of their experience of viewing their own 3D images and therefore a group interview may not provide true accounts of each individual's experience. Participants of group interviews may be led by others within in the group (Bryman, 2012). They may also feel uncomfortable presenting opinions that differ from those of the other participants. Additionally, there could be an increased risk of distress to interviewees when conducting a group interview as the individual interviewee will not be able to control the direction of the conversation and focus on areas that are most relevant to them (Bryman, 2012). An area that is particularly important to one interviewee may be greatly distressing or of little relevance to others. Conducting individual interviews allows the researcher to follow the direction that is most appropriate for the individual interviewee's experience.

3.3.3. Video-recording

Video-recordings are increasingly used to investigate clinical communication. They can reveal detail and important insight into clinical practice that could be difficult to access using other research methods (Parry *et al.*, 2016). Video-recording a phenomena of interest, in this case clinical consultations, may also remove some of the bias that are introduced by the observer during non-participant observation (Mays & Pope, 1995). During observations researchers aim to record exactly what happens, however it is not possible to capture everything that occurs in the setting (Mays & Pope, 1995). The researcher's own thoughts and responses to what they observe can influence the aspects deemed most salient or the way in which the aspects of the phenomena are perceived, potentially introducing bias to the data. Video-recording consultations can also result in a more complete data set as note-taking during or after observations can result in some data being missed. If the researcher records their notes after observation their memory may be impaired, but the researcher could miss important aspects of the interaction if notes are made during it (Corbetta, 2003). For this study, consultations were video-recorded for several reasons. Video-recorded consultations were analysed using the themes that emerged from the interview data, allowing confirmation of conclusions drawn from the interview data. Video-recordings allowed understanding of how images were integrated within the consultations and how patients responded to their images during their consultation. Points raised during the interviews were also clarified, when required, by re-watching the consultations. Data collected from the video-recorded consultations were also used in study two (as presented in Chapter Four).

3.4. Methods

3.4.1. Recruitment and participants

Participants were recruited to the study from September 2014 until June 2015. All eligible patients attending the clinic during this time were invited to participate. They were informed of the study by letter. The letter, which was sent from the clinic's lead consultant, included a letter of invitation, an information sheet and an expression of interest form along with a stamped addressed envelope so that potential participants could inform the researcher of their interest in participating. An email address and telephone number were provided for potential participants to express their interest in participating or to contact the researcher should they have any questions. The letter was usually sent to patients with their clinic information pack, four weeks prior to their appointment date. As the clinical team initially assessed eligibility, the number of patients invited to the study is unknown.

Patients attending the participating clinic were only eligible to participate if they were aged 18 years or over and if they had an appointment for a CT scan to be conducted prior to the MDT held on the clinic day so that a 3D image would be available for viewing by the patient in the afternoon consultation. Only patients with a new referral to the clinic were invited to participate, as this is when the images are normally viewed. Patients were excluded if they were aged under 18 years or unable to complete an interview in English.

Patient participants (hereafter referred to as patients) provided written informed consent for each element of the study. Informed consent was received by either a research nurse, employed by the West Midlands National Institute for Health Research (NIHR) Clinical Research Network, or the researcher. This was usually done upon the patient's arrival at the clinic. Two patients were not recruited until after their first clinic appointment. Participants were informed that they would still be able to participate in the other aspects of the study (i.e. non-participant observation and interview) should they choose not to consent to the video-recording of their consultation. Participants were recruited until data saturation was achieved. This is when analysing data no longer provides further understanding of the phenomenon (Glaser & Strauss, 1967). Prior to data collection, it was anticipated that data saturation would occur between ten and 15 interviews as previous qualitative research has identified this as a typical sample required to achieve data saturation (Guest, Bunce & Johnson., 2006).

Within each clinic session, there were usually two clinicians conducting consultations and one consultant. The clinicians saw approximately half of the clinic patients each and the consultant saw all patients attending that clinic session. The clinicians and consultants varied across the course of the study. Although the majority of patients saw a clinician and a consultant, only the clinician was interviewed. This was because it was the clinician who conducted most of the consultation with the patient. A maximum of three patients were recruited per clinic session to ensure no disruption occurred to the running of the clinic. For Chapters Three and Four, to distinguish the data collected from the consultants in the clinic from the data collected from the junior doctors and physiotherapist the term 'clinician' will be used to refer to the junior doctors and physiotherapist who participated in this study while the term 'consultant' will be used to refer to the two consultant participants.

All clinicians providing consultations to patients within the clinic were informed of the study. Consent to participate was received from clinicians conducting consultations with recruited patients. Consultants seeing patients in the clinic participated in the observation and video-recorded consultations. Retrospective consent was received from consultants.

3.4.2. Data collection

Patients attending this clinic are routinely shown their imaging results, including their 3D images, during their consultations. Clinicians were instructed to continue their normal practice during the study period. Interviews with patients explored the patients' experiences of viewing their 3D image and their experiences of their clinician and consultation. Interviews with clinicians explored the use of the images with each participating patient, as well as the use of 3D images within the clinic more generally. The research questions and published literature were used to develop interview guides. Interviews with patients were conducted face to face, by telephone or via Skype depending on the patient's preference and interviews with clinicians tended to be conducted face to face immediately after the clinic session. The consultations were video-recorded and observed by EP, where possible. EP was able to probe during interviews based on the individual consultation by using the observation notes. The video camera was placed in the consultation room prior to recruited patients' consultations. The video camera was directed towards the computer and desk within the room. This is usually the centre of the interaction as it is usually between the patient and the clinician. In this position, the camera captures the use of the image and the interaction surrounding it as the image is presented on the computer. This position also ensured that any physical examinations were not captured. The camera was only present in the consultation room for consultations where patients and clinicians had given consent for recording. The materials from this study can be found in appendices 1- 8.

3.4.3. Ethical considerations

This study was approved by the West Midlands NHS research Ethics Committee (Study Number: 150177).

3.4.4. Data analysis

Thematic analysis, as described by Taylor and Broad (1984) was used to analyse the interview transcripts and video-recordings. Before coding, EP listened to the audio recordings, transcribed the recordings and studied the transcripts to become immersed in the data (Ritchie & Spencer, 2002). The data was managed and coded using Nvivo 10.0. There were eight codes in total, five of which were based upon the study protocol and relevant research literature. A table presenting themes by participant can be found in Appendix 9. Initial coding of the data involved specifically searching the data for text relevant to these five codes. All remaining data relating to medical images within the interview transcripts were also coded and this resulted in three broad codes emerging during the analysis. In order to develop the analysis further after coding, a framework approach was used (Ritchie *et al.*, 2003). This method allowed constant comparison across and between cases. For each code, a separate table was created. Each table contained 14 rows and three columns; with one row per case and columns for patient data, clinician data and data from the video-recorded consultations, (an example table can be found in Appendix 10). Data analysis was conducted alongside data collection. This allowed refining of the interview topic guide and confirmation of data saturation. Video-recordings were analysed using a framework based upon the codes from the interview data. Recorded consultations were watched at least twice and in some cases three or four times. Any content relating to the codes was either transcribed or noted. EP read all of the data and the researcher supervisor (FG) read one third of the data. EP and FG discussed the codes and themes through-out the analysis. This allowed the reliability of the coding to be confirmed (Graneheim & Lundman, 2004).

3.5. Results

3.5.1. Participant characteristics

3.5.1.1. Patient recruitment and characteristics

Twenty-two patients were recruited to the study. Of the 22 patients, four consented but did not participate in the interview, observation and video-recording of their afternoon consultations. For one patient, this was because during the morning consultation the clinician decided the patient did not require any imaging tests, including the CT scan that was required for the 3D image or an afternoon consultation. For two patients, on viewing the 3D images the consultant decided that they would not be shown. This was because their abnormality related to soft tissues rather than bone and would be more suitably presented using 2D rather than 3D images. For the remaining patient, EP was unable to observe or video-record the consultation as it was at the same time as another recruited patient's consultation. This patient then withdrew before interview. A further patient consented to participate in the observation and the interview but not the video-recording of the consultation. However, she withdrew from the study before the interview. A further three patients participated in the video-recording and observations but were not interviewed as no images were shown during their consultations. This left 14 patients. Two of the recruited patients were shown only 2D images. For one patient (P12), this was because there was no 3D image available. In the other consultation (with P9) the clinician chose not to show the 3D images, showing the patient 2D images only. All 14 recruited patients participated in the interview, 13 in the observation and 10 in the video-recording. Consultations with four patients were not recorded. For one consultation this was because the patients' consultations overlapped with other recruited patients, so video equipment was not available and for the other three the video-recordings failed.

The majority of patients were white (93%), male (64%) and educated to A-level or above (57%). The mean age of patients was 38.3 (range 22- 50). Table 1 presents participant characteristics. Many patients travelled far to attend the clinic with only two patients living within 20 miles of the clinic and four patients living over 100 miles away. All recruited patients had seen previous consultants or other healthcare professionals (such as physiotherapists) prior to their appointment, with the onset of their symptoms or initial injury ranging from 12 months to 12 years before their appointment. Several patients had stated that this was their clinic of choice or that the consultants had been recommended to them. One patient (P8) had previously attended the clinic and had surgery by one of the clinic’s two consultants. He had since been discharged and attended the clinic with a new referral after his symptoms returned. Eleven patients mentioned previous experience of viewing their own medical imaging results while three patients said they had not seen their medical imaging results before. In addition to viewing their own medical imaging results, two of the patients (P1, P4) mentioned further experience of medical imaging; one through family members with knowledge of medical imaging and the other through research on the internet. Although patients had previously seen their medical imaging results, these tended to be X-ray, MRI or arthroscopy images. No patient mentioned having previously seen a 3D CT image. Two patients (P1, P6) had extensive knowledge of the hip joint prior to their appointment at the clinic, gained through either their work or their family members and their experiences relating to their condition. Half of the patients recruited were interviewed immediately after their consultation. These interviews were conducted face to face at UHCW. A further two patients were interviewed face to face, one thirteen days later in his home and the other twenty days later at Rugby St Cross Hospital when attending for treatment. One patient was interviewed via Skype seven days after her consultation. The remaining four patient interviews were conducted over the telephone up to six days after their consultation.

Table 1: Patient Characteristics

Patient Characteristics	Number
Age	
20-29	4
30-39	2
40-51	8
Gender	
Male	9
Female	5
Race	
White	13
Mixed	1
Education	
Degree	5
A level	2
Other	5
None	1
Unknown	1
Diagnosis	
FAI	10
Other	4

3.5.1.2. Clinician recruitment and characteristics

Table 2 presents clinician characteristics. Five clinicians and two consultants were recruited to the study. Of the five clinicians, one was excluded after participating in the observation and video-recordings as his patients were not shown any medical images during their consultations. These video-recordings and observation notes were not used in the analysis. This left a total sample of four clinicians who each saw between two and six patients. One patient was only seen by a clinician and not a consultant. All clinicians and consultants recruited to the study were male. One was a physiotherapist who had worked in the clinic for approximately seven years and three were doctors who were nearing completion of their specialist training in orthopaedics. Interviews with clinicians were conducted face to face immediately after the clinic session, where possible. In two cases, this was not possible, with one clinician interviewed two weeks after the consultation and the other completed in writing within three days of the consultation.

Table 2 presents clinician characteristics.

Clinician Characteristics	Number
Gender	
Male	4
Role	
Fellow	2
Registrar	1
Physiotherapist	1
Number of times interviewed	
Clinician 1	4
Clinician 2	2
Clinician 3	2
Clinician 4	3
Number of patient consultations	
Clinician 1	6
Clinician 2	3
Clinician 3	2
Clinician 4	3

3.5.2. Outline of results

This section, divided into four parts, will first outline how medical images are used within the clinic and present example images. Second, patients' experience of viewing their own 3D imaging results from their own perspective and the perspective of their clinicians and an observer through video-recorded consultations will be explored. Third, practical considerations related to sharing images with patients as raised by patients and clinicians will be presented. Finally, the perception of 3D images as truthful and authoritative will be discussed. A diagram presenting the four parts to the analysis can be found in Figure 4. In the results, the participants are numbered to preserve anonymity. Patient participants are prefixed with 'P', clinician participants are prefixed with 'C' and data collected from the video-recordings are prefixed with ‘VR’ followed by the prefix of the speaker. Quotes from consultants, taken from the video-recordings are prefixed with ‘consultant’.

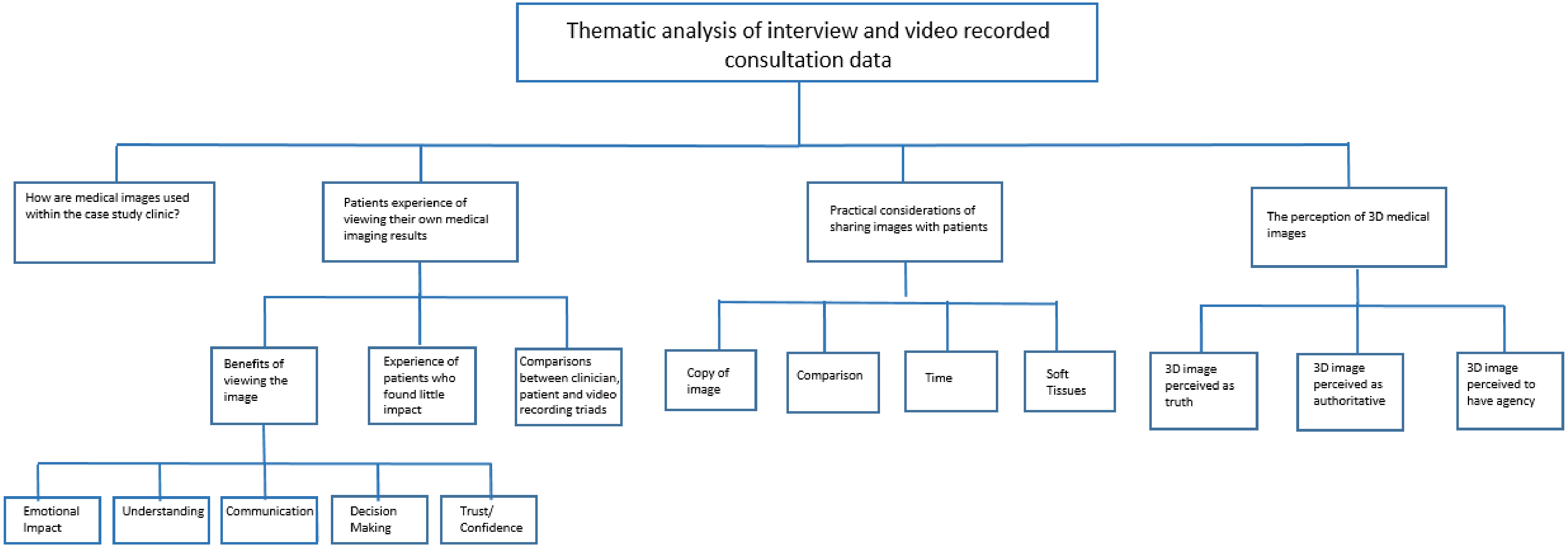

Figure 4: Diagram showing the four part of analysis.

The first part of the analysis (how are medical images used within the case study clinic?) provides a description of how the images were used based on the video-recorded consultation data. Sub themes are presented for the three overall themes (patients' experience of viewing their own medical imaging results, practical considerations of sharing images with patients and the perception of medical images).

3.5.3. How are 3D images used within the clinic?

Images (including 3D CT reconstructions, MRI images, 2D CT images, X-ray images and diagrams) are shown to patients when discussing diagnosis and treatment options in the clinic. Patients attending the clinic undergo different imaging tests depending upon their symptoms, patient history and referral information. Many patients are shown more than one image, with the specific images shown dependant on the nature of the patient's problem. Examples of the types of images viewed by patients in the clinic are presented in Figures 5 – 9 below.

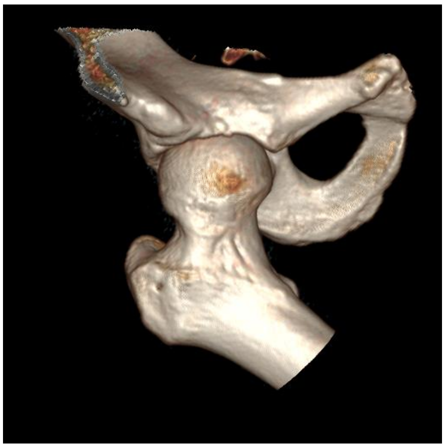

Figure 5: 3D CT image of the hemi-pelvis

3D images are generated from the digital data of CT scans. They can be rotated to view the hip from different angles. In this clinic the 3D images produced show only bone. 3D images were shown to patients to explain abnormalities of the shape of their bones and where the shape of the bones could be revised through surgery.

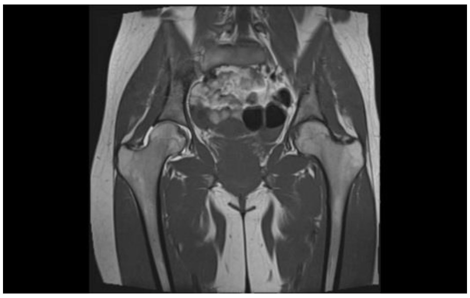

Figure 6: Coronal MRI of the hips and pelvis

MRI images can present soft tissues as well as bone at multiple cross sections of the joint. These are presented in stacks that can be scrolled through. MRI images are used within the clinic to show damage to the cartilage or labrum.

Figure 7: Axial CT image of the hips

2D CT scans display bones at different cross sections of the joint. These are also presented in stacks that can be scrolled through. Within the clinic, they were used to compare cartilage between the patient's symptomatic and asymptomatic hip, demonstrate loss of joint space and show osteophytes- additional bone, which has grown on the joint. They were also used within the clinic to show early signs of arthritis and were used to answer questions about arthritis.

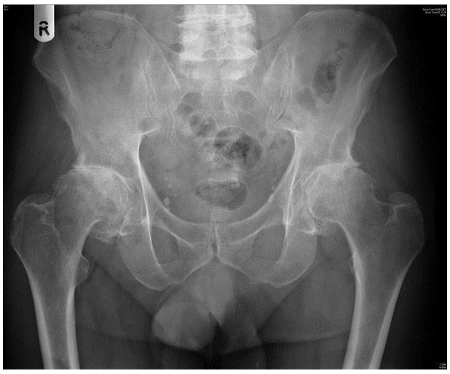

Figure 8: X-ray of the hips and pelvis

X-ray images show a 2D image of the bones from one viewpoint. They are used to examine and demonstrate to the patient the space between the femoral head and the acetabulum. They allow comparison of the joint space between hips and can indicate the condition of the cartilage.

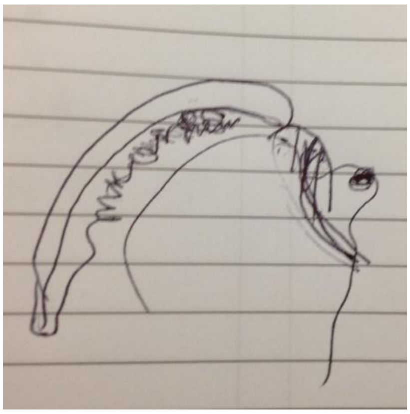

Figure 9: Diagram of the hip joint

Diagrams drawn by the clinician can provide patients with a simple representation of the joint. The diagram above was used to demonstrate the normal shape of the femoral head as well as wear and tear and extra bone.

3.5.3.1. Images seen by recruited patients

Twelve of the 14 patients were shown a 3D image and seven of these twelve were also shown other images. Two patients were shown 2D images only (as explained in section 3.5.1.1). Table 3 presents the types of images shown to each patient.

Table 3: Images shown to patients

Patient Number	Images shown to explain diagnosis and treatment
1	X- Ray, 2D CT, 3D CT, Diagram
2	X-Ray, 3D CT
3	3D CT
4	3D CT
5	3D CT
6	3D CT
7	3D, 2D CT
8	3D
9	X-ray, 2D CT
10	X-ray, 2D CT, 3D CT, MRI, Diagram
11	X-ray, 3D, MRI Diagram
12	X-ray, 2D CT
13	X-ray, 3D CT
14	X-ray, 3D CT MRI

3.5.4. The experience of viewing your own medical imaging results from patient, clinician and an observer's perspective

In this section, patients' and clinicians' perspectives on the impact for patients of viewing their own 3D image within a clinical consultation will be presented. First, the emotional impact of viewing 3D images will be outlined. Then, benefits for patients of viewing their image will be discussed. Benefits of viewing the images highlighted within the data were improved understanding of the condition; enhanced communication; assisted decision-making or behaviour change and increased trust or confidence in the clinician or treatment.

This will be followed by a discussion of the experience of patients who found limited impact in viewing their medical images.

3.5.4.1. Positive emotional impact

All patients who were shown a 3D image that depicted an abnormality during their consultation described the experience positively, using words such as "brilliant" (P14) and "fascinating" (P1) to describe their image. One patient explained that seeing her images reassured her that she hadn't damaged her hip by leading an active lifestyle and that she could now "move forward" (P14) as something could be done about her condition. Another patient said he felt justified having seen his 3D image, explaining that:

> I felt justified in pushing and going back every time to sort of get to this point… knowing that something was wrong and even though people couldn't find… couldn't sort of nail it down and they being able to nail it down sort of justified everything that I have done up until now (P13)

Two patients (P2, P11) said they felt relieved or less anxious after seeing their 3D image, as demonstrated by the quote below.

> I am a bit more relaxed about treatment because being able to see it I understand it better so I am not maybe as anxious about it (P2)

One of these two patients, however, explained that had his condition been worse than he was expecting, the image may have had the opposite effect. Additionally, patient 10 explained that she felt more anxious about the extent of her abnormality after viewing her image as "it's just never going to be a quick fix" (P10). She suggested that she may have felt better if she had not been shown her image by saying "I don't know whether it is better to be in the dark about that or not" (P10). However, she also said that she was interested in seeing the image and was glad that she had.

Clinicians said they believed the experience of viewing their own 3D images is a positive experience for patients. One clinician explained that 3D images, as well as other forms of imaging, could “improve their *(patients’)* hospital experience” (C3) and could be empowering for patients. Another clinician, however, said while that most patients enjoy seeing their 3D image, a minority of patients are uninterested.

Several patients appeared impressed by the images during their consultation, commenting, “they are terrific” (VR-P8); and “they are really good actually” (VR-P6) upon viewing their images. Patient 10 seemed very interested in her images and was the only patient to ask to see more images, specifically more MRI images. Additionally, one patient appeared overwhelmed during his consultation and this was acknowledged by his clinician who asked him “is that all a bit of a shock, you look a bit shell shocked” (VR-C2).

3.5.4.2. Improved patient understanding

Patients who were shown a 3D image that displayed an abnormality spoke about gaining understanding of their condition or potential treatment. Many patients demonstrated their understanding by explaining their condition in detail during their interview. One patient, who had been previously diagnosed with FAI, explained that the image and explanation improved his understanding of his condition, as demonstrated by the quote below:

> It makes me understand more about what’s going on in there because I didn’t fully understand what the problem was but seeing that and the way they explained it - it was 100% better (P3)

Patient 7 described the image as an aid which he felt “shone quite a large light” (P7) on the problem. He believed that he already had good knowledge of the hip and therefore felt the image could be of greater benefit to those who were less familiar with the joint.

When asked about the general use of 3D images within the clinic all clinicians said they thought the 3D image could aid patients' understanding. Patients' understanding was evident in the video-recordings. For example, one patient was shown where further resection of the bone could be done. The patient responded by saying that this clarified why the pain occurred with specific movements. Other patients asked questions specifically relating to the images or the explanation of the image, checking their understanding. The idea of a "light bulb" (P6) moment, the moment when an individual's understanding changes, was raised by one patient. Patient 6 explained this moment occurred for her father, who had accompanied her to her consultation, upon him viewing her image. She said that she had tried to explain her condition to him previously but that he had not understood until viewing her image. Clinician 1 said that he had observed this moment in his patients when showing them their 3D image. Furthermore, evidence of a "lightbulb moment" can also be seen for patient 10 though the recorded consultation.

3.5.4.3. A tool to aid clinician – patient communication

Three patients explained that the image reduced the use of medical jargon while another patient explained that the jargon didn't matter as he could see what was being talked about on the image as demonstrated through the following quote.

> When you could then physically see what they were looking for and you could see it, the terminology then sort of went in to insignificance because you then knew and you could see what it was that they were talking about (P13)

Clinicians 3 and 4 explained that they tried to use lay terms when communicating with patients and clinician 4 explained through the quote below that the image prevents him being "over technical" (C4).

> And I think with the images we can explain exactly what we mean in laymen's terms (C4)

The video-recordings revealed that medical jargon was used frequently by clinicians during the consultations but it was often explained. When discussing the images, clinicians tended to use basic language and less medical jargon, as demonstrated by the following quote; "That looks nice and smooth, suddenly this bit sticks out there" (VR8- Consultant 2). Patient 13 and clinicians 1 and 4 used the phrase "a picture paints a thousand words" when discussing the 3D image. This suggests that the image can present complex information more easily than can be presented using words. Additionally, patient 8 explained that if the doctor had just described the location of the abnormality without an image he would not have understood, again reinforcing the idea that the image is better able to present complex information.

3.5.4.4. Influencing patients' treatment decisions

Ten patients made a decision about treatment before leaving the clinic, including two patients who agreed to participate in a clinical trial. Four of the ten patients indicated that the 3D image aided their decision-making, as shown in the quote below:

> That's a good question, did they *(the images)* aid my decision… in my decision-making process yes completely (P1)

For one patient, viewing the image confirmed to her that she needed surgery as shown in the following quote:

> It *(the image)* confirmed the fact that I did need to go ahead with the surgery (P6)

One of the four patients, patient 8, initially said that the image did not affect his decision when asked about the role of the 3D image on his treatment decision. However, he later indicated that the image did play a role in his decision as demonstrated through the following quote.

> When he actually said surgery, I was a little bit shocked because it wasn't what I'd been expecting. But because of the imagery I very rapidly... it didn't take much time to align myself with the suggestion (P8).

Similar to patient 8, patient 13 also spoke about coming to a decision quickly after viewing his image explaining that:

> It *(the image)* made my mind up more or less on the spot… I knew what I wanted to have done in that I have it operated on (P13)

By comparison, one of the ten patients stated that the image had no role in his decision as he had decided on his treatment before attending the clinic. He explained that:

> I always knew that sitting and waiting wasn't an option… I don't think it (the 3D image) swayed me either way on the decision-making (P7)

Clinician 4 said that the 3D image could influence patients' treatment decisions. This included Patient 13 and a previous patient who he felt were reluctant to have surgery until viewing their images. He explained this through the quote below:

> When they actually see something there that probably shouldn't be there I think that's the thing, if the images showed nothing at all then you it (unclear) there's nothing wrong when they can actually see something I think it sort of tips them towards that *(surgery)* (C4)

Clinician 3, in contrast, said he believes patients trust their clinician to make treatment decisions for them. A change in the patients' preferred treatment was evident in two of the recorded consultations. From the video-recording it seemed that information delivered verbally about treatment influenced the patients' decisions, not their images. However, both patients indicated at interview that their image aided their decision-making.

3.5.4.5. Increasing patients' confidence

For some patients, viewing their 3D image increased their trust in their clinician, as demonstrated by one patient who explained "I am more trusting in him" (P2). Two patients, in contrast, described no longer being reliant upon trust after viewing their image, explaining:

> It *(the image)* enables you to understand what's going on so you are not in the dark; you are not just blind faith as it were (P14).

> Listening to your consultants simply give advice you are left with a big question mark… it's purely trust (P1).

These quotes suggest that for these two patients seeing their image provided them with greater confidence and certainty in the information they were given. On the other hand, several patients indicated that they already had trust in their clinician before viewing their image, with the image having no impact on their opinion of or trust in the clinician. Clinicians agreed that the 3D image could increase patients' confidence in their clinician, diagnosis or treatment and two clinicians stated that it could increase patients' trust in them. No change in patient trust could be seen in the video-recorded consultations.

3.5.4.6. The experience of patients who found little impact in viewing their image

Viewing their own medical imaging results had little impact for four patients, including two patients who saw only 2D images. One of these two patients explained that she could not understand the 2D images but understood the verbal explanation of the diagnosis, while the other patient explained that he understood his condition well prior to attending the consultation. One patient saw a 3D image with no known abnormality, which he felt was unhelpful as "there is nothing he can show me on it" (P5). Although in this instance he found the image unhelpful, he spoke positively about a previous experience of viewing the screen during an X-ray guided injection, where he could view the procedure as it happened and argued that images “will always make something more understandable” (P5). Similarly, to one of the patients who saw only 2D images, the fourth patient, who saw a 3D image with FAI, explained that although the image aided his understanding of his condition, he already knew what the problem was. He went on to say the image might be more helpful for someone with no prior knowledge of the condition.

3.5.4.7. Comparing patient, clinician and video-recording triads

Overall, patients and clinicians tended to agree on the type of impact that the 3D image had, with agreement that the image impacts upon understanding, decision-making, communication and trust or confidence. When looking at the individual triads (a patient, their clinician and their video-recording) in three cases the amount of impact described by the patient and clinician differed. In these three cases, the clinicians seemed to underestimate the impact of the image, as highlighted by table 4. The clinicians identified a concern which they felt could make the 3D image less helpful to patients. For example, a concern raised by one clinician was the size of the abnormality, with the clinician believing the patient’s abnormality may be too subtle for her to see in her image. These concerns were raised by the clinician or consultant in the video-recorded consultations as well. However, the patients appeared unaware of these concerns and described great benefits from viewing their images.

Table 4: Comparison of the three triads in which the clinician appears to underestimate the impact of the image

Triad	Patient Quotes	Clinician Quotes	Video-Recording Quotes
P6, C2	• He showed me the pelvis as a whole but obviously honed in on the fact that we had the bony ridge on my femoral neck junction which was really interesting to see actually…what was nice was that you can actually see it in the sense that you can actually see the bony ridge on the scan so it's interesting because then you can actually piece together as to why you're getting the pain and why obviously they need to have the intervention there so it's always quite nice then to see it and actually understand it and that's what's quite nice about the 3D that you actually then relate it to yourself.	• It wasn't like a really big CAM a really big CAM is very obvious actually and hers was quite subtle so I am not sure how much she could really appreciate that subtle abnormality. It was a bit difficult to appreciate on that scan.	• Can you appreciate that, it's quite subtle on you actually? (VR6-C2) • We were saying in the meeting what is sort of a typical CAM is a much more obvious bump (VR6-C2).
P13, C4	• When we looked at the 3D sort of scan it became very apparent what the issues were and then straight away it gave me a lot of confidence in you know what I wanted to do and where I was going to… my next move so it was quite rewarding to come and see the guys • The 3D imaging that really did put it in to perspective and you could rotate it round to show you the spur that was sticking out … so that was really good to see definitely.	• I think had the images been great you know they weren't • I think the CT scan (3D) had it of been better quality but at least you can see, this sort of gives them perspective of where it is and you can explain the movement of the hip.	• Now this picture is a bit rubbish really because there is a lot of noise in the front of it. That is not going to be a problem for us because we can remove all that noise that just requires a bit of post processing. (VR12-Consultant 2).

P1, C1	• I would say to me it was conclusive to me in understanding what my situation was and what my possibilities were • I'm fascinated; I am delighted that I can see the image so clearly • Would I rather have seen it *(the image)* or not? Absolutely, absolutely, a million times over.	• He was not a pure patient that would benefit from the 3D reconstructions because he was a moderate osteoarthritic patient.	• It's *(the 3D image)* sort of academic now (VR1-Consultant 1).

3.5.5. Practical considerations of sharing images with patients

Several practical considerations relating to the use of 3D images were raised. These were receiving a copy of their image, a comparator for their image, consultation time and the inability to view soft tissues. These will each be discussed in turn.

3.5.5.1. Copy of image

Seven patients wanted a copy of their image to take home, either to show others such as friends, family, employers or their GP or for their own reference. Patients who wanted the image for their own reference said that this would allow them to look at it "in my own time" (P6) and when "everything has calmed down" (P4). The majority of patients who wanted to show their image to others said this was because the image would help them explain their condition and increase others' ability to understand their situation. One patient wanted a copy of the image to use as "proof" (P3) of his condition. One clinician said he thought giving patients a copy of their image would be helpful to them. He explained that it can be empowering for patients, helping them feel as though they are participating in their care and aiding their understanding. In contrast, two clinicians raised concerns about giving patients a copy of their image. One was concerned that the image may be uploaded to social media while the other clinician said that patients "may end up self-diagnosing problems looking at their imaging" (C2). He explained that if they looked at their image in relation to information on the internet that does not relate to their condition, problems may arise for the doctor patient relationship as "time will have to be spent unpicking what a patient understands from looking at scans in their own time and referring to internet material" (C2).

3.5.5.2. Comparator

The 3D images used within this clinic usually present the symptomatic hip alone, without the patient's asymptomatic hip being visible, although it is possible to present both hips together. This is the choice of the consultant, as showing the symptomatic hip alone allows the area of interest to be more easily visualised. Additionally, the asymptomatic hip in FAI patients is often also abnormal in shape and so is not always an appropriate comparator. 2D images shown within the clinic presented both hips and so for some cases (where the asymptomatic hip was not also abnormal) provided a comparator. Two patients raised the desire for a comparator. Patient 8 explained that he felt he would have gained more if he were able to compare the abnormality of his hip shape with a normal shaped hip. Comparison between the patient's two hips was raised by clinicians 1 and 3. Clinician 1, speaking of patients with two abnormally shaped hips, said that seeing that their asymptomatic hip was also abnormal in shape would also be helpful to patients. He explained that this would help them to understand their hip should it become symptomatic in the future. Clinician 3, speaking about patients with only one abnormally shaped hip, explained that patients benefit from being shown both their hips so that they can see what a normal hip looks like as well as their pathological hip.

3.5.5.3. Consultation time

Patient 8 suggested that the use of the 3D image could reduce consultation time, as the image reduced the time in which it took for him to grasp the information he was given. He explained that without the image it may have either taken longer for him to understand what was wrong with his hip or he may not have understood his condition at all. Similarly, clinician 1 proposed that the use of images could reduce consultation times as he said patients can understand images more quickly than they can a verbal explanation.

3.5.5.4. Inability to see soft tissues

As outlined above, 3D images were used to explain abnormalities of the shape of the bone to patients. Several patients were also shown other images such as 2D CT, X-ray and MRI during explanations of problems relating to soft tissues such as cartilage. Several patients commented that on the 3D image the bone of the femoral head and the bone of the acetabulum appear to meet and the cartilage between the femoral head and the acetabulum cannot be seen. On the 2D image this cartilage appears as a gap, with the nature of the gap reflecting the condition of the cartilage. Several patients were interested to see their cartilage. This was often because they had previously been told about damage to their cartilage and so it was an important part of their pain. Patient 6, in contrast, said that seeing her bone alone made the image clearer for her. Clinician 2 also acknowledged the lack of division between the femoral head and acetabulum and the inability to display soft tissues within the image as a limitation of the 3D image. He explained that the 3D images were beneficial for displaying abnormalities of the shape of the bone, specifically CAM and pincer deformities, but that MRI or 2D CT images would be of more use in demonstrating wear and tear or soft tissue damage.

3.5.6. Trust and the perception of medical images as truthful, authoritative and agentic

The perception of medical images, specifically MRI, as agentic, authoritative and able to reveal the truth about our bodies previously described by Joyce (2008) was evident in the patients' accounts of viewing their 3D images. Six patients and one clinician described the image to be factual, providing evidence of the condition. This perception could provide a possible explanation as to why the 3D image influenced patients' trust or confidence in their clinician, the information they received or their planned treatment. Each of the three properties assigned to MRI by Joyce will now be considered to in relation to patients' account of viewing their 3D image.

3.5.6.1. 3D images as agents

Joyce observed that MRI was described as though it had agency. This means that MRI was considered to reveal information about a patient's health status without interpretation from humans. Patient 4, spoke about her 3D image answering why she has pain. This, similarly to Joyce's findings, ignores the role of both the radiologist who produced to 3D image and interpreted it and the clinicians who synthesised the information taken from physical examinations and patient histories with the interpretation of the image.

3.5.6.2. 3D images as authoritative

Joyce observed that the information gleaned from MRI was considered to be more accurate than information produced through other tests or physical examinations or provided by the patient and so MRI was treated as though it was authoritative. Within this study, patients considered the image to be evidence of the condition that their clinicians had described. They implied that without the image they would feel uncertain about the information that they are given. Patient 6 for example spoke of the imaging "backing up" the information she had heard, while patient 2 felt that "it seems more tangible because you can see it for yourself" (P2). Three patients appeared to trust the image more than the clinician, giving the image authority over the clinician. Patient 1 said that clinicians can make mistakes, which he contrasts to the 3D image which he perceives to be "concrete evidence" (P1). The use of the term 'evidence' suggests that he doesn't believe that the image can depict a mistake or misinterpretation.

3.5.6.3. 3D image as truth

Joyce noted that MRI and the images produced by the machine are described to provide a window into the body, revealing the truth about a patient's health status. Six patients implied that the 3D image revealed the truth about their condition, expressing a lot of faith in the image. The image was "proof" (P3) for some patients and was considered factual. Patient one for example described the image to be "conclusive to me understanding what my situation was and what my possibilities were" and explained that without the image it is "purely trust" (P1). The image appears to have convinced him of his condition and the treatments that were possible. Clinician 4 also spoke about the 3D image as though it were factual, through the statement "it takes the guess work out of it" (C4).

3.6. Discussion

3.6.1. Discussion of research findings

Data from patient and clinician interviews and from video-recorded consultations were used to understand the impact for patients of viewing their own 3D imaging results in a tertiary care orthopaedic outpatient clinic. Three main findings were evident. First, patients found benefit in viewing their 3D image when it depicted an abnormality. Second, patients considered their image to depict the truth about their condition, treating it as evidence. Finally, when clinicians considered the condition in which the image was presented in to be suboptimal, they underestimated its impact.

This study identified benefits for patients of viewing their own 3D images, including improved patient understanding, reduced medical jargon, aided decision-making and increased confidence in the clinician and recommended treatment. Several previous studies have also found benefits for patients of viewing their own medical images (Wiener *et al.,* 2013; Carlin *et al.,* 2014) while other studies have highlighted concerns (e.g. increased patient anxiety) of sharing images with patients (The *et al.,* 2000; Ogden *et al.,* 2009). Ogden *et al.,* (2009) reported increased anxiety in women who viewed the screen during their hysteroscopy procedure compared to women who did not view the screen, while concerns were raised by The *et al.,* (2000) about the impact of showing terminally ill patients their own medical imaging results. The context in which medical images have been shown in this study differs to those in which concerns were raised. This study focused on the impact of images to present information about a non-life threatening diagnosis and its treatment during a face to face consultation. This type of encounter may be better suited to sharing images with patients. This study identified the perception, previously explored by Joyce in relation to MRI, that medical images reveal truth about the body within patients' accounts of viewing their 3D image (Joyce, 2005; Joyce, 2008).

Patients considered their image to be evidence of their condition, which may explain why they found viewing their image beneficial and why the image increased confidence in clinicians and recommended treatments. Patients could arguably have more trust or confidence in their diagnosis and planned treatment; if they believe the image they are shown reveals the truth about their condition. As well as being an important outcome in its own right, trust has been positively associated with increased patient satisfaction, adherence to treatment and self-reported health status (Hall *et al.*, 2002b; Safran *et al.*, 1988; Thom *et al.*, 1999).

Published literature has highlighted concerns resulting from the perception of medical images as truthful, authoritative and agentic, which include disregard for other forms of information (Blaxter, 2009; Reventlow *et al.,* 2006). Two important questions arise from this finding. First, should the uncertainty that accompanies medical images be communicated to patients and the public? Improved awareness could lessen some of the concerns raised within the existing literature such as overreliance on imaging and disregard for other forms of information. From an ethical perspective, ensuring patients understand any uncertainty associated with their imaging results is also important. Second, would the benefits of viewing medical images as identified within this study be diminished if patients and the public had greater awareness of the uncertainty associated with medical imaging?

When comparing patient and clinician data at individual case level, a difference was found in the amount of impact patients and clinicians perceived the 3D image to have in three cases. Upon examining these cases further, this study found that clinicians underestimated the impact of the image if they perceived an aspect of the image to be suboptimal. Comparison with patient data revealed that patients were unaware or unconcerned by the aspects of the image that led the clinicians to believe the image may be less helpful to the patient. This indicates that 3D images could still be helpful for patients to view even in conditions which clinicians do not expect them to be.

In addition to these three main findings, this study also that found that patients wanted a copy of their own imaging results, usually for their own reference or to show others. Patients in the UK can access a copy of their imaging along with their medical records by application for a small fee, but they are not as easily accessible as foetal ultrasound images (National Health Service, 2015).

3.6.2. Study strengths and limitations

Three data sources were used to achieve triangulation of data. Bias resulting from the presence of the interviewer was minimised by the use of data from the video-recorded consultations. Potential biases (i.e. Interviewer effects) include the effect of the interviewer's characteristics (e.g. their gender, age or status) on the participants' response, and social desirability bias, where participants try to provide a socially desirable answer or where the participant responds in the way which they believe the interviewer wants. The data from the video-recording enabled confirmation of the points raised by patients and clinicians at interview, allowing greater confidence that these biases had not occurred.

The sample of patients participating in this study is unlikely to be representative of patients attending other orthopaedic outpatient clinics. Overall, our sample tended to be well educated and all patients had seen other health professionals about their condition. Many patients also had some knowledge of their condition prior to their appointment and a minority described themselves as experts in their condition. Most patients within our sample had active lifestyles or professions and they were motivated to either continue their activities or increase their level of activity. This may not be the case for patients attending other orthopaedic clinics.

Only five female participants were recruited to the study. Due to the risks associated with ionising radiation for future pregnancies, young female patients attending the clinic did not usually have a CT scan, from which 3D images could be produced. No obvious difference in the impact of the 3D image between male and female patients was found in our sample.

3.6.2.1. Reflection

The position of the researcher as an observer in the clinic, without a medical background, helped build a rapport with patient participants, particularly patients who considered themselves experts in their condition. These patients appeared very open with the researcher and seemed forthcoming in sharing their experience and knowledge of their condition. The researcher was typically present during recruited patients' consultations, giving patients more time to become familiar with the researcher before their interview. A minority of patients continued to refer to the researcher as a clinician even after being corrected and this may have impacted upon their openness. As data was collected over a period of several months, a good rapport was also built with the clinicians recruited to the study. This again may have aided data collection, as clinicians appeared open in their answers.

Although clinicians appeared open with the researcher, clinician interviews tended to be short and it was difficult getting clinicians to elaborate on their answers. This may have been because clinician interviews were usually conducted at the end of very busy clinic sessions, which often overran.

3.7. Conclusion

Overall, the majority of patients found benefit in viewing their 3D image, including improved understanding of their condition. Many patients implied that the image provided them with certainty, perceiving the image to depict the truth about their condition. Clinicians also highlighted benefits from presenting patients with their own 3D image and some of these benefits could be observed through the video-recorded consultations. However, clinicians did underestimate the impact of the image when they perceived the image or the condition in which it was shown to be suboptimal.

3.8. Chapter Summary

This chapter reported patients' and clinicians' experience of sharing 3D images during a clinical consultation. This chapter highlighted the perception of medical images as authoritative and able to reveal the truth about the body. The influence of informing people about the susceptibility for error in image interpretation will be explored using a psychological experimental design, in Chapter Six

The following chapter will examine whether the video-recorded consultations from the case study clinic are patient centred and will explore how medical images are used during the consultation, using the RIAS.

Chapter Four: Exploring the content and integration of medical images in orthopaedic clinical consultations.

4.1. Background literature summary

Chapter Four explores the content of orthopaedic consultations about a diagnosis and treatment during which medical images were shown to patients, using RIAS. This section will first define patient centred care and discuss existing literature examining communication in consultations about surgery, before introducing methods of assessing patient centredness.

4.1.1. Patient centred care

Patient centred care aims to address psychosocial as well as biomedical aspects of health, providing a more holistic approach than the traditional medical model (Levenstein *et al.*, 1986). For a clinical consultation to achieve patient centredness, the doctor should endeavour to know the individual patient and address the patient's agenda as well as their own (Levenstein *et al.*, 1986). As described in Chapter Two, the patient centred approach has been associated with improved outcomes in primary care and oncology, including greater compliance to recommended treatments and better disease management (Arora, 2003; Kaplan *et al.*, 1989); improved quality of life (Arora, 2003; Epstein et al., 2010); and greater satisfaction, wellbeing and enablement (Ishikawa *et al.*, 2002; Little *et al.*, 2001; Paasche-Orlow & Roter, 2003; Pawlikowska *et al.*, 2012) .

4.1.2. Communication in consultations about surgery

Levinson, Hudak & Tricco, (2013) argue it should not be assumed that communication practices effective in primary care will be effective in consultations about surgery. The content of surgical consultations differs from that of primary care, with surgical consultations tending to focus on biomedical information and educating patients, rather than psychosocial issues (Levinson *et al.*, 2013). Levinson *et al's.,* (2013) systematic review of surgeon – patient communication found the content of consultations is primarily biomedical (Bernhardt *et al.*, 1998; Levinson & Chaumeton, 1999; McNair *et al.*, 2016; Roter *et al.*, 1999; Van Dulmen, 1999), with little time spent on psychosocial content (Dulmen & Bensing, 2000; Kain *et al.*, 2009; Levinson & Chaumeton, 1999; McNair *et al.*, 2016; Roter *et al.*, 1999). Surgeons are required to communicate unique and challenging content to patients. They are required to explain technical and often complicated procedures to lay individuals. They must also explain risks and potential complications that can arise from surgery and aid patients in considering the consequences of having no treatment so that they can decide whether to opt for the procedure (Levinson *et al.*, 2013). Levinson and Chaumeton (1999) also found that, unlike in primary care, surgeons talk more during consultations than patients.

Within primary care and oncology, patient centred consultations are associated with better outcomes. It is unclear whether communication in surgical consultations would be improved if a more patient centred approach was adopted. Levinson and Chaumeton (1999) argue that the focus on biomedical information in surgical consultations could lead to patient dissatisfaction if psychosocial issues were raised. They propose that patients may have different expectations from a surgeon than they do from other healthcare professionals such as their general practitioner. The relationship between surgeon and patient is typically short term and perhaps more business-like, with less need for exploration of psychosocial issues (Levinson & Chaumeton, 1999). In contrast to this perspective, McNair et al (2016) found that during surgical consultations about oesophagectomy, 23 of 27 patients wanted to know more about the long-term consequences of their operation, including information relating to their quality of life after surgery and potential lifestyle changes relating to their work or social activities. Oesophagectomy is described by McNair et al., (2016) to be “one of the most morbid and mortal elective surgery procedures performed worldwide” (McNair et al., 2016 p6). Therefore, the type of information patients undergoing oesophagectomy wish to receive may differ from that of patients undergoing other surgical procedures. Consultations about

Oesophagectomy are likely to cover different content to consultations about orthopaedic surgery. Orthopaedic surgery is unique in that the majority of orthopaedic operations aim to improve a patient's quality of life, by restoring pain free movement for example, rather than saving or prolonging life. It likely that during orthopaedic consultations patients and surgeons will discuss the patient's lifestyle, activities and work, however there may be fewer psychological issues that require addressing during these consultations in comparison to primary care and oncology consultations for example. Fossum and colleagues (1998; 2004) explored patient centredness in orthopaedic consultations. They found 60% of 18 patients attending orthopaedic outpatient clinics made negative comments about their consultation, when watching a recording of the consultation with a researcher (Fossum *et al.*, 1998). Of the 18 consultations, four were categorised as positive, seven neutral and seven negative based on the patients' comments. During positive consultations more time was spent on patient centred tasks, specifically achieving shared understanding and involving the patient in the management of their condition (Fossum & Arborelius, 2004). During negative consultations more time was spend addressing the patient's reason for attendance, including addressing patients' ideas and concerns. Addressing patients' ideas and concerns are also typically considered to be patient centred tasks and have been found in consultations that are categorised as positive in general practice (Arborelius & Bremberg, 1992). This suggests that some elements of patient centred care may be important to patients attending orthopaedic consultations but that there may be a difference between what should be considered patient centred in general practice consultations and in orthopaedic surgical consultations. Therefore, the content of orthopaedic consultations and its effect should be studied.

4.1.3. Methods of assessing patient-centredness

As outlined in Chapter Two, several methods of assessing patient centred consultations have been developed, including The Henbest and Stewart Method, MIPS and RIAS. Each of these methods were considered, however RIAS was deemed most appropriate for this research. The Henbest Stewart Method focuses on the doctor's overall responsiveness (Henbest & Stewart, 1989). Thoughts, feelings, expectations and prompts by the patients, referred to as 'offers', are noted. The doctor's response to them is then scored in one of four ways: ignores, closed response, open response or specific facilitation (Mead & Bower, 2000a). As this study was interested in the content of the consultation as opposed to responsiveness, this method was not deemed appropriate.

RIAS is conducted by categorising every utterance made by both the doctor and the patient into one of 41 mutually exclusive and exhaustive codes. RIAS codes include reassuring, agreement, giving medical information and giving lifestyle information. The codes can be grouped into four categories: biomedical content, psychosocial content, task-focused utterances, socio-emotional utterances. RIAS has been widely applied in communication studies across the world in a range of medical specialities. RIAS is flexible and allows for the addition of new codes to be included (Roter & Larson, 2002).

MIPS, developed to assess patient centredness in oncology consultations, sought to overcome some of the difficulties experienced when applying RIAS in this setting. Ford *et al.,* (2000) argue that as RIAS only allows one code to be assigned to each utterance, coders at times may have to choose between two appropriate codes. For example, Ford *et al.,* (2000) highlighted that the question "how long do I have to live?" could be coded as both a medical question and a concern. They also argue that RIAS does not allow the content of affective utterances to be coded (Ford *et al.*, 2000). Using MIPS, every utterance is assigned to a content category and a mode of exchange, overcoming this problem.

RIAS was selected as the most the appropriate tool for this study. There are two reasons for this. First, RIAS has been previously applied to consultations about surgery, including orthopaedic surgery, therefore it is an appropriate method for analysing the consultations in this study. Second, RIAS is flexible and will allow the images shown during the consultations in this data set to be included in the analysis. The section below describes RIAS in more detail.

4.1.3.1. The Roter Interaction Analysis System

RIAS is a method of coding medical dialogue, devised by Debra Roter in the late 1970s. The method has since been extensively developed by both Debra Roter and Susan Larson and has been widely applied in communication studies across the world. The approach seeks to identify whether clinician and patient utterances are biomedical and task focused or psychosocial and affective (Roter & Larson, 2002). Physician task focused behaviour includes behaviour or speech aimed at gathering data or information giving. Affective physician behaviour encompasses all aspects of the physician’s speech or behaviour that has socio-emotional content. This could include building a social or emotional rapport or showing empathy or reassurance. Patient task focused behaviour refers to information seeking and the desire for knowledge and understanding. These behaviours include asking questions and giving information. Patient’s socio-emotional behaviours include expressing concern or optimism (Roter & Larson, 2002). Verbal dominance within the consultation is also used to assess patient centredness. An utterance refers to “the smallest discriminable speech segment to which a classification may be assigned” (Roter, 1991 p4.) Utterances may vary in length and can range from a single word to a sentence. A sentence is considered as one utterance if it conveys one item of interest. A sentence containing two thoughts or items of interest is coded as two utterances. If a sentence is divided by a pause of a second or more or interrupted then the sentence is coded as two utterances (Roter, 1991). Published studies have demonstrated good reliability when using RIAS (Ford, Fallowfield & Lewis, 1996; Mead & Bower, 2000a; Roter, Hall & Katz, 1987) indicating the method provides consistent results.

4.1.4. Summary

Research assessing the content of orthopaedic surgical consultations and its effect is sparse. Several studies have highlighted that consultations about surgery in general tend to have a biomedical focus and could be improved by including more discussion of psychosocial issues. However, further research is needed to understand the content of surgical consultations, particularly orthopaedic consultations which are unique in nature.

During the consultations analysed within this study, patients viewed their own medical imaging results. Medical images are shown to patients in clinical practice, but to date, research has not sought to understand how this may influence the content of consultations and whether they may aid or hinder patient centredness from being achieved.

4.1.5. Research questions

This study sought to address the following research questions, using the Roter Interaction Analysis System:

1) Are the consultations within the case study clinic patient centred?
2) How are the 3D images incorporated into the consultation dialogue?
3) Does the content of orthopaedic surgery consultations differ when an image is present?

4.2. Methods

This study used video-recorded clinical consultations collected as part of study one. A full description of the methods of data collection can be found in Chapter Three. To summarise, clinical consultations (in which patients were shown their own medical imaging results including 3D CT images) were video-recorded in one orthopaedic tertiary care clinic, specialising in FAI and hip preservation, in the UK NHS. Participants included patients over the age of 18 with a new referral to the clinic, who had an appointment for a CT scan before their consultations; clinicians conducting consultations within the clinic and the clinics' consultants. As described in Chapter Three, patients attending the clinic typically had two consultations in one day. During the first consultation, a patient history was taken and a physical examination was conducted and during the second consultation, the diagnosis and treatments were discussed. The patient history included questions about the impact of the patient's hip problem on their daily activities, such as sleeping, walking and driving, and on their work and leisure activities. Patients' first consultations were conducted by clinicians and their second consultations were typically conducted by both a clinician and a consultant.

4.2.1. Data analysis

The video-recordings were analysed to describe the content of the second consultations, as it was during the second consultations that images were shown to patients. Each utterance, from both the patient and the clinician, was categorised into one of 41 mutually exclusive and exhaustive codes (Roter & Larson, 2002). Each utterance relating to the image was also categorised into one of five additional image codes.

Five additional codes relating to the use of the image were devised after EP had watched the first set of video-recordings. These were refined through discussion with a RIAS expert and then applied to all the video-recordings by the RIAS coder during coding. They were: explains or shows image; patient responds to image; patient asks question about image; treatment explained using image and clinician answers a question using the image. Image codes were used alongside the existing RIAS codes.

The analysis of the video-recordings was anonymised. Video-recordings were coded by a trained RIAS coder and two were double coded to check reliability.

The analysis comprised three parts: (i) patient centredness, (ii) the use of the image within the consultation and (iii) comparison of this analysis with previous analysis of consultations about orthopaedic surgery, each of which are be explained below. Quotes taken from the recorded consultations are presented alongside the RIAS results to provide examples and context to the results.

4.2.1.1. Patient centredness

This study first examined whether consultations were patient centred. Patient centredness was assessed using three ratios. The first of these looked at verbal dominance. The sum of the doctor's (consultant and clinician combined) statements was compared to that of the patients to determine whether their contributions were equal. This was done by dividing the sum of doctor utterances by the sum of patient utterances, with a result of one reflecting an equal contribution. Within the existing literature, a result of one has been interpreted as patient centred (Neal *et al.*, 2006; Paasche-Orlow & Roter, 2003; Pawlikowska *et al.*, 2012). The amount of biomedical content was then compared to the amount of psychosocial content within the consultation. This was done by dividing the sum of biomedical utterances by the sum of psychosocial utterances. Finally, the psychosocial and socio–emotional utterances combined were compared to the biomedical and task focused utterances combined. Within the existing literature, a ratio of socio-emotional and psychosocial utterances to biomedical and task focused utterances of > 1 is considered patient centred (Paasche-Orlow & Roter, 2003; Pawlikowska *et al.*, 2012). Additionally, patient and doctor utterances were compared to see whether there is a difference in the content of patient and doctor utterances.

4.2.1.2. The use of the image within the consultation

The integration of the image within the consultation was assessed. The total number of statements relating to the image from both the patient and the doctors was calculated to give a sense of how much of the consultation included the image and how much patients contributed to the discussion of the images. The individual image codes were then considered separately. This was done by comparing the number of utterances coded into each image code and by looking at which RIAS codes related to the image utterances. This allowed understanding of what the image was used for in the discussion. The image codes gave a broad description of the use of the image in the consultation while the RIAS codes provided a more detailed description.

4.2.1.3. Comparisons with the existing literature

The analysis of the RIAS codes in this study was compared to the analysis of orthopaedic surgery consultations within the existing literature, namely Levinson and Chaumeton (1999). This was done by comparing two of the ratios of patient centredness (verbal dominance and biomedical versus psychosocial content) from this analysis to these ratios from Levinson and Chaumeton's analysis. Levinson and Chaumeton also report the mean number of physician and patient utterances coded as approval, laughter and humour and concern/worry and empathy. The mean number of utterances for each of these codes was compared between the consultations from this research and the consultations in Levinson and Chaumeton's study.

4.2.1.4. Integration of qualitative data from the video-recordings with the RIAS coding

The content of the video-recordings was used to provide more detail and to help explain the findings of the RIAS analysis. Before analysis of the RIAS codes, the video recordings were watched at least twice by the researcher. The recordings were then watched again after analysis to gain further understanding of the RIAS results. Relevant quotes from the recordings were transcribed verbatim. They are presented alongside the RIAS results, where appropriate.

4.3. Results

4.3.1. Summary of results

This section will firstly describe participant characteristics. Next, verbal dominance and patient centredness will be presented. The use of the image within the consultation will then be explored. Finally, the results from this analysis will be compared to orthopaedic consultations within the existing literature.

4.3.2. Participant characteristics

Consultations with ten patients attending the clinic between September 2014 and June 2015 were recorded. Nine were video-recorded and one was recorded for audio. The majority of patients were male (60%) White British (90%) and educated to at least A-Level or equivalent (70%). During eight of the consultations, patients were shown 3D images alongside 2D images. In the other two consultations, patients were only shown 2D images. All but one of the patients recruited to this study had two consultations during their visit to the clinic. Patient 11 only had one consultation, which included patient history, physical examination, and a discussion of his diagnosis and treatment. In this study, patients and clinicians are referred to using their identifier from study one. Four clinicians and two consultants were recruited to the study. During one consultation (P12), the patient was recruited to a clinical trial. As a result of this, the content of the consultation differed from typical consultations within the clinic as the patient was provided with additional information about the trial.

4.3.3. Patient centredness

4.3.3.1. Verbal dominance

Verbal dominance was firstly considered by looking at the contribution of each individual speaker within the consultation (namely clinicians, patients, consultants and family members). Clinician and consultant utterances were then combined to produce a total number of doctor utterances while patient and family member utterances were combined to produce a total number of patient utterances.

Overall, the doctors were dominant within the consultations. In five consultations the clinician was dominant, in two consultations the consultant was dominant and in two consultations the patient was dominant, as demonstrated in table 5. In consultation 14, it was not possible for the RIAS coder to distinguish between the clinician and the consultant and so all clinician and consultant utterances were coded together as ‘doctor’. The clinician or the consultant was dominant within this consultation. The patient’s contribution to this consultation was 28.5%, meaning the patients could not have been the dominant speaker even if the clinician and consultant were distinguishable from one another.

When comparing the combined doctor utterances to the combined patient utterances the doctors were dominant in all ten consultations. On average, patients’ contribution to the dialogue within the consultation was 33.8% (range 25.2 to 42.0) with a ratio of one patient utterance for every two doctor utterances. This is uncharacteristic of a patient centred consultation.

Table 5: Verbal dominance

Recording	**Doctor**			**Patient**			**Ratio**
	Clinician n(%)	**Consultant n(%)**	**Total n(%)**	**Patient n(%)**	**Family n(%)**	**Total n(%)**	**Patient : Doctor**
P1	207 (26.8)	370 (47.9)	577 (74.6)	196 (25.4)	N/A	196 (25.4)	1 : 2.9
P6	324 (54.9)	36 (6.1)	360 (61)	227 (38.5)	3 (0.5)	230 (39)	1 : 1.6
P7	364 (61.3)	32 (5.4)	396 (66.7)	198 (33.3)	N/A	198 (33.3)	1 : 2
P8	99 (37.5)	54 (20.5)	153 (58)	111 (42.0)	N/A	111 (42.0)	1 : 1.4
P9	129 (69.7)	N/A	129 (69.7)	56 (30.3)	N/A	56 (30.3)	1 : 2.3
P10	67 (19)	197 (55.8)	264 (74.8)	89 (25.2)	N/A	89 (25.2)	1 : 3
P11	313 (58.1)	N/A	313 (58.1)	226 (41.9)	N/A	226 (41.9)	1 : 1.4
P12	573 (55.6)	140 (13.6)	713 (69.2)	307 (29.8)	11 (1.1)	318 (30.8)	1 : 2.2
P13	209 (26.6)	248 (31.5)	457 (58.1)	330 (41.9)	N/A	330 (41.9)	1 : 1.4
P14	Unknown	Unknown	450 (70.3)	181 (28.3)	9 (1.4)	190 (29.7)	1 : 2.4
Total			3812 (66.2)			1944 (33.8)	1 : 2

4.3.3.2. Biomedical and psychosocial content

All of the ten consultations focused on biomedical information (as shown in Table 6) and thus would not be considered patient centred by the definition used in other clinical contexts. Only one consultation had a ratio of less than 1: 2, indicating that within this consultation for every two biomedical utterances there was one psychosocial utterance. Although, all consultations had more biomedical than psychosocial utterances, there was disparity between consultations, with a ratio of twenty two biomedical utterances for every psychosocial utterance in one consultation compared to less than two biomedical utterances for every psychosocial utterance in another. Patient 11 was the only patient recruited to this study who had one consultation as opposed to two. As a result of this, Patient 11's consultation contained a patient history and physical examination as well as a discussion of the diagnosis and treatment. However, no apparent difference in the ratio of psychosocial to biomedical utterances can be seen in Patient 11's consultation compared to the other consultations.

Table 6: Ratio of psychosocial to biomedical utterances for each consultation

Consultation Number	**Biomedical Utterances**	**Psychosocial Utterances**	**Ratio (Psychosocial : Biomedical)**
1	446	87	1 : 5.1
6	293	22	1 : 13.3
7	273	66	1 : 4.1
8	106	32	1 : 3.1
9	116	23	1 : 5
10	179	8	1 : 22.4
11	203	53	1 : 3.8
12	512	48	1 : 10.7
13	262	183	1 : 1.4
14	293	120	1 : 2. 4
Total	2683	642	1 : 4.2

Eighty-five percent of the 2683 biomedical utterances were coded as either "gives medical information" or "gives therapeutic information" revealing that much of the discussions involved giving information about a diagnosis and treatment.

4.3.3.3. Task focused and socio-emotional exchange

In line with past studies, biomedical utterances were grouped with task-focused utterances to create a total number of "doctor centred utterances". This group was compared to "patient centred utterances" which comprised psychosocial utterances and socio-emotional exchange. Previous studies have considered a ratio of less than one doctor centred utterance for every patient centred utterance to be patient centred (Pawlikowska, 2011). All of the ten consultations had a ratio of greater than one and thus do not fit the usual criteria to be considered patient centred (as shown in Table 7).

Table 7: Ratio of doctor centred to patient centred utterances for each consultation

Consultation Number	**Doctor Centred**	**Patient Centred**	**Ratio (Patient Centred : Doctor Centred)**
1	514	145	1 : 3.5
6	343	46	1 : 7.5
7	345	90	1 : 3.8
8	144	57	1 : 2.5
9	107	37	1 : 2.9
10	238	25	1 : 9.5
11	290	108	1 : 2.7
12	625	143	1 : 4.4
13	334	234	1 : 1.4
14	339	188	1 : 1. 8
Total	3279	1073	1 : 3.1

4.3.3.4. Comparing the content of doctor and patient utterances

This study then sought to explore whether there was a difference in the focus between the biomedical and psychosocial content of doctor and patient utterances (as shown in Table 8). Doctor utterances refer to clinician and consultant utterances while patient utterances refer to the patient and their family member's utterances. In all consultations, doctor utterances were primarily biomedical. Additionally, in five of the ten consultations patient utterances were also mostly biomedical. Where there were more psychosocial utterances, this was often marginal. There was one exception to this, P13. The majority of his utterances were psychosocial with 131 psychosocial utterances compared to 40 biomedical utterances. Similarly, to the other consultations, the doctor's utterances in P13's consultation were mostly biomedical with 222 biomedical utterances from doctors compared to 52 psychosocial utterances.

Table 8: Comparing the biomedical and psychosocial content of doctor and patient utterances

Consultation Number	Category	Doctor			Patient		
		Clinician	Consultant	Total	Patient	Family	Total
1	Biomedical	140	248	388	48	N/A	48
	Psychosocial	4	31	35	51	N/A	51
6	Biomedical	239	22	261	30	2	32
	Psychosocial	12	0	12	10	0	10
7	Biomedical	237	10	247	26	N/A	26
	Psychosocial	40	10	50	16	N/A	16
8	Biomedical	60	24	84	22	N/A	22
	Psychosocial	1	4	5	27	N/A	27
9	Biomedical	68	N/A	68	7	N/A	7
	Psychosocial	5	N/A	5	8	N/A	8
10	Biomedical	38	134	172	16	N/A	16
	Psychosocial	4	0	4	4	N/A	4
11	Biomedical	135	N/A	135	68	N/A	68
	Psychosocial	13	N/A	13	40	N/A	40
12	Biomedical	370	75	445	63	4	67
	Psychosocial	33	0	33	14	1	15
13	Biomedical	110	112	222	40	N/A	40
	Psychosocial	24	28	52	131	N/A	131
14	Biomedical			258	33	2	35
	Psychosocial			72	47	1	48

The content of the video-recordings was considered alongside the RIAS coding. Patient centred literature tends to assume that psychosocial issues are more important to patients than biomedical issues and therefore consultations where biomedical utterances are dominant are not considered patient centred. However, the qualitative data revealed that two patients within this sample were predominantly interested in biomedical concerns, asking very specific questions about their condition and treatment. This is demonstrated through the following questions asked by patients:

> "Do you go inside or outside?" (P1)*(referring to the surgical approach)*
>
> "And what about cutting muscle?" (P1)
>
> "What sort of size incisions are you typically making?" (P1)
>
> "So is there a full laberal tear or is it degenerative changes?" (P6)

Additionally, when Patient 6 was asked what she has been told previously about her condition, she responded by saying she has "right CAM, partial laberal tear and flattening of the femur" (P6), demonstrating her knowledge of her condition. This finding suggests that patients can be equally, if not more interested in the biomedical aspects of their condition compared to the psychosocial content. However, these two patients were perhaps unique in that they had a lot of knowledge of and interest in their condition which, as explained in Chapter Three, was gained from their work or their family members. This does not explain why there was a biomedical focus within all the consultations. Three consultations had a ratio of greater than ten biomedical utterances for every one psychosocial utterance, as demonstrated in Table 6, while the remaining consultations all had a ratio of less than five biomedical utterances for every one psychosocial utterance. Patient 6, as described above, appeared very interested in gaining biomedical information about her condition. Patient 12 was recruited to a clinical trial during her consultation, which may have altered the content of the consultation. Trial recruitment consultations have different aims to consultations about diagnosis and treatment (Realpe *et al.*, 2016) and thus may require more biomedical information to be communicated to patients. Patient 10's consultation contained the highest ratio of biomedical to psychosocial utterances with 22 biomedical utterances for every one psychosocial utterance. Unlike the majority of recruited patients, Patient 10 was not diagnosed with FAI. Her condition was perhaps more complex than FAI, which may account for the increased biomedical content. However, aside for this, no other distinguishing features of this consultation were identified, which could explain why this consultation contained more biomedical content than the other consultations.

In this study, psychosocial content typically related to the sports that patients participated in or wished to return to after treatment (including hurdling, kitesurfing and football) or patients' professions and whether their condition impacted upon their work. Psychosocial content was raised by doctors as well as patients, for example one patient was asked "so one thing I need to know is what your future plan is, so is it your intention to stay in (*name of patients employer)*?" (Consultant 2 to P13). After a discussion of the patient's work he was then asked "so what about sport?" (Consultant 2 to P13).

4.3.4. Exploring the use of images within the consultations

On average, the image was used during 12.9% (range: 4.5% - 30.6%) of the consultation. Doctors were verbally dominant during the discussions of the images (as shown in Table 9). All patients participated in the discussion about the image, although in several consultations their input was minimal. The mean number of doctor utterances relating to the image was 68, (range 11 -181) compared to a mean of 7 (range 1 – 15) patient utterances relating to the image.

Table 9: Verbal dominance during the discussion of the medical images

Consultation Number	Doctor (Clinician and Consultant)	Patient (Patient and Family Member)	Ratio (Patient : Doctor)	Percentage of consultation discussing image
1	181	10	1 : 18.1	24.7
6	66	4	1 : 16.5	11.9
7	50	1	1 : 50	8.6
8	11	1	1 : 11	4.5
9	16	3	1 : 5.3	10.3
10	101	7	1 : 14.4	30.6
11	42	11	1 : 3.8	9.8
12	49	9	1 : 5.4	4.9
13	66	15	1 : 4.4	10.3
14	100	9	1 : 11.1	11
Mean	68	7	1: 9.7	12.9

In all consultations, the majority of utterances relating to the image were coded as "explains image". In half of the consultations, the image was also used to explain treatment and in six consultations, the image was used to answer patients' questions. Table 10 shows the number of utterances coded into each image code for each consultation. Patients were also involved in the discussions of the image, even when their input was minimal. Patient 7, for example, only made one utterance related to the image. He asked a question about the image, suggesting engagement with the image.

Table 10: Frequency of each image code within each consultation and percentage of consultation discussing images

Image Code	**P1**	**P6**	**P7**	**P8**	**P9**	**P10**	**P11**	**P12**	**P13**	**P14**	**Total**
Explains Image	118	55	47	7	17	82	34	50	75	105	590
Patient Responds to Image	2	0	0	0	2	1	7	1	1	2	16
Patient Asks Question about the Image	5	0	1	0	0	4	2	0	2	1	15
Treatment Explained Using the Image	60	15	0	5	0	13	5	0	0	0	98
Clinician Answers a Question using the Image	6	0	3	0	0	8	5	0	3	1	26
Total	191	70	51	12	19	108	53	51	81	109	745

Boxes one and two present excerpts from the data to provide examples of discussion relating to the image codes. Box one shows a consultant explaining the image and the patient responding to the image. The consultant explains what can be seen in the image before explaining the problem with the patient's hip. Box two shows a patient asking questions about the image and his clinician answering a question using the image. In this excerpt from the recording, we can see that the clinician returns to a different image to answer the patient's question.

Con2	So this is the back of your hip joint here *(shows on 3D image)* and this is part of the socket *(shows on 3D image)* and that is the top end of the thigh bone *(shows on 3D image)*
P13	yes
Con2	and this is the shaft of the thigh bone *(shows on 3D image)* and there is the ball sitting inside the socket *(shows on 3D image)* – you will see the ball there as we come round *(as image is rotated by consultant).* Now at the back in this area as I move it you will sense there is a bit of a recess here and that is not surprising because if you put the ball in the socket like this *(demonstrating with hands)*
P13	mhmm
Con2	– you, and you are building this as part of your engineering you would make a recess there
P13	yes
Con2	so that you have a good range of movement
P13	yes
Con2	so we can see that recess there, now can you see that at the front here? *(shows on 3D image)* there is a little area here where the recess is not so good
P13	yes
Con2	yes
P13	so that should continue round?
Con2	it should – this little bit of bone here *(shows on 3D image)* is a little bit prominent
P13	mhmm
Con2	it is not big,
P13	mhmm
Con 2	it's not very very large and that is why you have been able to do all the things you can do without running into trouble
P13	mhmm
Con2	but what you have also see is that just here *(shows on 3D image)* there is a prominent bit of rim
P13	yes
Con2	of the socket and again if I move it you can see there is the edge of the socket there that looks nice and smooth and then suddenly this bit sticks out just here
P13	yes, so that should then come round smooth right the way round here *(points to image)*
Con2	yes so it be coming in like that *(shows on 3D image),* yes.

Box 1: An excerpt of a consultant explaining the image and diagnosis

P7	So going back to the other one *(3D image)* the left hip. Where you said you might reshape the bone
C2	yes
P7	my understanding of arthritis is it is the re-growing of the bone would that re-grow here then?
C2	Ah ok, yes, so this shape here *(shows on 3D image)*
P7	yes
C2	has probably been here since you were a teenager
P7	yes
C2	when I talked about re-growing of the bone, you are right, there are lots of different things that go on in arthritis, the main thing is you lose your cartilage
P7	Yes
C2	so the cartilage goes so you have got bone……
P7 & C2	bone rubbing on bone
C2	the bones response to that is to try and grow some extra bone
P7	yes
C2	to spread the load a little bit more. That's why I pointed out here *(shows on 2D image)*
P7	yes
C2	see here there is this nice notch
P7	yes
C2	and that is normal
P7	yes
C2	a little bit further down here *(shows on 2D image)* there is an extra bit of bone
P7	oh has that grown over the notch sort of thing?
C2	yes

Box 2: Discussion of medical images, where clinician answers patients question using the images

The additional image codes were coded alongside the RIAS codes. This allowed exploration of which RIAS codes were used when the image was being discussed. As expected, medical images were used to give patients medical and therapeutic information. Images were also used for what is described as "emotional" talk. Specifically, the image was used during statements of reassurance and concern. Utterances related to the image were also coded as "positive talk". As shown in Table 11, this means that during the discussion of the image, patients and physicians expressed agreement and laughed. None of the utterances related to the image were coded as "negative" talk.

Table 11: Number of image related utterances and the RIAS codes they relate to

Category	**Number of Image related Utterances**
Biomedical	551
• Gives Medical Information	450
• Gives Therapeutic Information	93
• Closed Medical Question	8
Positive Talk	34
• Agreement	31
• Laughter	3
Emotional Talk	28
• Concern	14
• Reassures	14

Examples of the use of the image to reassure patients were identified within the video-recordings. Reassurance utterances informed patients that an aspect of the image was normal or nothing to worry about. These are listed below.

> "But I wouldn't worry too much about that at all because you are not getting any pain there" (C3 to P11)

> “So that looks fine” (C3 to P11)

> “And that’s nothing sinister or anything to worry about all that is is little fluid filled pockets within the bone” (Con 1 to P10)

4.3.5. Comparison with Levinson and Chaumeton’s (1999) study

On average, there were almost double the number of utterances in the consultations in this study compared to the orthopaedic surgery consultations in Levinson and Chaumeton’s 1999 study. In both studies, the doctors were dominant within the consultations. However, patients made a slightly greater contribution to the dialogue in Levinson and Chaumeton’s study compared to the present study (as shown in Table 12).

In both sets of consultations, the doctor’s content was primarily biomedical, with over 14 biomedical utterances for every psychosocial utterance in the 1999 study and over eight biomedical utterances for every psychosocial utterance in the present study. The proportion of the doctor’s content that focused on biomedical information reduced considerably between the 1999 study and this study. In both data sets, a greater proportion of patient utterances were psychosocial compared to the proportion of doctor utterances that were psychosocial. Patients in this study made almost equal psychosocial and biomedical utterances.

The mean number of approval, laughter and humour and empathy utterances was similar in Levinson and Chaumeton’s 1999 study and this research. However, in the consultations analysed in this research, physicians typically expressed more concern or worry than physicians in Levinson and Chaumeton’s study.

Table 12: Comparison of analysis with Levinson and Chaumeton (1999)

Category	Levinson and Chaumeton's 1999	Present Study
	Mean (rounded to the nearest whole utterance)	
Consultation Length (minutes)	13	23
Total Utterances	291	576
Ratio of Utterances (Patient: Doctor)	1: 1.5	1:2
Content – Physician Utterances		
Biomedical	89	228
Psychosocial	6	28
Ratio of Utterances (Psychosocial: Biomedical)	1: 14.8	1: 8.1
Content – Patient Utterances		
Biomedical	58	36
Psychosocial	9	35
Ratio of Utterances (Psychosocial: Biomedical)	1 : 6.4	1: 1.02
Emotional Affect – Physician		
Approval, Laughter and Humour	10	9
Concern/Worry	1	7
Empathy	1	1
Emotional Affect- Patient		
Approval, Laughter and Humour	9	8
Concern/Worry	4	4

4.3.6. Reliability of coding

Two consultations (recordings 9 and 10) were double coded for reliability. A strong correlation was found between the initial coding and the double coding for reliability.

Previous studies have assessed the reliability of RIAS coding using Pearson correlation coefficients. As Pearson correlation coefficients measure linear association not reliability per se, intra-class correlation coefficients were measured in addition to Pearson's correlation coefficients to assess the reliability of coding. The overall coding reliability was .975 based on Pearson correlation coefficients. For consultation 9, the correlation coefficient was 0.988 and for consultation 10, the correlation coefficient was 0.947.

Overall coding reliability was measured. Reliability was also assessed for both double coded consultations separately and for the four main RIAS categories used in the analysis as demonstrated in table 13.

After consultation with a statistician, the reliability analysis was repeated with four codes removed. These four codes were deemed as outliers as they had very high frequency compared to the other codes and potentially skewed the results. The results of reliability analysis without the outliers are also presented in Table 13. For the reliability of the four main RIAS categories, two of the four codes were originally used in the biomedical content category; three were originally used in the task-focused category and one was originally used in the socio-emotional exchange category. None of the four codes were used in the lifestyle/psychosocial category. The analysis of these three categories was repeated without the outliers.

Table 13: Reliability of coding

	Pearson's R	Intra-class correlation Coefficient
Overall	.975	.979
With outliers removed	.881	.838
Consultation 9	.988	.978
With outliers removed	.902	.900
Consultation 10	.947	.917
With outliers removed	.743	.689
Biomedical Content	.952	.922
*With outliers removed**	.252	.313
Lifestyle/Psychosocial Content	.882	.969
No outliers		
Task Focused Content	.955	.965
With outliers removed	.674	.682
Socio-emotional exchange	.979	.970
With outliers removed	.778	.661

* Removal of outliers in this category removed most of the data

4.4. Discussion

4.4.1. Discussion of research findings

Several key findings were raised through the analysis. During consultations about hip surgery, doctors talked more than patients and the content of the consultation was primarily biomedical. On average, images were involved in approximately 13% percent of the discussion. They were mainly used to give medical and treatment information but also to answer patients' questions. Most of the utterances about the image were made by the doctor, with patients making a small contribution to the discussion of the images. Finally, this analysis revealed similar results to Levinson and Chaumeton's (1999) analysis of orthopaedic surgery consultations, with doctors verbally dominant and consultations focused on biomedical content in both data sets. In the present study, however, there was a greater discussion of psychosocial issues than previously identified.

As the consultations tended to be discussions of a diagnosis and treatment, with the codes "gives medical information" and "gives therapeutic information" most common, it seems logical that the clinician was dominant within the consultation. This is also consistent with the findings of Levinson and Chaumeton (1999) who found that doctors also spoke more than patients in consultations about surgery. Previous studies reporting a ratio of one for verbal dominance as patient centred have analysed consultations from general practice or oncology (Neal *et al.*, 2006; Paasche-Orlow & Roter, 2003; Pawlikowska *et al.*, 2012), where clinicians typically take patient histories using open questions allowing greater verbal dominance from patients. It could therefore be argued that for this type of consultation (i.e. a discussion about diagnosis and surgical treatments, where no patient history is taken) the ratio of doctor to patient utterances was appropriate.

Due to the nature of the consultations analysed it was expected that the majority of the dialogue would be biomedical content. A systematic review looking at communication with surgical consultations, including orthopaedics identified an emphasis on patient education and the delivery of biomedical information during consultations about surgery (Levinson *et al.*, 2013). Additionally, for nine of the ten recordings, the consultation was a discussion of a diagnosis and treatments only. The patient history, which may have included more psychosocial information, such as the impact of their hip pain on their activities, was taken during an earlier consultation. Furthermore, the type of diagnosis and treatment discussed during the consultations are largely mechanical with the majority of patients diagnosed with FAI and recommended an arthroscopy (a type of keyhole surgery) as treatment.

It is understandable that doctor utterances were primarily biomedical as they were delivering information about diagnosis and treatments to the patients. It could be argued that half of the patients were also more focused on biomedical information than psychosocial, as there were more biomedical utterances than psychosocial utterances for five of the ten patients. Alternatively, these patients may not have had an opportunity to introduce as much as psychosocial content as they would have liked, particularly as the doctors were verbally dominant within the consultations.

The analysis of the image codes along with the RIAS codes attached to the image utterances showed that, although medical images were primarily used to deliver medical information, they were also used to answer patients' question. This finding shows that medical images can be integrated within a discussion, as well as to present medical information.

Similarities were identified between the results of this analysis and Levinson and Chaumeton's 1999 study. Orthopaedic surgery consultations tend to be biomedical focused, with the doctor making a greater contribution to the dialogue than patients do. Patients in Levinson and Chaumeton's study made a greater contribution to the discussion than patients in the present study. This is could be due to the structure of the consultations examined. In the 1999 study consultations included taking the history, conducting the physical examination and education/counselling about the diagnosis and treatment. Consultations in this study differed as patients had two consultations with the clinician in one day. The consultations recorded for this study were the patients' second consultation in the clinic, which focused on education and counselling about the diagnosis and treatment. This could account for the difference in patients' contribution to the dialogue. Alternatively, patients in Levinson and Chaumeton's study could have been afforded greater input by their clinicians.

Compared to Levinson and Chaumeton's study, in this study there was a greater discussion of psychosocial issues, specifically discussion about patients' work and leisure activities. This suggests that it may not be the case that patients do not wish to discuss psychosocial content with surgeons, as previously argued by McNair *et al.,* (2016). Although patients may be focused on biomedical issues, these findings suggest there are psychosocial concerns that patients wish to address within orthopaedic surgical consultations. The difference in psychosocial content between the two data sets could be due to several reasons. Firstly, consultations in the current study were longer, allowing for more time for the discussion of psychosocial issues. On average, the length of patients' second consultations in this study was longer than that of their only consultation in Levinson and Chaumeton's study. The sample of clinicians used in the current study was small, with only four clinicians and two consultants from one orthopaedic clinic participating in the study. It could be that staff in this particular clinic are more aware of the importance of addressing patients' psychosocial concerns than in other clinics. The patients attending this clinic were also unique in that they were mostly very physically active or hoping to return to a high level of physical activity. Patients participated in competitive sport or had physically demanding professions, which their hip pain directly affected. Psychosocial concerns such as lifestyle may be more important to this sample of patients than to patients attending other orthopaedic surgery clinics. Finally, the image could have also contributed to the increased discussion of psychosocial issues. The use of the image to communicate medical information to patients may have enabled them to understand their condition and treatment more quickly, thus leaving more time for the discussion of psychosocial issues. Alternatively, the practice of showing patients their images could lead patients to feel that they have greater rapport with their doctor, leading them to raise psychosocial concerns. Carlin *et al.,* (2014), for example, found patients felt respected and valued when their clinician showed them their medical imaging results, improving their rapport with their clinician.

When considered alongside the findings of Levinson and Chaumeton's (1999) study and Levinson et al's., (2013) systematic review of patient centredness in surgical consultations, these findings suggest that the usual model of patient centredness based on primary care and oncology consultations may be inappropriate for surgical consultations. During consultations about surgery, clinicians tend to be verbally dominant and discuss large amounts of biomedical information with patients. This is likely due to the need to educate patients about surgical treatments including the risks of surgery in order to enable patients to provide informed consent. A model of patient centredness for surgical consultations may therefore differ to that of primary care or oncology consultations in which patients are encouraged to be verbally dominant with discussion focussing on psychosocial issues. It could be argued that a model that focuses on patient education and is therefore, biomedically focused may be more suitable to surgical consultations. Although the aim of surgical consultations may be to deliver biomedical information to patients, a model for surgical consultations should also encourage clinicians to address patients' psychosocial concerns.

4.4.2. Study strengths and limitations

This study used RIAS, an instrument widely used to assess the content of medical dialogue. RIAS codes are mutually exclusive and exhaustive allowing every utterance of the consultation to be coded and included in the analysis. A proportion of the consultations were also double coded for reliability.

As previously mentioned, the sample size was small with ten patients recruited from one orthopaedic clinic. Patients were typically well educated and had active lifestyles. Consequently, they may not be representative of the general population. The structure of these consultations may also differ from other orthopaedic surgery consultations as all but one of the patients had already had a consultation with the clinician earlier in the day. The recorded consultations, therefore, did not include introductions, patient histories and physical examinations, which could all alter the content of the discussion. As a result of these study limitations, these findings cannot tell us about the content of orthopaedic consultations more generally. However, they do provide an interesting description of the communication practices in one orthopaedic surgery clinic and offer insight as to how an image can be incorporated into a consultation.

Furthermore, limitations of the RIAS method have been identified. Mead and Bower (2000), for example, assessed the validity of three measures of patient centredness including RIAS, finding that the correlations between the three measures were low. This suggests that the three measures may not be assessing the same construct and questions the validity of the measures (Mead and Bower, 2000a). A further limitation of the method, as identified by Carrard and Mast (2015), is that it ignores differences in patients preferred interaction style. Adapting the interaction behaviour to the individual patient is central to the patient centred approach, however most methods of assessing patient centredness including RIAS adopt a one size fits all approach (Carrard & Mast, 2015). Despite these limitations, RIAS was selected for use in this study as previous studies have shown the framework to be a reliable method of assessing the content of consultations. Furthermore, RIAS allowed for the inclusion of the image within the analysis and allowed this data to be compared to the results of Levinson and Chaumeton.

4.5. Conclusions

Consultations about orthopaedic surgery tend to focus on providing patients with biomedical information. Medical images can be used within consultations to help communicate biomedical information to patients. They therefore may be a powerful tool for surgeons conducting consultations. Although discussion of psychosocial issues appears limited within orthopaedic surgery consultations, there are psychosocial issues that require attention from surgeons.

4.6. Chapter Summary

Chapters Three and Four both explored the use of medical images during clinical consultations about FAI. The following chapter will explore the public's opinion of orthopaedic and oncology 3D images, presenting findings from focus groups to understand whether they believe the benefits of viewing 3D images highlighted from the case study clinic may be found in different clinical contexts and whether they foresee any concerns of sharing 3D images with patients.

Chapter Five: Exploring perspectives on 3D images and their potential for use in clinical consultations: findings from six focus groups.

5.1. Background summary

Building on the findings from study one, this study sought to gain feedback from the public on a selection of 2D and 3D images. Data from the orthopaedic clinic case study revealed that patients may benefit from viewing their own 3D images, with patients and clinicians reporting improved understanding, communication and confidence. This study aimed to explore whether the public think that the benefits identified in study one would be found in different clinical contexts and whether they believe there are any wider concerns of sharing images with patients.

Research has indicated that the use of images (including pictures and diagrams) within clinical consultations or health information leaflets may be helpful to patients, particularly in relation to recall and understanding of health information. Furthermore, images may also influence behaviour with UV photographs of sun damage shown to students during psychological experiments reducing sunbed used compared to a control group (Gibbons *et al.,* 2005). Research has also described patients' experiences of viewing their own 2D images within a range of clinical contexts including general practice consultations (Carlin *et al.,* 2014) and consultations about lung cancer, including end of life discussions (The *et al.,* 2000). Additionally, Ogden *et al.,* (2009) have studied women's experiences of viewing the screen during their hysteroscopy procedure (Ogden *et al.*, 2009). These studies have highlighted both benefits (i.e. improved understanding) and negative consequences (i.e. anxiety) of sharing 2D and endoscopic images with patients. Little is known, however, about how lay people experience viewing 3D images and whether this experience would differ from viewing 2D or endoscopic images. In addition to understanding how patients experience viewing their own 3D and 2D images, it is important to consider whether there are any practical or ethical considerations of sharing images with patients.

5.1.1. Research questions

Focus groups were used to address the following research questions:

1) How do 3D orthopaedic and oncology images compare to 2D images?
2) Are there benefits of sharing medical images with patients?
3) Are there concerns about sharing medical images with patients?
4) Would lay audiences like 3D images to be used within clinical consultations, how, in which circumstances and to what extent?

5.2. Statement of methods and justification for the study design

This study used six focus groups with lay participants from local public and patient groups to gain a wider perspective on the potential impact for patients of viewing their own 3D images.

Focus groups are widely used within exploratory research to elicit the views of a group of individuals on a specific topic. The approach, initially used within market research, gained popularity during the 1980s and is now adopted by researchers from a wide spectrum of disciplines (Bryman, 2012).

Focus groups allow researchers to learn how people discuss a topic of interest (in this case medical images) and understand their collective view of the phenomena (Krueger & Casey, 2014). They allow participants to probe and challenge one another's views. Furthermore, participants are likely to notice and comment if one participants contradicts themselves or expresses a view that appears illogical (Krueger & Casey, 2014). Participants may also raise ideas relating to the image that other participants would never have considered on their own. Focus groups allow participants to voice agreement with the ideas of others, contributing to the formation of their collective view (Krueger & Casey, 2014). During a focus group, the researcher is able to observe whether opinions are modified in response to the ideas of others. Hearing other views and receiving feedback on their own ideas enables participants to modify their views (Kruger & Casey, 2014). Modification such as this is rare within individual interviews, as interviewers tend not to challenge interviewees or offer their own alternative ideas (Kruger & Casey, 2014). According to Bryman, focus groups can therefore create a more realistic account of the respondent's views (Bryman, 2012).

As this study was interested in accessing a collective view of sharing medical images with patients from members of the public as opposed to learning about participants' individual experiences, focus groups were deemed the most appropriate method of data collection. Additionally, focus groups were favoured over individual interviews to address the research questions for this study as individual interviews may be challenging for participants who have not been exposed to medical images before. Participants may not have previously considered the use of medical images within a consultation and thus may find discussing the topic with others preferable to forming views alone. Focus groups provided participants with the opportunity to reflect upon the ideas of others when forming their responses.

Focus groups were formed of lay participants recruited from existing public and patient groups. Focus groups with lay audiences (not patients viewing their own imaging) were selected as an appropriate method to address the research questions. These participants have the potential to be or have previously been patients. The practice of viewing their own medical imaging results is something that all participants could have previously encountered or may encounter in the future. They were however not receiving medical information about themselves during the focus group. This allowed the presentation of a range of different images for a variety of conditions.

Six was selected as an appropriate number of groups for this study. This is because this study sought to gain a wider perspective on the practice of sharing medical images with patients from lay individuals rather than achieving data saturation. Kruger and Casey (2014) recommend conducting just three or four groups with a target audience before deciding whether additional groups are required. Two groups, conducted with the students did not generate rich data and therefore a further four groups were conducted.

Between four to eight participants were recruited to each focus group. Smaller groups were deemed most appropriate for this research study. Discussion tends to be more difficult to facilitate in larger groups with less people wishing to raise their ideas. Quiet members also tend to find it more difficult to speak up in larger groups and are more likely to actively participate in smaller groups (Bryman, 2012). Smaller groups have also been suggested to contain greater diversity of opinions or disagreement. It is thought that this is due to more confidence to disagree in a small group and because in a smaller group one member is less likely to become more dominant than the others (Bryman, 2012).

5.3. Methods

5.3.1. Data collection

Participants were recruited to six focus groups from two local public groups with an interest in science, two local orthopaedic patient groups and from the University of Warwick Psychology department. For four of the six groups, participants were recruited by email and for the other groups at group meetings. EP attended one local scientific interest group meeting and one local orthopaedic patient group meeting to explain the purpose of the focus groups to those attending and to hand out information sheets, contact details and a list of potential dates for the focus group to those interested in participating. For the other scientific interest group and orthopaedic patient group an email was sent to one member who then invited other members of their groups to participate. For the scientific interest group, the member provided other members of the group with the researchers contact details as well as the information sheet and list of potential dates with each member interested in participating contacting the researcher directly. For the orthopaedic patient group, the member provided other group members with the information sheet but arranged the focus group with the researcher on behalf of all members interested in participation. For the student focus groups, a lecturer from the psychology department sent an email to all psychology students. The email included the information sheet, contact details of the researcher and a list of potential dates. The sample was opportunistic and dependent upon potential participants reading the recruitment email or attending the meeting in which the focus groups were raised and then choosing to participate.

Focus group guides were developed based upon the research questions, published literature and the initial analysis of the orthopaedic clinic case study data (as described in Chapter Three). Focus groups explored the impact for patients viewing their own medical images as well as wider considerations that may arise from sharing medical images with patients. During the focus groups, participants were shown a selection of orthopaedic 2D and 3D images including images of FAI. They were also shown 2D and 3D images of liver cancer and healthy virtual colonoscopy images. These were all anonymised. The focus group began with images of the hip and pelvis and participants were shown a 2D and a 3D image for each condition to allow comparison. The first images were always of FAI as this was the most frequent image shown to patients recruited to study one. Further hip conditions were then shown to focus group participants depending upon the time available. Where groups engaged in lengthier discussions, fewer images were shown. Participants were then shown images of the soft tissues, specifically images that did or could present gastrointestinal cancers. This included a 2D image and a 3D image that present liver cancer and 3D virtual colonoscopy, which showed no pathology but was used to present how bowel cancer could be detected and presented in the image. The focus groups concluded with two 3D rotating video clips, one of the heart and one of the arteries that feed into the heart. These were presented with the aim of ensuring the focus groups concluded on a more positive note after potentially distressing discussions of cancer images, rather than to gain feedback on the heart images per se. Focus groups were recorded for audio.

Focus groups were formed of people with similar interests or backgrounds as each group was recruited from one source. In some instances, the participants knew one another. Their shared interest created a sense of unity from which they discussed the images, with some groups identifying their shared interest as an important factor in their collective view of the images. The materials for this study can be found in appendices 11-13.

5.3.2. Ethical considerations

Potential participants were informed of the topics to be covered during the focus groups and the types of images that they would be shown (i.e. orthopaedic and oncology images) prior to participation. Participants recruited to the focus groups from the University of Warwick Psychology department were compensated £6 for their time, which is the standard rate of pay for research participation within the department. Participants provided written consent. The NHS Research Ethics Committee approved this study (Study Number: 150177).

5.3.3. Development of materials

Materials for the focus groups were developed with assistance from Dr Wellings (a research supervisor for this project and a Consultant Radiologist). Dr Wellings provided a selection of images, each with a description of the medical condition, symptoms and treatment. Dr Wellings and the researcher went through each image to be used during the focus groups to confirm understanding. The written descriptions were taken to the focus groups to refer to when required. This ensured that the information given to participants was accurate.

5.3.4. Data analysis

At the beginning of each focus group the researcher and focus group participants all introduced themselves and their backgrounds. These introductions and the researcher's first description of each image were summarised during transcription. The remaineder of the focus groups' discussions were transcribed verbatim. EP was immersed in the data by listening to the audio recordings, transcribing the recordings and studying the transcripts before coding (Ritchie & Spencer, 2002). The data was managed and coded using Nvivo 10.0. All data from the focus group transcripts relating to medical images were coded into one of eight codes, with a deductive framework approach (Ritchie *et al.*, 2003) used to develop the themes. The framework approach relies on the generation of central themes which are searched for within the data (Bryman, 2012). A framework of six themes was developed based upon the research questions and the themes that emerged from the interview data from study one. These themes were (i) communication, (ii) decision-making, (iii) practical considerations of sharing images with patients, (iv) the context in which the image is shown, (v) participants perceptions of medical images and (vi) comparing 2D and 3D medical images. Additional themes grounded from the focus group data were also added to the framework. Additional themes were ethical considerations of sharing images with patients and participants experience of viewing their own images. Themes were compared across focus groups. A table presenting themes by focus group can be found in Appendix 14. After the transcripts had been coded the data were organised into tables (as shown in Appendix 15) to allow comparison across and between groups. EP and FG discussed the codes and themes throughout the analysis to ensure reliability and coding (Graneham & Lundman, 2004).

5.4. Results

5.4.1. Participant characteristics

Thirty-one individuals participated in six focus groups. The majority of participants were female (74%). Twelve students participated in two focus groups. Within the student focus groups, all participants were female and the mean age of participants was 21.2 (range 18-27). 42% of student participants were Asian or British Asian and 33% of participants were white British or white European. Table 14 presents the characteristics of students participating in focus groups. The mean age of participants in the patient and public focus groups was 68.8 (range 55-75). Eight were male and 11 were female. All participants of the patient and public focus groups were white and the majority were well educated, with nine out of the 13 participants who completed the question on the demographic questionnaire asking about highest educational qualification having at least a Bachelor's degree. Within one focus group, there were two members of one family present. Table 15 presents the characteristics of participants from the patient and public focus groups.

Table 14: Participant Characteristics – Student Groups (Groups 1 & 2)

Participant Characteristics	Number
Age	
18-19	4
20-25	3
26-30	2
Unknown	3
Gender	
Male	0
Female	12
Race	
White	2
Asian	5
Mixed	1
Black	1
Unknown	3

Table 15: Participant Characteristics – Patient and Public Groups (Groups 3-6)

Participant Characteristics	Number
Age	
50-59	2
60-69	3
70-70	9
Unknown	5
Gender	
Male	8
Female	11
Race	
White	14
Unknown	5
Education	
Higher Degree	5
Degree	4
Other	3
Unknown	7

5.4.2. Summary of results

This section will firstly present participants' comparison of 2D and 3D images. In addition, four main themes were found within the data. These four themes are presented in figure 10. Three of these themes were based upon the research questions outlined above. These were: the impact of sharing images with patients from an individual perspective (which highlights the benefits for patients of viewing their images -RQ2); the wider impact of sharing images with patients (which highlights concerns of sharing images with patients –RQ3) and the clinical context in which the image is shown (RQ4). An additional theme, participants' perceptions of medical images, was also developed during the analysis of the data. Each of these is explored separately below. In the results, the focus groups are numbered to preserve anonymity and are prefixed with 'FG'.

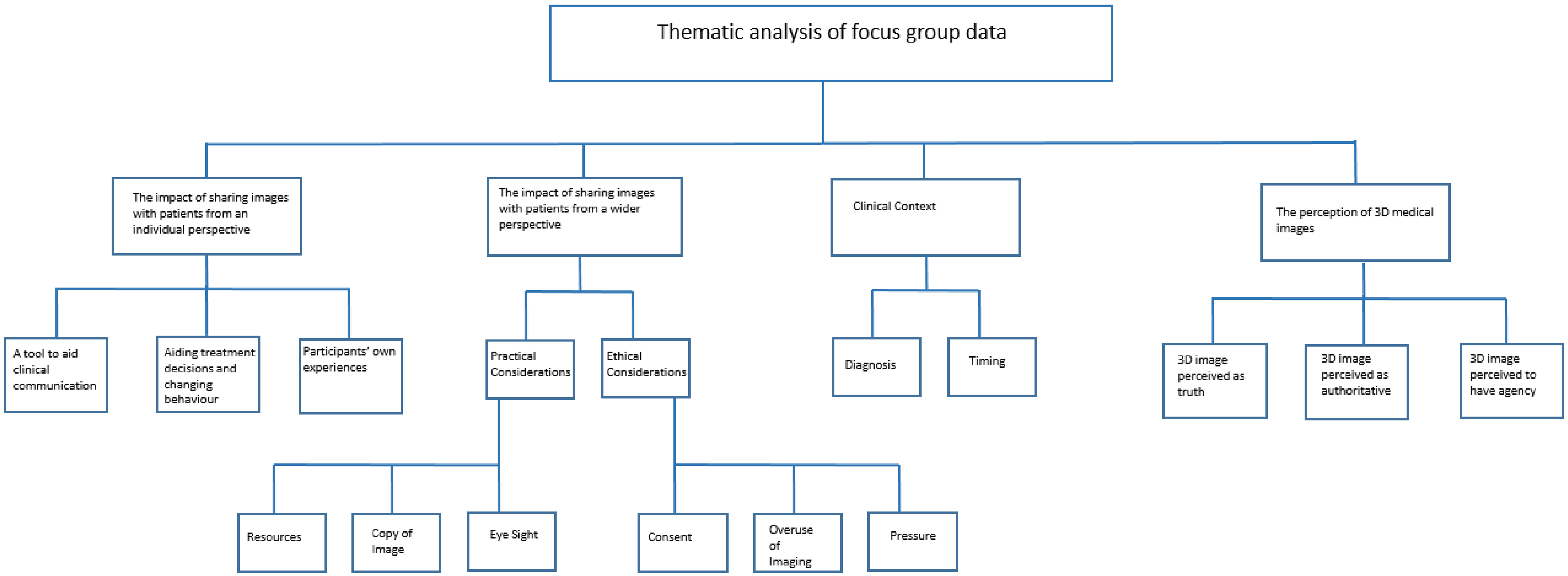

Figure 10: Diagram showing the four overall themes that emerged from the focus group analysis.

5.4.3. Comparing 2D and 3D images

Table 16 presents whether the 2D or the 3D image was favoured for each condition, for each group. For some conditions, focus groups did not discuss which image they favoured or they did not agree on which image they favoured. These are recorded in Table 16 as not reported (N/R). Overall, participants tended to prefer 3D orthopaedic images to 2D images and tended to agree 3D images would be more helpful to patients. However, there were exceptions to this with one focus group favouring the 2D image for all three orthopaedic conditions and two groups favouring the 2D image for one condition.

Table 16: Image preference of each focus group for each condition discussed

Group	FAI	Healing Fracture	Avascular Necrosis	Liver Metastases
FG1	2D	2D	2D	2D
FG2	N/R	3D	3D	2D
FG3	3D	N/R	3D	2D
FG4	N/R	2D	N/R	2D
FG5	3D	3D	2D	N/R
FG6	3D	3D	N/R	2D

This suggests that the experience of viewing medical images may vary between conditions and individuals, with some favouring 3D and some favouring 2D. Interestingly, only one group favoured one image type across all conditions.

Where the 3D image was favoured, this was often because participants felt the abnormalities were not as obvious on the 2D images. Participants also found the ability to rotate the 3D image helpful as it allowed the hip to be viewed from a variety of angles (FG1, 4, 6). Two groups contrasted their understanding of the 2D image to that of the 3D image, explaining that from the 2D image they understood there was a problem but from viewing the 3D image they understood what the problem was. Additionally, two groups explained that the 3D image was more recognisable.

Three groups stated that they would like to view both 2D and 3D images, with one group emphasising the more information the better. Further, one participant explained that she liked the simplicity of the 2D image and would like to see it before viewing a 3D image.

For the images of liver metastases, all five focus groups who compared the 2D axial CT images to the 3D image favoured the 2D image. For two groups this was because the 3D image was too "scary" (FG1, 2). Focus group 6 similarly described the 3D image as "gruesome" but also explained that metastases were clearer on the 2D images because they could see the contrast between tissues better on the 2D image. In the other two groups participants explained that the 3D image does not add anything to the 2D image as it shows "no real depth" (FG4) with one group adding that the 2D image is "adequate enough" (FG3).

Participants also highlighted that the severity of a condition could appear different depending on whether it was presented on a 2D or a 3D image. For example, Group 6 argued that the healing fracture looked much worse on the 2D image while group 1 stated that the liver metastases looked much worse on the 3D image.

5.4.4. Considering the impact of sharing images with patients from an individual perspective

All six focus groups indicated that the 3D images they were shown during the focus group could aid understanding. Within two focus groups, participants felt there could be positive emotional benefits for patients of viewing their own medical images. They explained that viewing the image could be a comfort for patients who may be "relived there was a reason for your pain" (FG6). Participants also described the images to be "reassuring" and "encouraging" and explained that the image may "make someone more at ease" (FG6) when they have to have treatment.

In two focus groups the idea of increased confidence in the clinician and diagnosis were raised. Participants explained that if their clinician showed them 3D images it would increase their confidence, as they would know that they have quality information and that their condition was being looked at properly.

Participants also spoke about the impact of images on communication and behaviour as well as their personal experiences of viewing their own medical images. These are discussed in detail below.

5.4.4.1. A tool to aid clinician - patient communication

Communication was discussed within all six focus groups. Participants spoke about the importance of clinicians explaining the image, the use of medical jargon when discussing medical images and conditions and the potential for medical images to help build a rapport between clinicians and patients. These will now be explored in turn.

Many participants emphasised the need for the image to be explained throughout the discussions as demonstrated through statements such as "the explanation is just as important as the image" (FG3). One group explained that they believed the image "wouldn't be helpful on its own" (FG4) while one participant implied that without an explanation she would not understand the condition as she would have "no idea what I was looking at" and "no idea just how wrong something was" (FG1). Two groups elaborated on this further, stating that not only was an explanation required but a skilful one. Participants thought an unskilful explanation could cause negative consequences. For example, if the explanation was poor it could be “frightening” (FG4) or could cause patients to “panic … and get carried away” (FG1). One participant commented that “the most useful bit of information” for her understanding of the condition FAI was the statement accompanying the 3D image. The statement, as recalled by the participant, was “that side should be curved like that side” (FG3). This statement relies on the presence of an image so that viewers can compare the two sides; suggesting that it is the combination of the image and the explanation that is important.

Focus group participants commented that they would like the whole of the image to be explained rather than the clinician simply explaining the relevant aspects. They wanted to know what is normal and what is abnormal within the image. One participant explained that they “can’t help but deviate and look at other parts” (FG5) to which other participants in the focus group agreed and said that they would want to know if these parts are relevant too. Additionally, one group mentioned that while a clinician might know that something that looks terrible on an image can be treated, the patient does not necessarily know this upon seeing their image so consideration of the type of information that accompanies images is needed.

Medical jargon was raised during three focus groups, with participants indicating that the use of a medical image could replace medical jargon when communicating with patients. One group explained, as demonstrated through the quote below, that they believed the condition FAI could not be explained without an image unless medical jargon was used.

> You couldn’t explain it without an image I don’t think because you’d need to use some technical language. One consultant could explain to another consultant what the problem was but to a layperson you couldn’t, you need an image to show what’s wrong (FG3).

The phrase a “picture is worth 1000 words” was also raised during two of the focus groups (FG4, FG6). This suggests that participants believed the image could convey information more easily than words.

Three groups also discussed the potential for images to help build a rapport between doctor and patient. One participant explained that she found the use of images during consultations encouraging as it allows the patient to bond with their clinician. Similarly, group six explained that being shown their images could make them feel more respect for their clinician. They explained that they want to their consultants to talk to them and treat them like adults.

5.4.4.2. Aiding treatment decisions and changing behaviour

Focus group participants spoke about the impact of viewing medical images on behaviour. Behaviours discussed included making treatment decisions, changes to lifestyle and acceptance of their condition. During these discussions, participants spoke about the images they were shown during the focus group and some participants spoke about images they had seen during their own clinical consultations.

Three focus groups argued that viewing medical images might encourage patients to have the treatment recommended to them or to change their health behaviours and lifestyle. They explained that this is because the image may make the condition more real and it may frighten patients into reality. Participants in one group described the image as a “medical tool” (FG6) for this purpose: to shock patients into realising their condition and the choice they have to make. This view of the image as a tool to shock was based upon one participant’s personal experience of viewing his own medical imaging results. He described the experience to be shocking and upsetting but reflected that it did prompt him to change his lifestyle. In another focus group, participants spoke of the use of medical images to promote behaviour change in asymptomatic individuals. They proposed that a 3D image presenting cancer could be used to prompt smoking cessation as smokers could be told “if you don’t stop now this is what it might look like" (FG1). They believed the image could be used to "shock someone seeing what might happen" (FG1) reinforcing the idea of the image as a medical tool. In contrast, one group suggested that viewing their own medical imaging results could also discourage patients from opting for suggested treatments.

A final aspect of behaviour that was discussed within one focus group was acceptance. Participants stated that viewing an image might force people to face up to their condition and if there was no curative treatment, accept their limitations and "move on". When this point was raised participants were not discussing life-threatening conditions, they were referring to limitations that may impact upon their daily activities or their quality of life.

5.4.4.3. Participants' own experiences of viewing their own medical images

Six participants spoke about their experiences of viewing their own medical imaging results during the focus groups. Three of these participants saw 2D images and the other three saw endoscopic images. Five of these participants described their experiences positively, explaining that it was "absolutely amazing" (FG4) and "as a patient it made me feel content" (FG5). The other participant found experience less positive, describing it as "disturbing really" (FG6). Although he described viewing the image to be "very shocking, very upsetting", he also explained that the image had been useful as it prompted him to change his lifestyle. Additionally, he emphasised that he was predominantly unhappy with the way the image was presented to him rather than unhappy at viewing the image in itself. He was shown his images without warning which he believed was not an acceptable approach.

Additionally, one participant had experience of viewing a 3D image of a family member who had been in a car accident, which she described as 'extremely helpful to understand the breaks' (FG5).

5.4.5. Considering the impact of sharing images with patients from a wider perspective

Focus group discussions included consideration of wider issues relating to sharing images with patients during a clinical consultation. These have been divided into practical and ethical considerations.

5.4.5.1. Practical considerations

Several practical considerations were raised by focus group participants. These were the resources required to produce and show 3D images to patients; patients receiving a copy of their own image to take away and the patients' eyesight. They will each be discussed in turn.

The resources (namely time, equipment and costs) required to make and show 3D images to patients were considered by participants during five groups. These were raised briefly in two groups with participants asking what is the cost of producing the 3D image and whether "fancier equipment" is required? EP explained that 3D images are created using the digital data from 2D scans and so require no additional equipment. The other three groups discussed time. One group believed the additional time required to create and communicate the images was a potential barrier to their use because the additional time costs money. Another group argued that additional time would only amount to a matter of minutes per patient. In contrast, one participant in another focus group proposed that, in the long term, showing images to patients could save time and money if patients know and understand their conditions. This perspective was also raised by a clinician and a patient in study one who argued that consultation times could be shorter if patients can grasp information more quickly.

Participants discussed keeping a copy of their image, with four groups enthusiastic about patients being able to keep a copy of their image. Three groups asked if patients are able to ask for a copy of their images while one group stated that they would ask for a copy. Participants said that patients may benefit from keeping a copy of their image as it would allow them to show their images to their families and friends and study their images in their own time which may “jog their memory to ask a question” (FG6). Within one group, participants argued that if patients are to be given an image to take away they should also be given a written explanation to accompany it, as they had discussed that “the explanation is as important as the image” (FG3). Similarly, group four expressed concern about the amount of verbal information patients receive, emphasising the importance of giving patients written information, including hospital records (FG4). Two groups appeared less enthusiastic about patients keeping a copy of their image. However, they did state that if patients wanted a copy they should be allowed one. Further, one group was concerned that patients who have taken a copy of their image home may start to misinterpret their image if they forget the information that they were told alongside it.

One group also noted that the patient’s eyesight is a factor to consider, explaining that the helpfulness of the image can depend on how well they can “focus on the different colours” (FG6). This was raised during a discussion comparing a 2D image of liver metastases to a 3D image of liver metastases where the differences between normal tissue and metastatic tissue were subtle and could be hard for people with poor eyesight to distinguish.

5.4.5.2. Ethical considerations

Several ethical considerations were raised by focus group participants. These included patient consent, overuse of imaging and pressuring patients.

Three groups explained that patients should be asked if they wish to view their images before they are shown. For one group, this appeared to be an important issue that dominated their discussions. Within this group, one participant had been previously shown his imaging results without being asked beforehand, which he described as distressing. Participants explained that while some patients will want to view their images, others would not. One group stated that the wishes of patients who do not want to view their images should be respected. In contrast, participants in one group argued that it is perhaps more complex than that. If the doctor's duty is to explain a medical condition to a patient in a way that they understand and are able to use to make an informed choice, then they may need to show them an image in order to do this (as demonstrated by the quote below).

> So the mere fact that someone says 'I don't want to know' isn't necessarily the end of the consultation… and pictures might help (FG3)

Furthermore, one patient, who had previously asked to view her imaging results, commented that patients who do want to view their images might not have the courage to ask.

One group expressed concern about the potential for overuse of imaging. They were worried that clinicians may ask for more CT scans if showing 3D images to patients made them seem more patient-friendly. They were also worried that patients may ask for more imaging tests if they became aware that 3D images of the insides could be taken. The main reason for their concern was the high levels of ionising radiation in a CT scan and they were worried patients may ignore the radiation aspect if they wanted a 3D image.

A further consideration raised within one group was the use of images to pressure patients. As previously described, several participants discussed the use of medical images as a tool for shocking patients and promoting behaviour change and generally argued that the use of the image in this way was justified. However, one participant described feeling "nervous about it *(the image)* being used as a shock tactic" (FG4). He described this as "brow-beating the patient" (FG4) if the patient does not follow the recommended treatment.

5.4.6. <u>The impact of the image in different clinical contexts</u>

Focus groups discussed the context in which the image is shown, specifically the type of illness demonstrated within the image and the time at which the image is shown. These are discussed in turn below.

5.4.6.1. Illness

Within five focus groups, participants discussed the type of illness presented in the image. They often contrasted viewing images of bone to that of cancer, stating that while they believed images of bones may be helpful to patients, patients may not want to see images of more serious conditions such as cancer. Within one group, participants proposed there may be a difference in emotional impact between seeing guts as opposed to bones and implied that seeing guts may have a more negative impact as they could cause patients to feel a sense of vulnerability. Further, in two focus groups participants were less confident that the images of cancer would aid patient understanding, with one patient explaining "I don't think it adds any extra to what my mental image of metastases in my liver" (FG3) and one commenting "it's not simple is it" (FG4).

Interestingly, in response to a comment that virtual colonoscopy images "could be scary" for patients, one participant argued that the "whole thing is scary" (FG3) rather than the image per se.

One 3D orthopaedic image depicting Avascular Necrosis (AN) was described as frightening and upsetting by some participants, with one participant explaining that "I think that some probably would be distressed to see that- it has a cancerous look about it"(FG3). Another participant said they would feel disheartened to see the image of AN. This image was described as "horrendous" (FG5), "terrible" (FG6) and "revolting" (FG6) while other orthopaedic 3D images such as the image of FAI were described as fantastic" (FG6) and "amazing" (FG6).

Participants in four groups expressed concern about showing patients their images if there was no (curative) treatment available and two groups explained in this instance the images could have adverse effects. In three of the four groups, participants were hypothesising how other patients would feel but claimed that they would still want to see their own image in the absence of a treatment. However, in the fourth group a participant said that while they “wouldn’t mind having an image” of something that is treatable, they did not think they would want that of something serious. Within one group, a participant seemed more concerned by this, frequently raising the question of whether the experience of viewing the image would be different if no treatment or less straightforward treatments were available. Although he acknowledged he would not know how someone in that situation is going to feel, he was concerned that there may be a lasting impact of the image with patients saying “I keep waking up and seeing that picture” (FG3).

Within one group, participants also discussed whether images should be shown if there is one “clear cut” (FG4) treatment option. One participant explained they he was not sure there was a reason to show images to patients in this context stating, “I am not sure it adds a great deal”. He was speaking about a specific example (AN) in which the patient would need a hip replacement and said that he believed that the patient would probably have an idea of their diagnosis. It may not be the case that all patients with a “clear cut” treatment are aware of their diagnosis so the image may still be helpful in those cases.

The presence of comorbidities was also raised within one group who argued that sharing images with patients would be more complex if there were several problems rather than one simple problem, as the clinician would have to decide which aspects of the images are important and which should be disregarded.

5.4.6.2. Time

Participants discussed the appropriate time for sharing medical images with patients, with two groups indicating that images should be shown at a later consultation rather than immediately after diagnosis, particularly after a diagnosis of cancer. One group stated that after a diagnosis of cancer viewing an image may be scary for patients, while the other group explained that patients viewing hip images had probably had at least one consultation so may be better prepared to view their images in comparison to a "first time diagnosis of cancer"(FG4). In study one, all recruited patients had previously attended a previous consultation about their hip complaint before being referred to the clinic. This may have prepared them somewhat for viewing their images.

Further, two groups discussed whether patients should be shown their images repeatedly, either pre and post treatment or to monitor their condition. Both groups agreed that seeing a post treatment image would be beneficial with one explaining that "once you have been shown one you need to be shown the rest, you know good or bad" (FG6). One of these two groups also discussed the use of images to monitor a condition, specifically one that does not require any intervention at the present time but may do in the future. They argued that it could be helpful for patients to see how their condition has changed and that sharing images intended to monitor the condition with a patient would "make it easier for both sides to see how far it has developed". However one participant indicated that imaging patients after treatment could be problematic, explaining that it would be unnecessary radiation for the patient.

Furthermore, one participant also considered the appropriateness of showing patients endoscopic images during the procedure which he claimed was a "higher risk" (FG4) as neither the patient nor the clinician knows what they will find or how the patient will react if something can be seen within the image.

5.4.7. Perceptions of medical images as truthful, authoritative and agentic

Focus group participants spoke about the images as though they were the truth, and as though they had authority and agency. This perception, identified previously by Joyce (2008), was in part found within the data collected for study one.

Participants within five of the six focus groups described medical images, both those that they were shown during the focus group and those that they had experienced during their own clinical consultations, as factual. Participants used phrases such as “it is evidence” and “there is no doubt about it” (FG3), “it’s a true record” (FG5) and “the truthful image” to convey their perception of the image as a fact. One participant elaborates further explaining that people can interpret what they want to hear but when they are shown an image “there is no two ways about it” (FG3). This replicates the findings from study one where patients considered their medical imaging results to be truthful and factual. In contrast, within the other focus group one participant described the image as a “representation” (FG1) suggesting that she did not consider the image factual. Similarly, one participant, while viewing the virtual colonoscopy images, observed that the images shown do not reflect what the bowel actually looks like, with no villi visible. She suggested that perhaps patients should be made aware of this, although she was unsure as to whether there would be any harm in patients having an inaccurate idea of what the inside of their bowel looks like. This shows that she was aware that medical images do not convey evidence.

A minority of participants also appeared to give the image authority and agency. Two focus groups gave the images authority over the clinician during their discussion, with one group stating that “it’s also a demonstration that they know precisely what’s wrong and where rather than saying we think we have got the problem” (FG3). This group appeared to trust the image more than the clinician, with one participant explaining that if they were just told rather than shown the image they might question, “how do you know exactly?” (FG3). The idea of greater trust in the image than in the clinician was also indicated within another focus group through the following quote “being able to see it with your own eyes and not having the doctor put a spin on it” (FG2).

Within one group, participants indicated greater trust in the clinician than the image. While discussing 2D and 3D images presenting liver cancer they explained that if the clinician had told them another aspect of the image was the cancer that would be just as believable. They also questioned, “how do you know that it is not just a slight difference in the liver tissue rather than a cancer?” (FG4). This could suggest that acceptance of the information given about an image is reliant upon trust in the clinician.

One participant, talking about his experience of viewing his own images during the imaging test, spoke about the procedure and images as though they had agency. He stated that the “procedure showed me that whatever the pain I was getting is not from the gut” (FG4). This indicates the belief that imaging procedures can reveal the truth about our bodies, ignoring the interpretation and manipulation of images by radiologists. He explained that he believed that perhaps his doctor had ordered the test to show him his insides were all right, which suggests that believing is related to seeing and described the experience of seeing his images as “very, very powerful” (FG4). The notion of agency was also indicated by one participant who described the imaging tests as an MOT. He explained he asked his clinician if “if you don’t mind I would like to come every year just for safety’s sake like having an MOT” (FG3) when he was told he no longer required surveillance scans. This implies that he believes the image reveals the body’s condition and can show what, if anything, is wrong. One participant, by comparison, acknowledged that the image does not give a diagnosis in a cancer image, for example you can only see what she described as “big black blobs” (FG4).

5.5. Discussion

This study had four main findings. Firstly, participants proposed patients would find benefit in viewing their own medical images. These benefits included better understanding of a medical diagnosis, improved clinician – patient communication and positive changes to health behaviour and lifestyle. Second, the majority of participants perceived medical images to be truthful and several participants described them to be authoritative and agentic. However, interestingly, a minority of focus group participants were aware that medical images are representations as opposed to evidence and indicated greater trust in the clinician than the image. In two focus groups, participants thought that the severity of the condition appeared to differ between the 2D and 3D images. This is interesting as it highlights that the image is a representation and is not demonstrating one truth. These two findings – the benefits of the image and the perception of the image - were both raised in the data collected from an orthopaedic clinic case study, as discussed in Chapter Three. The other two other main findings were as follows. One, there are several practical and ethical considerations associated with sharing images with patients during their consultations that may need addressing, and two, there may be certain clinical contexts where the sharing of medical images is more appropriate than others.

One ethical consideration raised in this study was the use of images to pressure patients into accepting recommended treatments. Many felt that this use of images was perhaps justified while in comparison one group was concerned about images being used in this way. The *et al.,* (2000) has previously described medical images being used to convince patients diagnosed with lung cancer that they had a tumour. They were also used as "proof" that the treatment was working when they began to feel worse from the side effects of chemotherapy. The notion that medical images can be used as evidence to convince patients is concerning, as it could lead to patients feeling unable to evaluate their own bodily sensations and their symptoms (The *et al.,* 2000). The use of images as proof to convince patients of their illness reinforces the perception of images as truthful, authoritative and agentic as identified with the data collected in study one and previously identified by Joyce (2008).

A further ethical consideration raised by one focus group was the potential for overuse of imaging, which they argued might result from more patients wanting 3D images and clinicians wanting to appear patient-friendly. This concern has been raised within the existing literature with Gelb *et al.,* (1996) demonstrating that with anterior cruciate ligament injuries and isolated meniscal legions, for example, MRI is overused, with the MRI making a contribution to the diagnosis in only three of 72 cases. Overuse of imaging has, in part, been attributed to the perception of medical images as truthful, authoritative and agentic by sociologists (Joyce, 2008; Roberts, 2012). The belief that images can reveal the truth and can provide more accurate information than can be gleaned through physical examination or patient histories could lead to requests for imaging tests when they are not clinically needed (Joyce, 2008; Roberts, 2012). These two ethical considerations raised within these focus groups emphasise the importance of patients' and the public's perceptions of medical images and highlight the consequences that these perceptions can have.

Additionally, participants raised the idea that clinicians should seek verbal consent before showing patients their imaging results with many participants arguing that it is the personal choice of the patient and their right to decide whether they want to know about their condition or see their images. Although medical professionals are encouraged to give patients more information about their condition and prognosis not all patients want this. Clarke *et al.,* (2008) for example, found 36% of 120 patients recruited from general urological and surgical outpatient clinics did not wish to know their prognosis while Elkin *et al.,* (2007) found that only 44% of 73 elderly patients with metastatic colorectal cancer wanted information about survival and 52% preferred a passive role in decision-making. Regarding prognosis, Back and Arnold (2006) propose asking patients how much they want to know. This strategy, similar to asking patients if they want to view their own imaging results, could allow clinicians to tailor the amount of information given to individual patients. On the other hand, some participants felt that it was the clinician's duty to ensure that patients are fully informed and that images may be required in order to achieve that. The lack of guidance as to how to communicate information that patients do not want to receive could create a complex dilemma for clinicians who are required to provide patients with enough information to allow them to make an informed decision about their care but who are also expected to respect the wishes of their patients who do not want information about their condition or prognosis. The use of medical images within a clinical consultation adds further complexity, particularly if consent is sought before sharing them. Images could potentially enable clinicians to better equip their patients to make informed decisions as they could improve patient understanding, but could also hinder patients if they choose not to view them.

The notion of acceptance was raised within one focus group. Participants in group 6 said that viewing their own medical imaging results might help patients to accept their diagnosis and the limitations that result from it. Acceptance of chronic conditions has been associated with positive outcomes. For example, acceptance of chronic pain has been associated with less pain, less depression and less disability, as well higher daily uptime and better work status (McCracken & Eccleston, 2003). Similarly, Richardson et al., (2000) found that patients with higher acceptance of insulin dependent diabetes mellitus had high coping capability and higher metabolic control. This is almost in contrast to the suggestion from P10 from study one who questioned whether it was better to be in dark about the extent of her condition.

Participants argued that some clinical contexts might be more appropriate to sharing medical images with patients than others. They argued that during consultations about cancer, for example, patients might find viewing images frightening or upsetting. Additionally, one of three participants who had viewed their own endoscopy images during the procedure described the experience as higher risk than viewing images during a consultation, and another found the experience distressing. Similarly, Ogden *et al.,* (2009) found that viewing images during a hysteroscopy could have negative emotional consequences (i.e. anxiety). This suggests that showing an image during a consultation may be more appropriate than during a procedure and that consultations about certain conditions (i.e. orthopaedic conditions) may be better suited to sharing images than consultations about other conditions such as cancer.

5.5.1. <u>Study strengths and limitations</u>

The use of focus groups with lay participants allowed an in-depth discussion between participants about some of the important considerations associated with showing patients their own images. This complements the data collected in study one, while also gaining an additional perspective. Focus group participants considered viewing the image from the perceptive of an individual patient, providing triangulation of study one data, and considered the wider impact of sharing images with patients. This provided a better understanding of some of the potential barriers as well as benefits to sharing images with patients in clinical practice.

In the focus groups with public and patient groups, the position of the researcher as a non-medical professional interested in learning about participants' perspective of medical images was helpful in building a rapport with participants. Participants in these four groups spoke openly and were forthcoming with their comments and views. In these groups, the balance of power between participants and the researcher appeared equal. The researcher provided the framework for the discussion and presented the medical images to participants, while participants understood that the researcher was interested in their insight and experience. In contrast, the focus groups with students (FG 1 and 2) were less successful. Typically, student participants were not forthcoming in discussing the images. There are two possible reasons for this. One, student participants may have had less experience of health services. This appeared to be the case as during student focus groups there was very little discussion of participants' personal experiences of health care. Second, the position of researcher as a doctoral researcher may have hindered participants' openness. Undergraduate students may have perceived the researcher as having more authority or knowledge than they have.

This sample of focus group participants is unlikely to be representative of the wider public. As participants volunteered to participate there may be a degree of self-selection bias, with participants more interested in viewing medical images potentially more likely to participate. Additionally, the majority of this sample were also very well educated and were either under 27 or over 55 years of age resulting in a large group of the population (27-55 year olds) unrepresented.

A further limitation of the data collected, the presence of a dominant member within one focus group, may have led to the bias within the data collected from this group. Efforts to minimise the dominance of one participant over the others during focus groups were made, including clear instructions and an explanation of the purpose of the focus group at the beginning, as well as intervention from the researcher to bring other participants into the discussion. However, in one group the relationships between participants may have influenced responses and dominance within the group.

A further limitation of this study is that participants were shown a limited selection of images with all orthopaedic images being of the hips and pelvis. It may have been beneficial to show participants other orthopaedic images such as the knee or shoulder to understand whether images would be beneficial in discussions about these joints.

5.6. Conclusion

In certain clinical contexts, for example during a consultation about hip conditions, viewing medical images may be beneficial to patients. However, there are several concerns that should be considered when sharing images with patients. These include considering whether to ask a patient if they want to view their images before showing them and considering how the images is used, for example, is the image being shown in order to pressure a patient into accepting treatment?

5.7. Chapter Summary

This chapter explored the public's opinion of 3D images and their potential for use in clinical consultations. The subsequent chapter will compare the experience of viewing 3D images alongside a diagnosis to viewing 2D images or no image alongside a diagnosis using an experimental design. The experiment will draw on findings from studies one and three (Chapters Three and Five) exploring the impact of an image on participants' understanding of medical information and trust in medical information.

Chapter Six: Comparing the experience of viewing 3D CT images, 2D CT images and no image alongside a diagnosis.

6.1. Background

Communication between healthcare professionals and patients can be difficult, resulting in some patients being unable to recall or comprehend the information that they are given. Research has found that images including pictures, diagrams and 2D images may aid patient understanding and recall when shown to patients during clinical consultations or accompanying medical information leaflets (Houts *et al.,* 2006; Vilallonga *et al.,* 2012; Weiner *et al.,* 2012). However, showing patients their own 2D images may also cause anxiety (Carlin *et al.,* 2014; Ogden *et al.,* 2009). 3D images are now available for use within clinical practice. They are potentially easier for lay people to understand than 2D images as organs and structures are more easily identifiable. Study one and study three (as presented in Chapters Three and Five, respectively) report benefits for patients of viewing their own 3D images. However, little is known about how the experience of viewing 3D images in a clinical consultation compares to that of 2D images or no images.

Studies one and three also found that patients trusted their medical images and often considered them as evidence depicting the truth. This perception of medical images has been identified previously by Joyce (2008) and has been a cause for concern among sociologists. This perception ignores the occurrence of errors within image interpretation and implies that medical imaging tests can provide certainty. Sociologists have argued that this perception of medical images could result in overuse of imaging, disregard for other forms of information and impairment to the doctor patient relationship. The effect of communicating uncertainty within medicine, as well as in other settings such as environmental health risk assessments, is unclear (Johnson & Slovic, 1995; Schapira *et al.*, 2001). Communicating uncertainty could enhance the trustworthiness of a source but it could also cause confusion. Johnson and Slovic (1995), for example, found that communicating uncertainty about health risks led to perceptions of honesty in some participants but perceptions of incompetence in others (Johnson & Slovic, 1995).

This study compared the experience of viewing 3D images, 2D images or no image alongside a diagnosis, using two laboratory experiments. Experiment one asked participants to rate how viewing 3D images, 2D images or no image alongside a diagnosis affected their understanding, perceived accuracy, trust, satisfaction and feelings of vulnerability, uncomfortableness and anxiety. Experiment two compared participants' ability to recall information about diagnoses across conditions where they viewed 3D images, 2D images and no image. Experiment two also examined whether informing people of the uncertainty inherent in diagnostic imaging affects their trust in the diagnosis and how accurate they perceive the diagnosis to be. Informing the public of the uncertainty inherent to medical imaging and the potential for error in image interpretation may have negative consequences (e.g. reduced trust in a diagnosis). Therefore, it is important to examine the relationship between informing participants of the potential for error in image interpretation and trust in a diagnosis in order to understand how the results from medical imaging tests can be better communicated to the public in the future. Additionally, experiment two investigated whether participants in this study were susceptible to inattentional blindness by examining whether they could detect an image of a monkey superimposed onto a medical image. The effect of informing participants of the uncertainty inherent to medical imaging and the ability to manipulate images on participants' ability to detect the monkey was also examined.

6.1.1. Research questions

Using an experimental design, this study sought to answer the following research questions, through two laboratory-based experiments.

Experiment One

1) What is the difference between viewing a 3D image, a 2D image, or viewing no image along with a verbally delivered diagnosis on participants' self-reported ratings of:
    a. understanding of the diagnosis
    b. perception of how accurate the diagnosis is
    c. feelings of vulnerability
    d. trust in the diagnosis
    e. feelings of anxiety
    f. satisfaction with the way in which the diagnosis was delivered
    g. uncomfortableness during the diagnosis
2) What is the difference between viewing a 3D image and a 2D image on:
    a. Participants enjoyment of viewing the image
    b. Participants interest in the image
    c. How helpful participants found the image
3) Do participants prefer to hear a diagnosis accompanied by 3D images, 2D images or no images?
4) At two-week follow up, can participants recall the medical images they were shown during the experiment?
5) At two-week follow up, can participants recall the diagnoses they were given during the experiment?

Experiment Two

1) What is the difference between viewing a 3D image, a 2D image, or viewing no image along with a verbally delivered diagnosis on participants':
    a. understanding of the diagnosis
    b. perception of how accurate the diagnosis is

c. trust in the diagnosis

d. recall of the diagnosis

2) Does informing participants of the occurrence of errors within image interpretation affect their trust in the diagnosis or how accurate they perceive the diagnosis to be?

3) When shown a selection of images, can participants identify the images that they were shown during their diagnoses?

4) Whilst completing a simple counting task, do participants notice a small picture of a monkey superimposed onto a 3D image (are they susceptible to inattentional blindness?)?

5) Does informing participants of the ability to manipulate 3D images make them more or less likely to notice the monkey during a simple counting task?

6.1.2. <u>Statement of methods and justification for the study design</u>

This study sought to quantify the difference between the experience of viewing 3D images, 2D images and no image alongside a diagnosis. High control over extraneous variables and a large sample size were therefore required. An experimental design using applied psychology experiments was deemed most appropriate for this study.

As outlined in Chapter Two, experimental research has generated theories to further understand human behaviour, with relevance to everyday life (Goodwin, 2008). Psychology experiments have been used to study a wide range of phenomena including attention, memory, speech, and perception (Goodwin, 2008).

Psychological research using laboratory-based methods has previously faced criticism for being artificial; lacking in mundane realism and ecological validity. However, Goodwin (2008) argues that the concerns associated with conducting research in artificial settings can be outweighed. Valuable insight into human behaviour has been ascertained through psychology laboratory experiments and these findings can often be applied to natural settings (Goodwin, 2008). Laboratory based research can be favoured, particularly for exploratory studies such as this one, as it can offer greater control of the environment, quicker and more efficient data collection and fewer ethical issues. Using a non-clinical setting to gather exploratory information on the experience of viewing 3D images, 2D images and no image allowed enough data for quantitative analysis to be collected.

This study used two applied laboratory experiments. Laboratory experiments allowed greater control of extraneous variables. For example, all participants were presented with exactly the same diagnoses using the same vocabulary. This would not have been possible using a patient population in a natural clinical setting as patients may have slightly different diagnoses and because doctors are unlikely to present the diagnosis to each patient in exactly the same way. The use of laboratory experiments eliminated interruptions such as phone calls or messages from colleagues and influences from third parties such as family members who are often present in natural clinical consultations, ensuring that the consultations were conducted in exactly the same way for each condition. High control allowed causality to be determined as any difference between the experiences of viewing 3D images, 2D images and no images could only be due to the image.

Adopting an experimental approach allowed for a repeated measures design where each participant was able to experience each image condition. A repeated measures design would not be possible within a clinical setting, as patients are likely to only receive one diagnosis and are shown one or more images or no images. A between subjects design could be used to compare the experience of viewing 3D images, 2D images and no image alongside a diagnosis in clinical practice. However, this design could be problematic as there could be variation in individual differences between patients. Profession, education level and previous medical history, for example, are just three of many factors that may influence how patients experience hearing a diagnosis with and without images. Consequently, if a between subjects design was used it would be difficult to determine whether the variance in participants' experience was a result of the presence or type of image or individual differences between patients.

Students were recruited as participants for this study. The use of students raises fewer ethical issues than the use of patients and allows a large sample of participants to be recruited more quickly than would be possible if a patient population was used. As much as 86% of studies published within the journal of consumer psychology and 74% of social psychology studies recruit only university students as participants. This is in part due to their large numbers and availability. Goodwin (2008) argues that it is unlikely that basic processes such as cognition, attention and perception differ greatly between students and the wider population. However, the findings from studies which use student based samples are often generalised with caution.

The study was higher in ecological validity and mundane realism than basic psychology experiments as the experiments were conducted as simulated clinical encounters. The methods, materials and the setting used for the study resembled those of a clinical consultation as much as possible (ecological validity). For example, the experiments were conducted in a private room on a one to one basis with the researcher taking the role of the clinician and participant taking the role of the patient. Further, these experiments had mundane realism as participating in a consultation with a doctor in which they receive medical information is something that participants may have to do in real life. It is likely that many participants will have participated in a clinician-patient interaction before and will be somewhat familiar with how consultations are conducted. Survey data has indicated young adults attend consultations with healthcare professionals. In 2008-09 in England the overall consultation rate for males aged between 15 and 24 was two consultations per person per year and for females aged between 15 and 19 and 20 and 24 the consultation rate was four and six consultations per person per year, respectively (The Information Centre for Health and Social Care, 2009). The majority of the participants in this study were aged between 18 and 24.

This was an exploratory study which sought to highlight areas of interest or concern for further study. For example, if experiments with students revealed that one of the images caused high anxiety and was unhelpful then further work applying this image within different contexts and to different populations is likely to be futile. However, if the study revealed that one of the images was helpful in aiding participants' understanding then further research could be undertaken in order to understand whether the image is beneficial to other populations. Psychology experiments, such as these which allow for comparison, can therefore be used effectively within exploratory research as they can suggest focus or direction for further study and can contribute to a larger body of work by offering triangulation of data, for example.

6.1.3. Ethical considerations

Ethical approval was obtained from the University of Warwick, Department of Psychology Ethics committee. Participants provided written consent. Prior to the start of the study, they were informed of the study procedures; types of images they would be viewing and their right to withdraw at any time. Participants were fully debriefed at the end of the study and were given the opportunity to ask questions. It was not expected that participants would experience distress as a result of participating. However, participants were made aware prior to participation that hip conditions would be discussed to discourage those that may find the particular topic distressing from participating. All participant data was kept in accordance with the Data Protection Act (1988).

6.1.4. Development of experimental materials

Materials for these experiments were developed with assistance from Dr Wellings (a research supervisor for this project and a Consultant Radiologist). This ensured that the information given to participants was accurate.

6.2. Experiment one

6.2.1. Methods

6.2.1.1. Recruitment and participants

Participants were recruited through the University of Warwick Research Participants Panel: SONA, which is primarily made up of undergraduate students. All members of the panel were invited to participate and were informed of the study by advertisement on the SONA system website. The sample was opportunistic and dependent upon individuals reading the experiment details and then choosing to participate. To be eligible for inclusion in this study, potential participants were required to speak English with normal or corrected to normal vision. Participants currently studying or who have previously studied medicine were not eligible to participate. This criteria was clearly stated clearly on the study information accompanying the advertisement. Participants were compensated £3 for their time, which is the standard amount for an experiment of this length. The experiment lasted approximately 30 minutes, 15 minutes for the experiment and 15 minutes for the follow up questionnaire.

6.2.1.2. Apparatus and stimuli

The experiments used three different case-study diagnoses: (i) avascular necrosis (AN) (Diagnosis A) (ii) femoral- acetabular impingement (FAI) (Diagnosis B) and (iii) slipped upper femoral epiphysis (SUFE) (Diagnosis C). These medical conditions were selected as they are appropriate for the typical age range of the sample population. SUFE and FAI occur in young people while AN may occur as a result of trauma, and is thus also applicable to young adults. For each diagnosis there were two 2D CT images and two 3D CT images (see Figures 11 and

12 for examples). Within the 2D condition, participants were shown two different images: an axial image and a coronal image. Within the 3D condition they were shown the same image (in different orientations), firstly from a dorsal view followed by an anterior view. For each condition this gave participants a front view and a top view of the hips (as shown in figures 11 and 12). For the no image condition participants heard the diagnosis alone and were not presented with an image. During the no image condition, the screen was black. The medical images were provided by a consultant radiologist and were shown to participants on a computer using Microsoft PowerPoint. Diagnoses scripts were used in the experiment to ensure that identical information was given to each participant. Ten sentences made up each diagnosis script. They explained what the medical condition was as well as possible causes, symptoms and treatments. They were developed with assistance from the consultant radiologist, to ensure that the information given to participants was accurate.

Figure 11: (a) Axial 2D CT image of the hips with SUFE, (b) coronal 2D CT image of the hips with SUFE

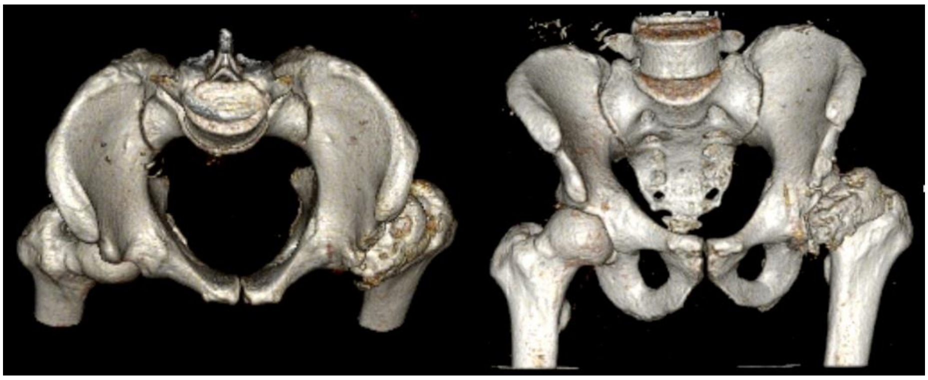

Figure 12: (a) Dorsal view of a 3D CT image of the hips with AN, (b) anterior view of a 3D CT image of the hips with AN

Directly after hearing each condition, participants were asked to rate their experience of each diagnosis. This was done using Likert scales asking participants to agree with statements about the diagnosis, ranging from 1 (strongly disagree) to 7 (strongly agree). There were seven statements asking participants to rate: (1) how well they thought they understood the diagnosis; (2) how accurate they perceived the diagnosis to be; (3) how vulnerable the diagnosis made them feel; (4) how much they trusted the diagnosis; (5) how anxious the diagnosis made them feel; (6) how satisfied they felt with the diagnosis and (7) how uncomfortable the diagnosis made them feel. For the 2D and 3D conditions, three additional questions were asked: first, did participants enjoy viewing the images; second, did they find the images interesting and third, did they find the images helpful. The materials used in experiment one can be found in appendices 16-20.

6.2.1.3. Procedure

The experiment was piloted with three volunteers prior to data collection. It was conducted within the Department of Psychology at the University of Warwick. The experiment was conducted as a simulated clinical consultation, with the researcher taking the role of the clinician and the participant the patient. The experiment was conducted on a face-to-face, one to one basis in order to make the encounter as similar as possible to a real clinical consultation. Each participant heard three different medical diagnoses about hip conditions (Diagnosis A, B and C). The diagnoses were delivered orally, using the scripts described above. The order that the diagnoses were presented in was counterbalanced across participants. Participants were presented with different image types (e.g. 2D, 3D or no image) for each diagnosis. Again, the order of the image type was counterbalanced across participants. This counterbalancing resulted in nine different combinations with 14 participants completing each combination. Participants completed a short, self-complete questionnaire after each condition and after hearing all three conditions participants were asked to report which condition they preferred.

Participants were contacted by email two weeks after participating in the experiment and were given a follow-up questionnaire to complete. The follow up questionnaire asked whether participants could recall the 2D and 3D images that they saw during the experiment. Participants were also asked if they could remember the medical information accompanying each condition: 2D image, 3D image and no image. If they were able to recall the information, participants were asked to rate their experience of each diagnosis. This was done using Likert scales asking participants to agree with statements about the diagnosis, ranging from 1 (strongly disagree) to 7 (strongly agree). The same seven statements used in the experiment were used at follow up. Participants were also asked which condition they preferred again.

6.2.1.4. Data analysis

GPower version 3.1 was used to calculate the required sample size. The power analysis showed that 126 participants would provide a power of at least 0.8, based on an alpha of 0.05 and a small effect size (0.15). Data collected was analysed using SPSS version 21. Kurtosis, skewness and Kolmogorov-Smirnov test with Lilliefors correction were used to test whether the data was normally distributed and Mauchly's test of sphericity was used to test whether the variance between the different groups was equal. The effect of image type on participants' experiences of the three diagnoses during the experiment and at follow up was examined using repeated measures ANOVAs and t-tests. It was hypothesised that participants would report greater understanding, trust and satisfaction when a diagnosis is accompanied by an image compared to no image and that the effect of the 3D image would be stronger than that of the 2D image. A one-sample Chi - Square test and McNemar's tests were used to determine whether there was a difference in preference for the three conditions. It was hypothesised that participants would prefer the diagnoses accompanied by an image compared to no image.

6.2.2. Results

6.2.2.1. Participant characteristics

One hundred and twenty six healthy subjects participated in experiment one. Seventy-four participants were female. Participants were aged between 18 and 39 years (mean = 21.5). The majority of participants described themselves as Asian/Asian British. For 73 participants English was not their first language; however all participants had a good level of spoken and written English so language was not a barrier. Seventy-six participants had previously viewed their own medical imaging results and four participants had a problem with their hip. One hundred and twenty-four of the participants were students, while the remaining two participants were university staff. Participant characteristics are presented in detail in Table 17.

Table 17: Participant characteristics – Experiment One

Participant Characteristics	Number (%)
Age	
Mean	21.48
Range	18-39
Gender	
Male	52 (41.3)
Female	74 (58.7)
Ethnicity	
Asian/Asian British	77 (61.1)
Black	3 (2.4)
White	32 (25.4)
Mixed/Multiple Ethnic Backgrounds	2 (1.6)
Other Ethnic Background	11 (8.7)
Prefer not to say	1 (0.8)
First Language	
English	53 (42.1)
Other	73 (57.9)
Previous/ Current Hip problem	
Yes	4 (3.2)
No	122 (96.8)
Previously viewed own medical imaging results	
Yes	76 (60.3)
No	50 (39.7)

6.2.2.2. Parametric assumptions

Non-parametric tests (i.e. Chi- Square and McNemar's) were used for the categorical variable: 'preference'. The remaining variables were ordinal. Parametric tests are often used for ordinal date as well as interval or ratio data if the remaining assumptions are met as they are more robust than non-parametric equivalents.

Normality of data was tested for the ordinal variables using kurtosis, skewness and Kolmogorov–Smirnov test with Lilliefors correction. *Z* scores for the kurtosis and skewness between -1.96 and 1.96 are considered consistent with a normal distribution of data. Based on the skewness and kurtosis, all but one of our ordinal dependent variables were consistent with a normal distribution. The variable 'helpfulness' had a positive kurtosis which indicates that the data was more peaked than would be expected if the data were normally distributed. Kolmogorov–Smirnov tests with Lilliefors correction were also performed to confirm whether the data were normally distributed. The results from the Kolmogorov-Smirnov test suggest that all the ordinal dependent variables are consistent with a normal distribution as the null hypothesis that the data were not normally distributed was rejected. The Kurtosis, skewness and Kolmogorov–Smirnov tests with Lilliefors correction are presented for each of the dependent variables in Table 18.

Table 18: Kurtosis, skewness and Kolmogorov – Smirnov test with Lilliefors correction for the dependent variables

Variable	Kurtosis	Skewness	Kolmogorov – Smirnov test (with Lilliefors correction)
Experiment			
Question 1 – Understanding	.259	-.533	D(378) = .192, p < .001.
Question 2 – Perceived Accuracy	.479	-.779	D(378) = .214, p < .001.
Question 3 – Vulnerability	-.956	.131	D(378) = .128, p < .001.
Question 4 – Trust	.439	-.915	D(377) = .220, p < .001.
Question 5 – Anxiety	-1.042	.140	D(378) = .155, p < .001.
Question 6 - Satisfaction	-.054	-.848	D(378) = .199, p < .001.
Question 7 – Uncomfortable	-.564	.613	D(378) = .177, p < .001.
Extra Question 1- Enjoy	-.048	-.739	D(378) = .178, p < .001.
Extra Question 2- Interesting	1.029	-1.155	D(378) = .249, p < .001.
Extra Question 3- Helpful	2.777	-1.493	D(378) = .247, p < .001.
Follow- Up			
Question 1 – Understanding	.224	-.737	D(164) = .219, p < .001.
Question 2 – Perceived Accuracy	.419	-.836	D(167) = .201, p < .001.
Question 3 – Vulnerability	-1.107	.283	D(167) = .152, p < .001.
Question 4 – Trust	.601	-1.025	D(167) = .229, p < .001.
Question 5 – Anxiety	-1.058	.286	D(166) = .169, p < .001.
Question 6 - Satisfaction	-.613	-.1.039	D(167) = .220, p < .001.
Question 7 – Uncomfortable	-.958	.444	D(167) = .178, p < .001.
Extra Question 1- Enjoy	.374	-.946	D(123) = .192, p < .001.
Extra Question 2- Interesting	.753	-1.102	D(123) = .217, p < .001.
Extra Question 3- Helpful	1.883	-1.297	D(123) = .241, p < .001.

Homogeneity of variance and sphericity were assessed using a Levene’s test and Mauchly's test of sphericity respectively. Where the assumption of sphericity was violated, Greenhouse-Geisser corrections were used.

6.2.2.3. Comparing the experience of viewing a 3D image, a 2D image and no image alongside a diagnosis.

Figure 13 shows the mean rating scores for each question. Table 19 shows the results of the repeated measures ANOVAs conducted on each question to see if there was an overall difference in mean ratings across the three different image conditions. The results showed that there was a significant difference in ratings for understanding of the diagnoses; perceived accuracy of the diagnoses; trust in the diagnoses; satisfaction with the communication of the diagnoses and how uncomfortable participants felt during the diagnoses, depending on which image they saw. There was no significant difference in how vulnerable or anxious participants felt hearing the diagnosis between the different image conditions.

Table 19: Results of repeated measures ANOVAs showing the overall difference in mean ratings across the three image conditions

Variable	Test of significance
Understanding	$F(1.827,228.34) = 63.44$, $p <.001$, $\eta_p^2 = .337$
Perceived accuracy	$F(1.786,223.29) = 34.14$, $p <.001$, $\eta_p^2 = .215$
Vulnerability	$F(2,250) = .766$, $p =.47$, $\eta_p^2 = .006$.
Trust	$F(1.652,204.90) = 26.09$, $p <.001$, $\eta_p^2 = .174$
Anxiety	$F(1.812,226.49) = 2.51$, $p = .089$, $\eta_p^2= .053$.
Satisfaction	$F(1.641,205.15) = 94.80$, $p <.001$, $\eta_p^2 = .431$.
Uncomfortableness	$F(1.854,231.75) = 4.29$, $p = .017$, $\eta_p^2 = .033$.

*Greenhouse-Geisser corrections were used when the data failed to achieve the assumption of sphericity.

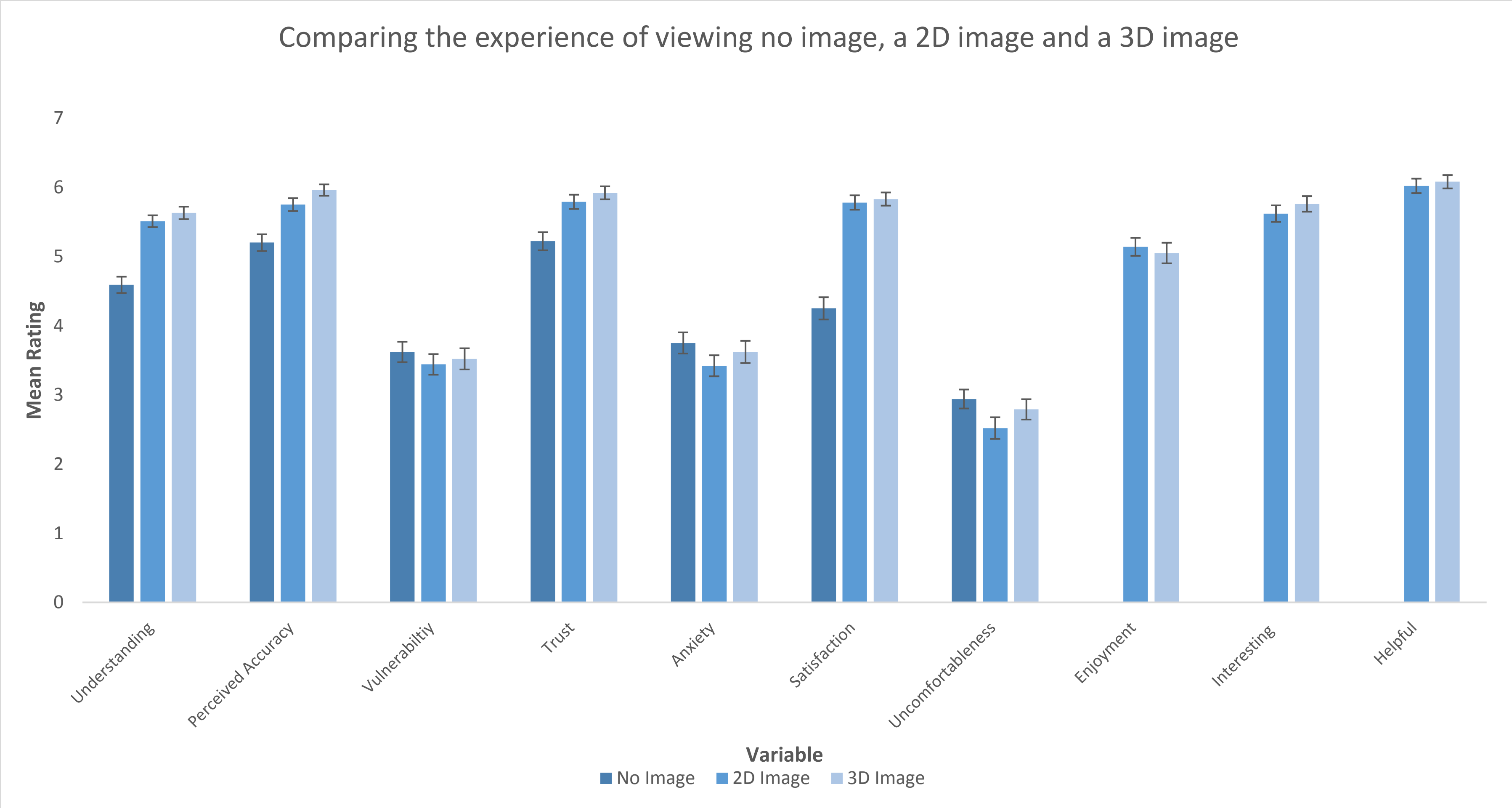

Figure 13: Mean ratings for each question in Experiment One depending on image condition

Table 20 breaks the significant results down into individual t-tests in order to compare each image presentation to each other. Participants reported better understanding of the diagnosis in the 2D image condition and in the 3D image condition compared to the no image condition. However, there was no significant difference between participants' understanding of the diagnosis between the 2D and the 3D image conditions. Participants perceived the diagnosis to be more accurate in the 2D image and 3D image condition compared to the no image condition. Additionally, participants perceived the diagnosis to be more accurate in the 3D image condition compared to the 2D image condition. Participants reported greater trust in the diagnosis in the 2D and 3D image conditions compared to the no image condition. No significant difference in participants' trust in the diagnosis was found between the 3D image and the 2D image conditions. The results also showed that participants reported greater satisfaction with the way in which the diagnosis was communicated in the 2D image and 3D image conditions compared to the no image condition. There was no significant difference in the participants' satisfaction with the way in which the diagnosis was communicated between the 3D image and the 2D image conditions. Interestingly, participants reported feeling less discomfort during the 2D image condition compared to the no image condition and the 3D image condition. There was no significant difference in how uncomfortable participants felt between the no image and the 3D image conditions. There were also no significant differences between viewing a 2D or a 3D image when participants were asked to compare images in terms of enjoyment, interest and helpfulness (all $ts \leq 1.44$, $ps \geq .153$).

Table 20: Results from individual t-tests for each significant independent variable

Variable	Conditions Compared	Test of significance
Understanding	No Image, 2D Image	t(125) = -8.88, p<.001, d= -0.796
	No Image, 3D Image	t(125) = -9.26, p<.001, d= -0.881
	2D Image, 3D Image	t(125) = 1.480, p=.141, d= 0.122
Perceived accuracy	No Image, 2D Image	t(125) = -5.35, p<.001, d= -0.456
	No Image, 3D Image	t(125) = -7.39, p<.001, d= -0.655
	2D Image, 3D Image	t(125) = 2.79, p = .006, d= 0.215
Trust	No Image, 2D Image	t(124) = -4.83, p<.001, d= -0.44
	No Image, 3D Image	t(124) = -6.46, p<.001, d= -0.549
	2D Image, 3D Image	t(125) = 1.480, p=.141, d= -0.118
Satisfaction	No Image, 2D Image	t(125) = -10.70, p<.001, d = -1.004
	No Image, 3D Image	t(125) = -10.77, p<.001, d = -1.063
	2D Image, 3D Image	t(125) = -.584, p=.560, d= 0.045
Uncomfortableness	No Image, 2D Image	t(125) = 2.89, p = .005, d= 0.272
	No Image, 3D Image	t(125) = .91, p = .364, d = 0.094
	2D Image, 3D Image	t(125) = 2.15, p = .034, d=0.168

6.2.2.4. Preference

The majority of participants (n=80, 63.5%) preferred the diagnosis to be accompanied by 3D images. Of the remaining participants, 44 (34.9%) preferred the 2D image condition and 2 (1.6%) preferred the no image condition. A chi square test revealed that the difference in preference across all three conditions was significant; X2 (2, N= 126) = 72.571, p <.001.

When comparing preference across the individual conditions, the results showed that participants preferred the 3D image over the 2D image, χ^2 (1, N=126) = 9.879, p = .002 and the no image condition, χ^2 (1, N=126) = 72.305, p<.001. The 2D images were preferred to viewing no image, χ^2 (1, N=126) = 36.543, p<.001.

6.2.2.5. Follow- up questionnaire results

In total, 106 participants returned the follow up questionnaire. Nine participants completed the questionnaire incorrectly and were excluded from the analysis, leaving 97 participants.

Recall of the medical images was high. Sixty-eight participants (70.1%) stated that they were able to recall the 2D images they were shown during the experiment and 71 participants (73.2%) stated that they were able to recall the 3D images they were shown during the experiment.

Recall of the information given in the diagnosis was lower. Forty-two participants recalled the diagnosis accompanied by no image, 59 participants recalled the diagnosis accompanied by 2D images and 66 participants recalled the diagnosis accompanied by the 3D images. Twenty-three (24%) of the 97 participants who completed the follow-up questionnaire could not recall any of the diagnosis. Not all participants fully completed the follow-up questionnaire as they could not remember the information they were given in the diagnoses. As a result of this, the data set is incomplete and did not achieve sufficient statistical power. However, the data were still explored tentatively.

At follow up, the majority of participants (n=49, 50.5%) preferred the diagnosis to be accompanied by 3D images. Of the remaining participants 39 (34.9%) preferred the 2D image condition and 3 (3.1%) preferred the no image condition. Six (6.2%) participants indicated that they could not recall the images. A chi square test revealed that the difference in preference across all three conditions was significant; X2 (2, N= 126) = 72.571, p <.001. Eighty participants (87.9%) continued to prefer the same condition at follow up as during the experiment while 11 participants (12.1%) changed their preference between the experiment and follow-up. Seven participants changed from preferring the condition with 3D images to the condition with 2D images. Three participants changed their preference from the condition with 2D images to the condition with 3D images and one participant changed their preference from the 3D image condition to the no image condition.

The benefits of viewing an image (either 2D or 3D) compared to no image persisted at follow up. Figures 14 shows the mean scores for each question at follow up. Table 21 shows the results of the repeated measures ANOVAs conducted on each question to see if there was an overall difference in mean ratings across the three different image conditions. The results showed that there was a significant difference in understanding of the diagnoses; perceived accuracy of the diagnoses; trust in the diagnoses and satisfaction with how the diagnoses were communicated. There was no significant difference in how uncomfortable, vulnerable or anxious participants felt hearing the diagnosis. There was also no significant difference in participants' ratings of enjoyment, interest or helpfulness between the 2D and 3D image conditions.

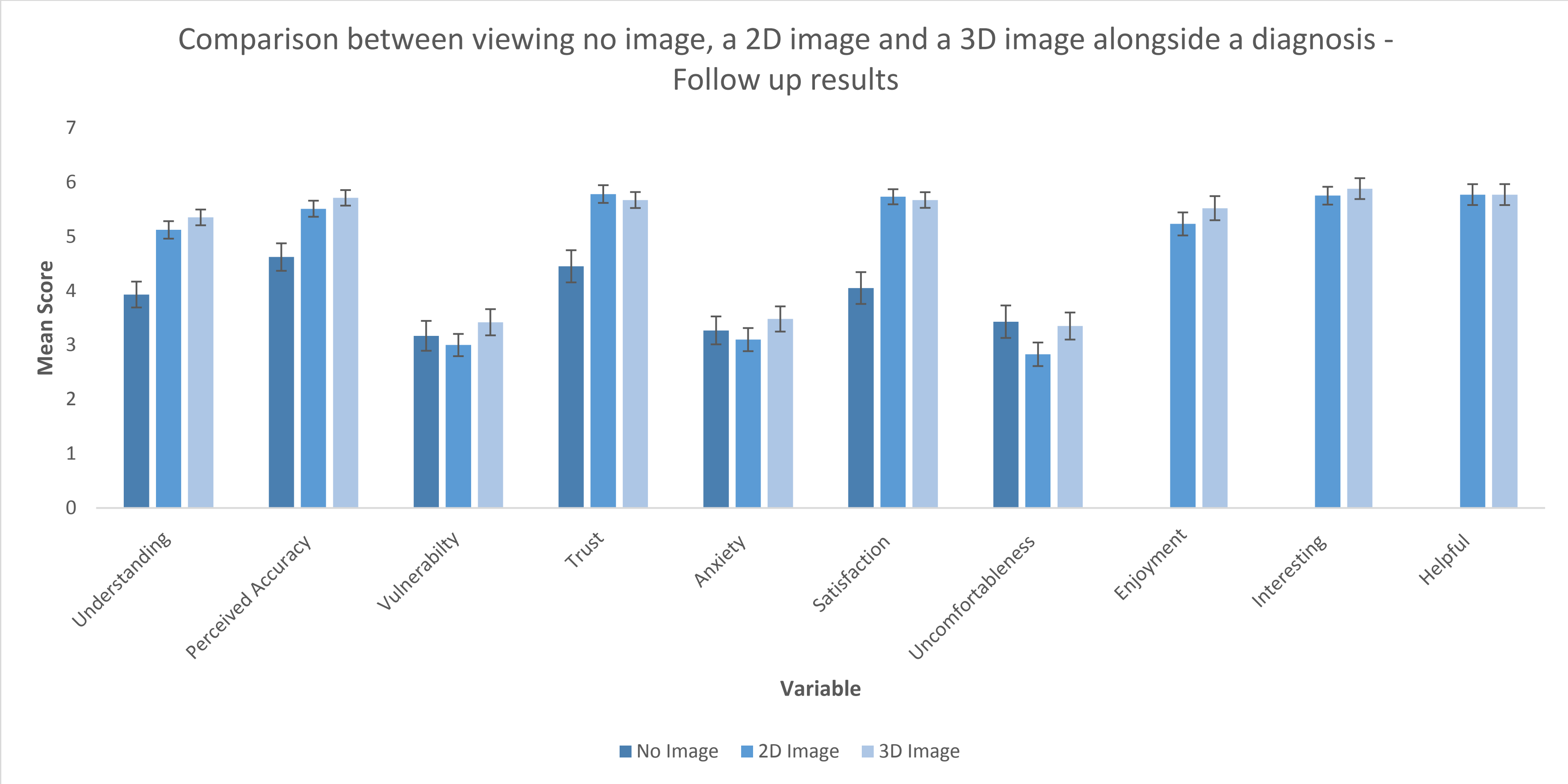

Figure 14: Mean ratings for each question in Experiment One depending on image condition, at follow up

Table 21: Results of repeated measures ANOVAs showing the overall difference in mean ratings across the three image conditions at follow - up

Variable	Test of significance
Understanding	$F(2,70) = 21.88$, $p < .001$, $\eta_p^2 = .385$
Perceived accuracy	$F(1.558,56.10) = 18.55$, $p < .001$, $\eta_p^2 = .340$
Vulnerability	$F(2,72) = 2.082$, $p = .132$, $\eta_p^2 = .055$.
Trust	$F(2,72) = 14.37$, $p < .001$, $\eta_p^2 = .285$
Anxiety	$F(2,70) = 2.48$, $p = .091$, $\eta_p^2 = .066$.
Satisfaction	$F(1.473,53.04) = 25.38$, $p < .001$, $\eta_p^2 = .413$.
Uncomfortableness	$F(1.568,56.45) = .834$, $p = .414$, $\eta_p^2 = .023$.

*Greenhouse-Geisser corrections were used when the data failed to achieve the assumption of sphericity.

Table 22 breaks the significant follow up results down into individual t-tests. Participants reported better understanding of the diagnosis in the 2D image condition and in the 3D image condition compared to the no image condition. Additionally, participants reported better understanding of the diagnosis in the 3D image condition compared to the 2D image condition. Participants perceived the diagnoses to be more accurate in the 2D image and 3D image condition compared to the no image condition. Additionally, participants perceived the diagnoses to be more accurate in the 3D image condition compared to the 2D image condition. Participants reported greater trust in the diagnoses in the 2D and 3D image conditions compared to the no image condition. No significant difference in participants' trust in the diagnoses was found between the 3D image and the 2D image conditions. The results also showed that participants reported greater satisfaction with the way in which the diagnosis was communicated in the 2D image and 3D image conditions compared to the no image condition. However, there was no significant difference in the participants' satisfaction with the way in which the diagnosis was communicated between the 3D image and the 2D image conditions. There were no significant differences between viewing a 2D or a 3D image when participants were asked to compare images in terms of enjoyment, interest and helpfulness (all ts ≤ 1.44, ps ≥ .153).

Table 22: Results from individual t-tests for each significant independent variable, at follow up

Variable	Test of Significance	
Understanding	No Image, 2D Image	t(37) = -4.71, p<.001, d = -0.802
	No Image, 3D Image	t(39) = -6.19, p<.001, d= -0.985
	2D Image, 3D Image	t(51) = -2.081, p=.042, d = -0.272
Perceived Accuracy	No Image, 2D Image	t(37) = -5.12, p<.001, d= -0.556
	No Image, 3D Image	t(39) = -4.36, p<.001, d= -0.695
	2D Image, 3D Image	t(52) = -2.22, p = .031, d= -0.251
Trust	No Image, 2D Image	t(37) = -4.28, p<.001, d= -0.613
	No Image, 3D Image	t(39) = -4.36, p<.001, d= -0.752
	2D Image, 3D Image	t(52) = 1.04, p=.303 d = 0.135
Satisfaction	No Image, 2D Image	t(37) = -6.18, p<.001, d= -1.072
	No Image, 3D Image	t(39) = -5.20, p<.001, d= -1.102
	2D Image, 3D Image	t(52) = -.566, p=.574, d = -0.085

6.2.2.6. Comparison between experimental results and follow up

Comparison was made between participants' responses during the experiment and their responses at follow up. Paired t-tests were used to analyse the data so only participants who had provided responses to both the experimental questionnaire and the follow-up questionnaire were included in the analysis, giving a sample of between 41 and 66 depending on the question.

Participants' responses were similar at follow up to the responses given during the experiment with only the responses for understanding changing significantly at follow up in every condition. In this case, in all three conditions understanding was significantly lower at follow up. The reduction in self-reported understanding was greater for the no image condition and the 2D image condition compared to the 3D image condition. The mean score for understanding reduced by .66 in the no image and 2D image conditions compared to .39 in the 3D image condition.

Participants' trust in the diagnosis and their perceptions of how accurate the diagnosis was reduced at follow up, with a significant reduction in participants' perceived accuracy at follow up for the 2D image and no image conditions and a significant reduction in participants' trust in the 3D image and no image conditions (as shown in Table 23).

Table 23: Comparison between experiment and follow up data

	Variable	Experiment Mean (SD)	Follow - up Mean (SD)	Significance
Understanding	No Image	4.59(1.34)	3.93(1.52)	t(40) = 2.923, p = .006, d = 0.461.
	2D Image	5.78(.86)	5.12(1.23)	t(57) = 4.347, p = <.001, d = 0.622.
	3D Image	5.74(1.04)	5.35(1.17)	t(64) = 2.717, p = .008, d = 0.354.
Accuracy	No Image	5.02 (1.39)	4.62(1.64)	t(41) = 2.166, p = .036, d = 0.263.
	2D Image	5.90 (.94)	5.51(1.14)	t(58) = 2.943, p = .005, d = 0.373.
	3D Image	5.97 (.82)	5.71(1.16)	t(65) = 1.953, p = .055, d = 0.259.
Vulnerability	No Image	3.57 (1.64)	3.17(1.78)	t(41) = .234, p = .136, d = 0.234.
	2D Image	3.34 (1.79)	3.00(1.58)	t(58) = 1.465, p = .148, d = 0.201.
	3D Image	3.47 (1.77)	3.42(1.96)	t(65) = .208, p = .836, d = 0.027.
Trust	No Image	5.14 (1.42)	4.45 (1.92)	t(41) = 2.94, p = .005, d = 0.409.
	2D Image	5.86 (1.15)	5.78 (1.25)	t(58) = 1.958, p = .055, d = 0.066.
	3D Image	5.97 (1.10)	5.67 (1.19)	t(65) = 2.141, p = .036, d = 0.262.
Anxiety	No Image	3.61 (1.46)	3.27 (1.64)	t(40) = 1.3, p = .201, d = 0.219.
	2D Image	3.42 (1.75)	3.10 (1.64)	t(58) = 1.754, p = .131, d = 0.189
	3D Image	3.76 (1.87)	3.48 (1.88)	t(65) = 1.313, p = .194, d = 0.149
Satisfaction	No Image	4.29 (1.78)	4.05 (1.90)	t(41) = .944, p = .351, d = 0.130.
	2D Image	6.02 (1.01)	5.73 (1.06)	t(58) = 2.013, p = .049, d = 0.280
	3D Image	5.89 (1.01)	5.67 (1.17)	t(65) = 1.449, p = .152, d = 0.201
Uncomfortableness	No Image	2.82 (1.17)	3.35 (1.65)	t(65) = -3.192, p = .002, d = -0.371.
	2D Image	2.49 (1.5)	2.83 (1.67)	t(58) = -1.681, p = .098, d = -0.214.
	3D Image	3.07 (1.45)	3.43 (1.94)	t(41) = -1.366, p = .179, d = -0.105.

6.3. Experiment two

6.3.1. <u>Methods</u>

6.3.1.1. Recruitment and participants

There were one hundred and twenty six participants in experiment two, 121 participants were recruited by the SONA research participant panel (as described in experiment one). The remaining five participants were approached by EP in the research laboratory. To be eligible for inclusion in this study, potential participants were required to speak English with normal or corrected to normal vision. Students currently studying or who have previously studied medicine were not eligible to participate. Additionally, experiment one participants were ineligible to participate. Experiment two lasted approximately 30 minutes.

6.3.1.2. Apparatus and procedure

The three diagnoses, including medical images and diagnosis scripts, used in experiment one were also used in experiment two. This experiment was made up of three tasks. The first was the simulated clinical consultation as described above. This task examined participants' ability to recall the information contained in each of the three diagnoses through a multiple-choice questionnaire. This task also asked participants to rate their understanding of each diagnosis, their trust in each diagnosis and how accurate they perceived each diagnoses to be. The second task examined participants' ability to recall the medical images that they were shown to investigate whether recall of 3D images was better than that of 2D images. The third task examined participants' susceptibly to inattentional blindness. Previous research has shown that medical images are susceptible to inattentional blindness from radiologists (Drew *et al.*, 2013; Potchen, 2006). This study sought to investigate whether lay participants could also potentially be affected by inattentional blindness when viewing medical images. Furthermore, this study aimed to examine whether participants' expectations affect detection of the monkey. If participants were told that medical images were prone to errors, did this mean they were more likely to detect the monkey? Or were they more likely to trust the image as the researcher was being ‘up-front’ in disclosing all erroneous information making them less likely to detect the monkey?

Experiment two was also piloted with three volunteers prior to data collection. At the beginning of the experiment participants were given information about medical images to read. Half were given ‘basic information’ about how CT images are produced and half were given ‘detailed information’ which explained how CT images are produced and informed participants about miss errors and over diagnosis within image interpretation. The purpose of giving participants this extra information was to investigate whether hearing the detailed information (explaining the uncertainty inherent in diagnostic imaging) affects people’s trust in the diagnosis and how accurate they perceive the diagnosis to be. The experiment then followed the same format as experiment one with each participant hearing three medical diagnoses about hip conditions; one accompanied by two 2D CT images, one accompanied by two 3D CT images and one accompanied by no image. After each diagnosis participants were asked to rate their experience of each diagnosis. This was done using Likert scales asking participants to agree with statements about the diagnosis, ranging from 1 (strongly disagree) to 7 (strongly agree). There were three statements asking participants to rate: (1) how well they thought they understood the diagnosis; (2) how accurate they perceived the diagnosis to be and (3) how much they trusted the diagnosis. The questionnaire also included six multiple-choice questions about the diagnosis. The multiple choice questions assessed participants’ ability to recall the following details about each diagnosis: (1) the name of the condition; (2) a brief description of the condition; (3) the cause of the condition; (4) symptoms; (5) treatments and (6) which hip joint was affected (left, right or both).

Following this, participants were shown four 2D images, one of which they were shown during the diagnoses and three previously unseen images of hips, and four 3D images, which again included one image that participants were shown during the diagnoses and three images previously unseen. Participants were asked to identify which images they had previously been shown. This was done to investigate whether 3D images were more memorable than 2D images.

Next, participants were given information about some problems hypothesised by the researcher about 3D images. Within the basic information group, participants were informed of one problem: the inability to see the division between different bones within 3D images, while participants within the detailed information group were informed of two problems. These were the inability to see the division between different bones within 3D images and the ability to manipulate 3D images. This was done to reiterate to participants in the detailed information group that medical images should not be perceived as certain. This was also done so that the next task made sense to participants. The next task followed immediately after this information, with participants asked to count the number of bones that they could identify within one 3D image. This was firstly demonstrated by the researcher using a 3D image. Participants were then asked to count the number of bones within a second 3D image, an image in which a picture of a monkey was superimposed onto one of the bones (as shown in figure 15). After counting, participants were asked if they noticed anything unusual about the image and if they answered no, then were then shown an image of the monkey (as presented in figure 16) and asked to find it. As described in Chapter Two, inattentional blindness occurs when noticeable events or changes are unexpected or occur while a different task is being performed. As this experiment was interested in examining whether participants were susceptible to inattentional blindness, a simple task was given to participants. The task of counting bones was chosen as it was simple and it required participants to look at every part of the image, ensuring they fixated on the monkey. A monkey was chosen as it is easily recognisable as an object that should not appear in a medical image. Primates have also been used in previous experimental studies of inattentional blindness (Drew *et al.*, 2013; Simons & Chabris, 1999). The materials used in experiment two can be found in appendices 21-25.

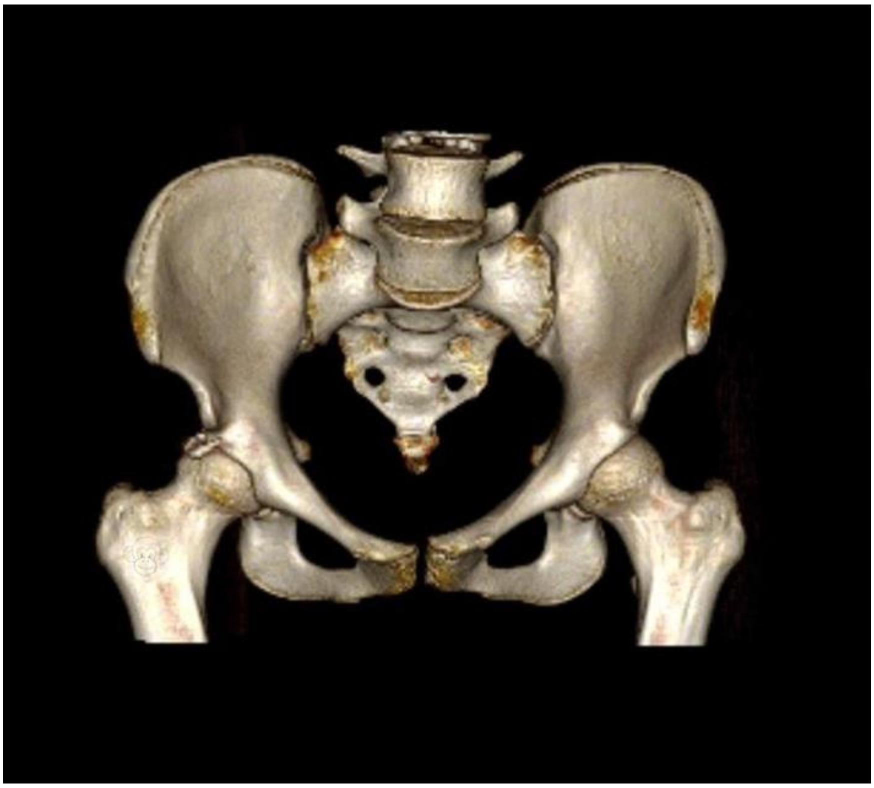

Figure 15: 3D image of the hips and pelvis with an image of a monkey superimposed onto the right femur.

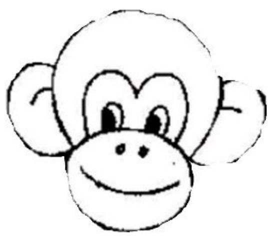

Figure 16: Image of the monkey superimposed onto the 3D image of the hips

6.3.1.3. Data analysis

Power calculations and parametric assumptions were tested using the same methods outlined in experiment one. A two way mixed method ANOVA was used to look at the interaction between image type (i.e. no image, 2D image or 3D image) and information type (i.e. basic or detailed) for each measure. The impact of image type on understanding, trust and how accurate participants perceived the diagnosis to be was then explored using t-tests. The impact of information type on understanding, trust and how accurate participants perceive the diagnosis to be was also explored using t-tests. It was hypothesised that there would be a difference in participants' ratings of understanding, trust and perceived accuracy between those in the detailed information condition and those in the basic information condition. It was anticipated that participants in the detailed information group (i.e. those who were informed of the uncertainty inherent to medical imaging) would report reduced understanding and trust and perceive the diagnoses to be less accurate than those in the basic information group as they would be aware that the images are susceptible to interpretation errors. Alternatively, participants in the detailed information group could report greater understanding and trust and perceive the diagnoses to be more accurate as informing participants of the uncertainty within medical image interpretation may lead participants to trust that the experimenter is being honest with them.

A repeated measures ANOVA was used to examine the effect of image type on participants' ability to recall the information contained in the diagnoses. It was hypothesised that participants would be better able to recall a diagnosis that was accompanied by an image compared to no image and that the effect would be stronger for the 3D image compared to the 2D image. This hypothesis is based on psychological experiments studying cross modal attention (as described in Chapter Two) which suggest that visual information has more attentional weight compared to auditory stimuli. Alternatively, the image could distract participants from the auditory stimuli, hindering recall of the diagnosis.

Finally, Chi - Square tests were used to compare participants' ability to identify the 2D image they had seen out of three foil images to their ability to identify the 3D image they had seen out of three foil images. Chi - Square tests were also used to compare whether there is a difference in participants' ability to detect the monkey superimposed onto a 3D image between participants who were informed that 3D images could be manipulated (detailed information group) and participants who were not informed 3D images could be manipulated (basic information group). It was hypothesised that participants in the detailed information group would be more likely to detect the monkey superimposed onto the 3D image as they would be aware that the image could be manipulated. Alternatively, participants in the detailed information group may be less likely to detect the monkey anomaly, as they may trust that the experimenter is being honest with them.

6.3.2. Results

6.3.2.1. Participant characteristics

One hundred and twenty six healthy subjects participated in experiment two. 86 participants were female. Participants were aged between 18 and 43 years (mean = 20.8). The majority of participants described themselves as Asian/Asian British. For 76 participants, English was not their first language. Fifty-seven participants had previously viewed their own medical imaging results and four participants had a problem with their hip. One hundred and twenty-four participants were students, while the remaining two participants were university staff. Further participant characteristics can be found in Table 24.

Table 24: Participant characteristics – Experiment Two

Participant Characteristics	Number (%)
Age	
Mean	20.8
Range	18-43
Gender	
Male	40 (31.7)
Female	86 (68.3)
Ethnicity	
Asian/Asian British	68 (54)
Black	5 (4)
White	44 (34.9)
Mixed/Multiple Ethnic Backgrounds	4 (1)
Other Ethnic Background	4 (1)
Prefer not to say	1 (0.8)
First Language	
English	59 (46.8)
Other	67 (53.2)
Previous/ Current Hip problem	
Yes	4 (3.2)
No	122 (96.8)
Previously viewed own medical imaging results	
Yes	57 (45.2)
No	69 (54.8)

6.3.2.2. Parametric assumptions

Normality of data was tested for the ordinal variables using kurtosis, skewness and Kolmogorov – Smirnov test with Lilliefors correction. Z scores for the kurtosis and skewness between -1.96 and 1.96 are considered consistent with a normal distribution of data. Based on the skew and kurtosis, all of our ordinal dependent variables were consistent with a normal distribution. The kurtosis, skewness, and KS Liliefors with correction for the dependent variables are presented in the table 25.

Table 25: Kurtosis, skewness and Kolmogorov – Smirnov test with Lilliefors correction for the dependent variables

Variable	**Kurtosis**	**Skewness**	**Kolmogorov – Smirnov test (with Lilliefors correction)**
Understanding	-.086	-.521	D(378) = .199, p < .001.
Perceived Accuracy	-.119	-.626	D(378) = .249, p < .001.
Trust	-.200	.762	D(378) = .227, p < .001.
Recall of Medical Information	-.282	-.985	D(378) = .199, p < .001.

6.3.2.3. The interaction between image type and information type

For the dependent variable understanding, the interaction between information type and image type was non-significant: F(2.248, 227.76) =.994, p = .373, np^2= .016. For the dependent variable trust, the interaction between information type and image type was non-significant: F(1.837, 227.76) =.152, p = .842, np^2= .001. For the dependent variable accuracy, the interaction between information type and image type was non-significant: F(2,248) =.271, p = .763, np^2= .002.

6.3.2.4. The effect of image type on understanding, trust and accuracy

Figure 17 shows the mean rating scores for understanding, perceived accuracy and trust for all image conditions in experiment two. Table 26 shows the results of the main effects for image type from the repeated measures ANOVAs conducted on each question to see if there was an overall difference in mean ratings across the three different image conditions. The results showed that there was a significant difference in understanding of the diagnoses, perceived accuracy of the diagnoses and trust in the diagnoses.

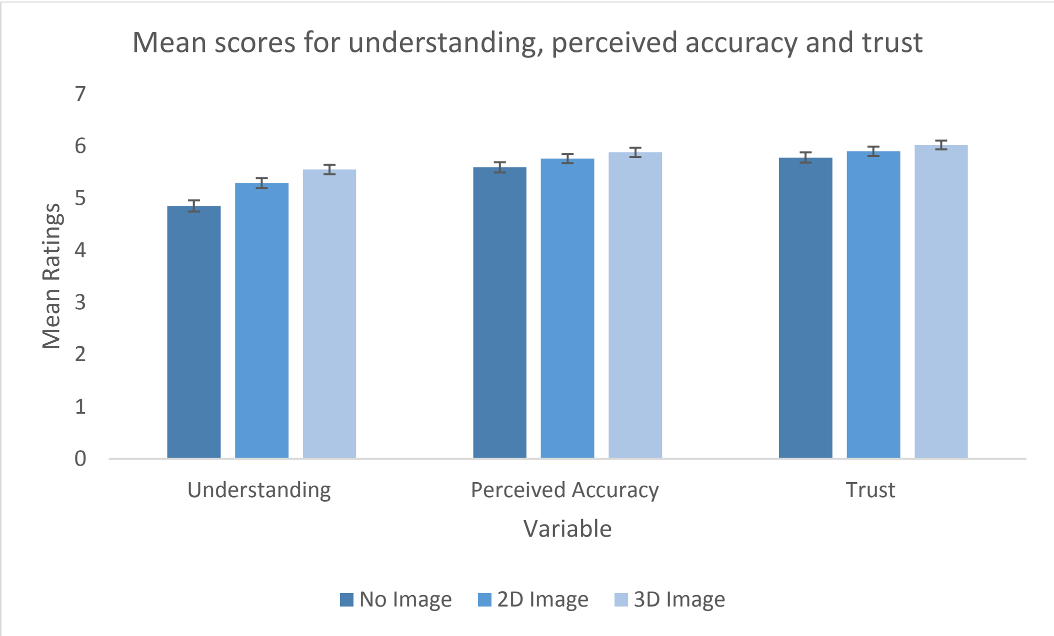

Figure 17: Mean understanding, perceived accuracy and trust scores for each image condition

Table 26: Results of repeated measures ANOVAs showing the overall difference in mean ratings across the three image conditions

Variable	Test of significance
Understanding	F (2,250) = 28.7, p <.001, np2 = .187
Perceived accuracy	F (2,250) = 7.65, p =.001, np2 = .058
Trust	F (1.862, 232.74) = 6.47, p =.002, np2 = .049

Table 27 breaks the significant results down into individual t-tests. Participants reported better understanding of the diagnosis in the 2D image condition and in the 3D image condition compared to the no image condition. Further, participants reported greater understanding in the 3D image condition compared to the 2D image condition. Participants perceived the diagnosis to be more accurate in the 2D image and 3D image condition compared to the no image condition. However, no significant difference in how accurate participants perceived the diagnosis to be was found between the 2D and 3D image conditions. Participants reported greater trust in the diagnosis in the 3D image condition compared to the 2D image and no image condition. No significant difference in participants' trust in the diagnosis was found between the 3D image and the 2D image conditions.

Table 27: Results from individual t-tests for each significant independent variable

Variable	Conditions Compared	Significance (T-test)
Understanding	No Image and 2D Image	t(125) = -4.52, p<.001, d= -0.387.
	No Image and 3D Image	t(125) = -7.34, p<.001, d= -0.629.
	2D Image and 3D Image	t(125) = -3.00, p=.003, d= -0.249.
Perceived Accuracy	No Image and 2D Image	t (125) = -2.39, p=.018, d= -0.162.
	No Image and 3D Image	t(125) = -3.58, p<.001, d= -0.278.
	2D Image and 3D Image	t(125) = -1.68, p= .096, d= -0.122.
Trust	No Image and 2D Image	t (125) = -1.78, p= .077, d= -0.115.
	No Image and 3D Image	t(125) = -3.37, p=.001, d= -0.235.
	2D Image and 3D Image	t(125) = -2.00, p=.047, d= -0.124.

6.3.2.5. Does receiving detailed information about medical imaging production and interpretation influence trust and perceived accuracy?

Figure 18 shows the mean understanding, perceived accuracy and trust scores for each image and information type. The results of two-way mixed methods ANOVAs investigating the main effects of information type revealed that mean perceived accuracy scores were higher when participants received detailed information about medical image production and interpretation compared to participants who only received basic information (see Figure 18), $F(1, 124) = 5.03$, $p = .027$, $\eta_p^2 = .039$. However, there was no significant difference in ratings for understanding or trust between these groups.

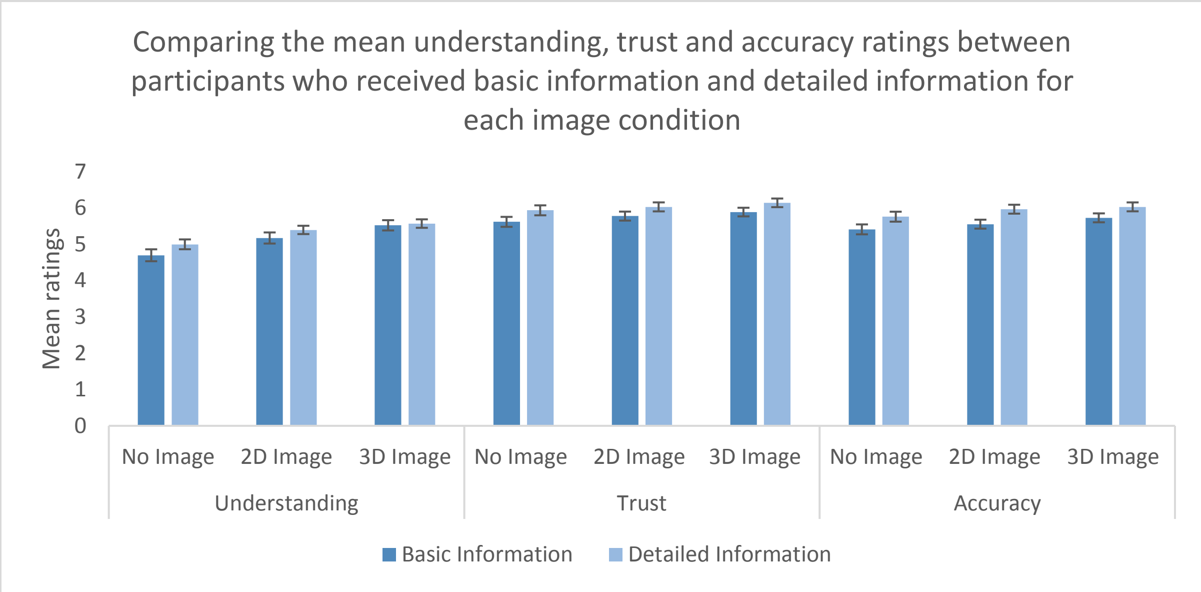

Figure 18: Mean ratings by information type for each image condition

When broken down into individual t-tests, the results showed that when the diagnosis was accompanied by 2D images, participants in the detailed information condition perceived the diagnosis to be more accurate than participants in the basic information condition. In the no image condition and the 3D image condition, no significant difference in participants' ratings of perceived accuracy were found between the detailed information and basic information conditions.

6.3.2.6. Recall of the diagnoses

There was a significant difference between viewing 3D images (M = 4.79 SD = 1.13), 2D images (M = 4.71, SD = 1.18); and viewing no image (M=4.40, SD=1.17) on participants' ability to correctly answer questions about the diagnosis; F (2,250) = 5.13, p =.007, np2 = .039. Participants were better able to recall information about the diagnosis when it was accompanied by 2D images (t (125) = -2.44, p=.016, d= -0.264) or 3D images (t (125) = -2.98, p=.003, d= -0.339) compared to the no image condition. There was no difference in the participants' ability to recall information about the diagnosis between the 2D image and the 3D image conditions; t (125) = -.68, p= .496, d= -0.069.

6.3.2.7. Recall of images

When asked to identify the image that they had seen out of three foil images, 116 (92.1%) participants correctly recalled the 3D image they were shown during the diagnosis and 110 (87.3%) participants correctly recalled the 2D image they were shown during the diagnosis. Compared to chance (n=31.5, 25%), recall of both types of medical images was high. There was no significant difference between recall of the 2D images and recall of the 3D images (χ (1) = 0.522, p = .470, ϕ =.064).

6.3.2.8. Inattentional blindness

When asked to count the number of bones within the 3D image, 115 (91.3%) participants failed to notice the picture of the monkey superimposed onto the image. This failure to notice the anomaly was not because it was perceptually difficult to see as when they were told about it and asked to point it out 74 of the 115 (64.3%) were able to find it. The remaining 41 (35.7%) participants were all able to see the monkey when it was pointed out to them by the researcher. This shows that these images are susceptible to inattentional blindness. Interestingly, a chi square test revealed that participants who were given the extra information about the ability to manipulate the images (the detailed information group) were less likely to see it than participants who were not given this information (the basic information group) (χ (1) = 8.07, p = .005).

6.4. Combining experiment one and experiment two data

To increase statistical power, data from the Likert scales of data from experiment one and experiment two were pooled together for analysis. Overall, the results showed that participants reported greater understanding when the diagnosis was accompanied by the 2D image compared to the no image condition (t(251) = -9.38, p<.001, d= -0.59). However, participants reported an even greater level of understanding when the diagnosis was accompanied by a 3D image over the no image and 2D image conditions: (t(251) = -11.70,

$p<.001$, $d= -0.755$ and $t(251) = -3.17$, $p=.002$, $d= -0.186$, respectively). Overall, participants perceived the diagnosis to be more accurate when it was accompanied by the 2D image compared to the no image condition ($t(251) = -5.65$, $p<.001$, $d= -0.317$). However, they reported an even greater level of perceived accuracy when the diagnosis was accompanied by a 3D image over the no image and 2D image conditions: ($t(251) = -7.81$, $p<.001$, $d= -0.477$ and $t(251) = -3.18$, $p=.002$, $d= -0.173$, respectively). Overall, participants reported greater trust when the diagnosis was accompanied by the 2D image compared to the no image condition ($t(250) = -4.97$, $p<.001$, $d= -0.29$). However, they reported an even greater level of trust when the diagnosis was accompanied by a 3D image over the no image and 2D image conditions: ($t(250) = -7.08$, $p<.001$, $d= -0.401$ and $t(251) = -2.48$, $p=.015$, $d= -0.115$, respectively).

6.5. Discussion

This study showed a number of interesting findings. First, participants reported benefit in terms of satisfaction, understanding, trust and perceived accuracy in viewing medical images alongside a verbal diagnosis. This benefit was still present two weeks later. Furthermore, they showed a clear preference for viewing a 3D image alongside diagnosis compared to a 2D image or no image at all. Second, viewing an image led to better recall of information about the diagnosis compared to when no image was shown. Third, informing participants of the occurrence of errors within medical image interpretation did not negatively impact upon their trust. Finally, participants who were informed of the ability to manipulate medical images were more susceptible to inattentional blindness.

Using two laboratory based experiments, this study found that when a diagnosis was accompanied by medical images (either 2D or 3D) participants were better able to recall the diagnosis, reported increased satisfaction, understanding, and trust and they perceived the diagnosis to be more accurate compared to when the diagnosis was accompanied by no image. These results support the findings of previous studies that have found the use of images (pictures, diagrams, and 2D images) within a clinical consultation or accompanying written medical information can lead to improved patient understanding (Carlin *et al.,* 2014) and increased satisfaction (Vilallonga *et al.,* 2012). Furthermore, the combined results of experiments one and two showed that the use of 3D images led to greater ratings in understanding, perceived accuracy and trust in the diagnosis compared to the use of 2D images or no image. Participants also preferred to receive a diagnosis accompanied by a 3D image compared to a 2D image or no image. No significant difference in anxiety was found between viewing 3D images, 2D images and no image alongside a diagnosis. This is in contrast to Ogden *et al's.,* (2009) findings. Ogden *et al.,* (2009) found that women who viewed the screen during their hysteroscopy procedure reported greater anxiety than those who did not. Similarly, Carlin *et al.,* (2014) also found that some patients felt anxious after viewing their 2D CT and MRI images during a clinical consultation. There are several reasons why the results from this study may differ from those of Ogden *et al.,* (2009) and Carlin *et al.,* (2014) First, the context in which the images were shown in Ogden et al's (2009) study (i.e. during a procedure) differs from the type of consultation imitated within these experiments. It could be that viewing images during a procedure results in more anxiety than viewing them after, during a conversation. Second, Carlin *et al.,* (2014) did not compare the experience of viewing an image to hearing a diagnosis alone. Patients who are not shown their images may be just as anxious as those who are shown their images or potentially more anxious. Alternatively, the results from this study could be due to the use of healthy subjects as opposed to patients.

No significant difference in trust in the diagnosis was found between participants who were given detailed information about image interpretation, including the occurrence of miss errors and over diagnosis, and those who were not. However, participants in the detailed information group perceived the diagnosis to be more accurate on average. These findings are important as they indicate that being open about the uncertainties inherent in medical imaging may not be damaging to patients' confidence in medical information. This could be because by informing participants about uncertainties the source may appear honest, as found by Johnson and Slovic (1995). This study also found that the majority of participants did not notice a monkey anomaly superimposed onto a 3D image of the pelvis while completing a simple counting task. Furthermore, participants in the detailed group who were given upfront information about medical image interpretation and the ability to manipulate medical images showed greater inattentional blindness (as they were less likely to notice the monkey) than those who were not given this information. One reason for this could be that if participants in the detailed group believed that the experimenter was being honest then they would be more willing to accept the diagnosis and image to be accurate, causing them to fail to detect the subsequent image manipulation. Clearly, information given to people about the fallibility of images not only affects the experience of viewing the image but also what is objectively perceived by viewers. The data have implications for how accompanying information about medical images can affect the way a person views it.

6.5.1. Study strengths and limitations

This study compared the experience of viewing 3D images, 2D images and no images alongside a diagnosis, using a repeated measures design, in a laboratory setting. A laboratory study was selected over a clinical setting for this study for two reasons. First, a laboratory study using a repeated measures design allowed direct comparison of the experience of viewing 3D images, 2D images and no images, with each participant exposed to each image type. This would be difficult to study in a clinical setting where patients can either be presented with one or more image types or no images, making comparison between images and no images impossible. Second, by exposing participants to the three different image types, they were able to make an informed choice as to which they preferred. Again, this would not be possible to investigate in a clinical setting.

A repeated measures design was favoured, as it would minimise the effects of individual differences between participants (e.g. experience of viewing medical imaging results or experience of suffering from a hip condition). Counterbalancing was used to minimise order effects (i.e. participants gaining more knowledge as they heard more diagnoses) that might result from using the same participants in each condition. Counterbalancing also minimised the impact of any differences in understand-ability of the three diagnoses.

This experiment was conducted as a simulated doctor patient consultation, with diagnoses delivered on a face to face, one to one basis. This allowed experimental controls to be maintained while imitating, as close as possible, a real world setting. The experimental design allowed for control of extraneous variables that would not be possible in a clinical setting. Two limitations of this design are that participants heard three diagnoses about their hip during one consultation which is unlikely to occur in clinical practice. Additionally, to ensure that all participants received the same information, participants were also unable to ask the researcher questions about the diagnoses during the experiment, which does not reflect typical clinical practice.

With 126 participants, the analysis of all data collected during the experiments achieved a power of at least 0.8. Therefore, the probability of a type II error (where the null hypothesis is incorrectly rejected) was low. However, the majority of the analysis of the follow up data was underpowered. Power within the follow up analysis varied from 0.05 to 0.84. This is likely to be due to the small sample sizes used within the analysis of the follow up data, with as few as 37 participants for some analyses, and small effect sizes for some variables. The probability of incorrectly rejecting the null hypothesis is therefore much greater for the follow up data and care should be taken when drawing conclusions from the follow up data.

There are several further limitations of this study. Healthy subjects were used within these experiments and their responses may differ from those of real patients facing a medical diagnosis. The sample was made up of young, well-educated participants. Thus, it is unrepresentative of the general population and unlikely to be representative of patients attending orthopaedic outpatient consultations. Previous research has shown that the use of pictures can improve health communication, particularly for patients who have low literacy skills (Houts *et al.,* 2006). The sample was made up of well-educated participants; therefore, the results may underestimate the benefits of presenting an image alongside a diagnosis. Additionally, English was not the first language of 59.1% of participants. An opportunistic sampling strategy was also employed which may have resulted in self-selection bias with participants more interested in medical images more likely to volunteer to participate. Consequently, these results may not be generalizable to the wider population.

6.6. Conclusions

Patients may benefit from viewing their own medical images alongside a diagnosis. When an image was presented alongside a diagnosis, participants reported greater understanding of the diagnosis, greater trust in the diagnosis and greater satisfaction with the way in which the diagnosis was communicated. Additionally, informing patients of the occurrence of errors within diagnostic imaging to provide a more realistic understanding of medical imaging results may not necessarily have a negative impact upon patient trust.

6.7. Chapter Summary

This chapter compared the experience of viewing 3D images alongside a diagnosis to viewing 2D images or no image alongside a diagnosis. The following chapter will synthesis the findings from the four studies presented in this thesis, before discussing the strengths and limitations of the research and the implications this research has for clinical practice.

Part Three

Chapter Seven: Synthesis and conclusions

This PhD project, comprising four separate studies, sought to explore the impact for patients of viewing their own medical imaging results within a clinical consultation. Through this thesis, four research objectives were met. These are outlined below.

1) Explore the impact of a patient's own 3D image when shown to the patient in a clinical consultation, from the perspective of the patient, clinician, an observer and lay participants. To learn:
    a. Are there benefits for patients of viewing their own imaging results?
    b. Are there concerns about the practice of sharing images with patients?
    c. In what circumstances should images be shown to patients?
2) Understand how 3D images can be incorporated into patient centred consultations?
3) Compare the experience of viewing 3D images alongside a diagnosis to viewing 2D images or no image alongside a diagnosis?
4) Understand whether informing participants of the occurrence of errors within image interpretation and the ability to manipulate medical images affects their trust in the diagnosis and how accurate they perceive the diagnosis to be.

Data was collected using multiple methods. Qualitative interviews, non-participant observation, video-recordings of clinical consultations and focus groups were used to address the first research objective. Data from the video-recorded clinical consultations was used to meet objective two while objectives three and four were met by data collected from psychology laboratory experiments.

Two epistemological perspectives underpinned this thesis to address the research objectives. An interpretivist epistemology (underpinning studies 1 and 3) allowed understanding of participants' (patients and lay volunteers) individual experience of viewing 3D medical images and clinicians' individual experiences of sharing medical images with patients. A post-positivist epistemology, as adopted in study four, allowed the hypothesis that viewing a medical image alongside a diagnosis would be beneficial in comparison to hearing a diagnosis alone to be tested.

This chapter will firstly summarise and synthesise the key findings from this research before discussing strengths and limitations of the thesis as a whole. Finally, this chapter will highlight the practical implications and main conclusions of the research results.

7.1. Summary and synthesis of research findings

This research had five main findings. First, it found that patients may benefit from viewing their own 3D images during a clinical consultation. Second, the experience of viewing 3D images alongside a diagnosis may be preferable to viewing 2D images or no image. Third, there are several important factors that should be considered when sharing medical images with patients, including patient consent and the clinical context or circumstance in which the image is shown. Fourth, patients and focus group participants perceived their 3D images to depict the truth, and to have authority and agency. However, informing patients of the possibility of error within image interpretation did not reduce their trust in a diagnosis. Finally, this study found that although the clinical consultations in which medical images were incorporated did not meet usual criteria of patient centredness, they were more patient centred than previous consultations about orthopaedic surgery analysed within the literature. Findings one and two will be discussed together below. The other three main findings will then be discussed in turn.

7.1.1. Benefits of viewing 3D images

Common themes were identified from patients' individual accounts of viewing their own 3D images during orthopaedic clinical consultations. These were improved patient understanding, improved clinical communication, increased trust in the diagnosis or clinician and aided decision-making. These benefits of viewing 3D images, as identified by patients in study one, were also highlighted across the other three studies.

Patients who viewed their own 3D images during clinical consultations in an orthopaedic outpatient clinic reported improved understanding of their condition. Their clinicians and volunteers who participated in focus groups also agreed that 3D images can aid patient understanding of a condition. Furthermore, using psychology laboratory experiments, study four found that participants reported greater understanding of a diagnosis when it was accompanied by a 3D image compared to a 2D image or no image. These findings support the results of existing studies that have reported that the use of images (i.e. pictures, 2D and 3D images) can aid patient understanding (Carlin *et al.,* 2014; Morris & Van Wijhe, 2010; Vilallonga *et al.,* 2012; Wiener *et al.,* 2012). Moreover, these findings suggest that 3D images may have a greater impact on patient understanding than 2D images. These findings are important as increased patient understanding can enable patients to participate in and make decisions about their care (Kaba & Sooriakumaran, 2007). Improving patient understanding is also important in ensuring that patients are fully informed about their condition and options before undergoing treatment (Morris & Van Wijhe, 2010).

All four studies within this thesis discuss the impact of 3D images on clinical communication. Results from study two showed that medical images (including 3D images) were used to explain the condition and treatment to patients and answer patients' questions. In studies one and three, patients, clinicians and focus group participants explained that the use of 3D images could reduce medical jargon and this was evident through the video-recorded consultations. Study four found that participants reported greater satisfaction with the way in which a diagnosis is communicated when it was accompanied by a 3D image compared to no image. Previous research has identified the use of medical jargon as a barrier to patient understanding of medial information (Wiener *et al.,* 2012). These findings suggest that by using 3D images when communicating information to patients, clinicians may be able to overcome this barrier.

Three studies (study one, study three and study four) reported that viewing 3D images could increase patients' trust or confidence in their clinician or the diagnosis. In study one, patients and clinicians explained that the 3D image could increase patient confidence in their clinician or diagnosis with some patients arguing that by seeing their image they were not longer reliant upon trust alone. In study three, two focus groups reported that viewing 3D images could increase their confidence, as they would know that their clinician had quality information. Study four found participants reported greater trust in a diagnosis when it was accompanied by a 3D image compared to a 2D image or no image. The impact of the image on decision-making was raised within two studies. In study one, four out of ten patients who made treatment decisions before leaving the clinic stated that the image aided their treatment decision. In study three, three of six focus groups felt that viewing 3D images may encourage patients to have treatment or make changes to their health behaviour or lifestyle. Finally, study four, found that participants were better able to recall medical information when it was accompanied by 3D images compared to no image.

These findings suggest that showing patients their own 3D images during consultations may be helpful. Previous research, focused on the use of 2D images or pictures within clinical consultations, found that images may aid clinical communication and patient understanding (Carlin *et al.,* 2014; Vilallonga *et al.,* 2012 Weiner *et al*., 2012). These findings provide further support for the use of images within consultations. They also provide some evidence that 3D images may be more helpful to patients than 2D images.

7.1.2. Considerations of sharing images with patients

Several factors that should be considered when sharing images with patients were raised. The two most important of these issues are discussed below while Chapter Five outlines all the considerations raised. First, the type of consultation in which images are showed should be considered. Patients recruited to study one viewed their own 3D images during outpatient consultations about hip surgery. The images were shown during discussions about diagnosis and treatment after the imaging test had been conducted. Data collected through focus groups in study three found that this type of consultation maybe more appropriate for sharing images with some patients than other types of consultation. There were two reasons for this. One, the types of conditions discussed with the case study clinic were not life threatening and they were typically treatable. Secondly, viewing images after the imaging procedure was considered more appropriate by focus group participants than viewing images during the imaging procedure. These two reasons may explain why this research project found patients benefited from their own imaging results while Ogden *et al.,* (2009) and The *et al.,* (2000) have found negative consequences of viewing images (as discussed in Chapter Five).

Second, the results from study three raised the question about whether clinicians should ask patients if they would like to see their images before showing them. In study one, patients were typically told they were going to be shown their images in advance of seeing them but they were not explicitly asked. One clinician in study one, however, did acknowledge that not all patients are interested in viewing their images. In study three, the majority of participants stated that patients should be asked if they would like to view their images. This could be potentially difficult for clinicians, who in respecting a patient's wishes to not view their images, may feel they have left a patient uninformed.

7.1.3. 3D images as truthful, authoritative and agentic

The perception of medical images as authoritative and as evidence that is able to reveal the truth about the body was found within studies one and three. This perception, previously identified by Joyce (2008) ignores the uncertainty associated with medical image interpretation. Concerns resulting from this perception have been raised, within the existing literature, including over use of imaging, disregard for other forms of information, pressuring patients and impairment to the clinician patient relationship, within the existing literature (Blaxter, 2009; Gelb *et al.,* 1996; Griffiths *et al.,* 2010; Reventlow *et al.,* 2006; The *et al.,* 2010). Two of these, over use of imaging and pressuring patients, were echoed by focus participants in study three (as discussed in Chapter Five).

Although concerns relating to this perception have been raised, this perception may also lead to some of the benefits of viewing 3D images that were reported by patients in study one and focus group participants in study three. For example, if patients consider their images to be evidence it is understandable that viewing their image could increase their trust in the information that they are given and this could in turn influence their decision-making.

The impact of communicating uncertainty within medicine and within other settings is unclear. Informing patients of the uncertainty associated with medical imaging may result in a more accurate perception of medical images but it may also result in negative consequences such as diminished trust. Results from study four found that informing participants about errors within image interpretation did not impact upon their trust. This suggests there may not be harm in trying to give patients a more realistic understanding of their medical images.

7.1.4. Patient centredness within orthopaedic surgical consultations

The findings from this research, when considered alongside the Levinson and Chaumeton (1999) study, suggest that the usual criteria for patient centredness within a clinical consultation may be inappropriate within orthopaedic surgical discussions. Both this study and that of Levinson and Chaumeton found that orthopaedic consultations are typically focused on biomedical information with a verbally dominant clinician. Possible explanations of why this may be the case within this setting has been discussed both within Chapter Four of this thesis and by Levinson and Chaumeton (1999). This research highlights that although orthopaedic consultations tend to focus on biomedical information there are psychosocial concerns that may be important to patients, specifically relating to their physical activities and the impact of their condition or treatment upon these activities. These findings suggest alternative criteria for evaluating patient centredness within orthopaedic consultations maybe needed.

Outcomes associated with a patient centred approach in primary care and oncology include greater compliance to recommended treatments and better disease management (Arora, 2003; Kaplan *et al.*, 1989); improved quality of life, (Arora, 2003; Epstein et al., 2010) and greater satisfaction, wellbeing and enablement (Ishikawa *et al.*, 2002; Little *et al.*, 2001; Paasche-Orlow & Roter, 2003; Pawlikowska *et al.*, 2012). Further research should seek to understand how these outcomes can be achieved within orthopaedic consultations. This was beyond the scope of this thesis. However, the results of study one indicated patients were satisfied with their consultations, describing their consultations and the experience of viewing their images within the consultations positively and highlighting benefits they experienced as a result of viewing their images. It may be that the personal element of viewing and discussing the patient’s own image together enabled the clinician to achieve some of the aims of patient centred care. For instance, this practice may result in the patient feeling that they are viewed and known individually by the clinician.

7.2. Strengths and limitations of the research

This section will discuss strengths and limitations of the PhD research as a whole. Strengths and limitations of the individual research studies are discussed in Chapters 3-7. This section will conclude with a reflection of some of the main challenges faced while conducting this research.

7.2.1. Strengths

This research project adopted a multi method approach. The use of multiple methods allowed triangulation and completeness of data, providing greater confidence in the findings. Triangulation, which is using more than one source of data to allow cross checking of findings (Bryman, 2012), was achieved within study one with observation notes and video-recordings of consultations used to confirm points raised at interview. For example, patients and clinicians discussed the use of medical jargon within the consultations. The video-recordings of consultations revealed that little jargon was used during the discussion of the images but much jargon was used at other times during the consultation. By using different research methods, a more complete answer to the overall research aim was achieved. For instance, the use of psychology laboratory experiments allowed 3D images to be compared to 2D images and no images. It was not possible to ascertain this data from the case study clinic. Additionally, focus groups allowed consideration of the context in which the image is shown (e.g. the type of medical condition presented in the image or when the image is shown) which again would not have been achievable in the case study clinic. By using multiple methods this project was able to answer multiple research questions related to the overall research aim.

Data collected in the qualitative aspects of this research project included in-depth exploration of patients', clinicians' and participants' experiences adopting an interpretivist epistemological approach, which could be probed, where appropriate, for further details. This approach allowed participants to explain their experience and their understanding of their experience in their own words. A post-positivist approach, which used quantitative data from psychology laboratory experiments, complimented the qualitative findings. The psychology experiments were able to demonstrate that when medical information was accompanied by 3D images participants reported greater understanding and trust than when it was accompanied by 2D images or no image. The use of two epistemological frameworks allowed two different but related research questions to be addressed appropriately. A post-positivist approach sought to explain the impact of viewing an image alongside medical information, while an interpretivist approach sought to understand this experience. The use of multiple paradigms, such as these, can increase confidence in the conclusions drawn when the findings of qualitative and quantitative data support one another. However, the use of multiple paradigms can also highlight inconsistences and the need to gain further understanding of a phenomenon of interest when qualitative and quantitative results yield conflicting conclusions. For this thesis, the use of two paradigms provided confidence in the findings and a more complete understanding of the impact of the image within a consultation than could be achieved with one paradigm alone.

Four bodies of literature were studied allowing this research to draw upon existing knowledge from different disciplinary perspectives. This allowed the impact of 3D images within clinical consultations to not only be considered alongside existing studies of clinical communication but also alongside psychological theories of attention and sociological perspectives of medical imaging. Understanding psychological theories of attention enabled hypothesis about the impact of the image to be formulated. This literature also provided insight as to why the image may have had the positive impact on understanding and recall that was found: as theories of attention suggest vision is the dominant sense and that individuals can look at a visual stimuli alongside a verbal stimuli without attentional impairment. Considering sociological perspectives of medical images allowed the findings of this research to be understood in relation to concerns about the use of medical imaging (e.g.

overuse of imaging), potentially providing a more balanced interpretation of the images' impact.

This research collected data from a range of audiences, namely patients, clinicians and lay participants. This allowed both the perspective of patients who have viewed their own 3D images or who may view their 3D images in the future and clinicians who share 3D images with patients to be explored. This research was able to gain feedback on 3D images from adults with a wide age range (18-75). The wide age range of participants sampled within the research suggests that viewing 3D images within a clinical consultation is something that could be beneficial to patients of all ages.

7.2.2. Limitations

Further outpatient clinics were sought to study (as discussed in Chapter Three). However, the use of 3D images was less widespread than expected at the start of the project. As a result of this, this thesis is primarily focused on hip conditions, particularly FAI, with 3D images of FAI used in each of the four studies. Studies one, two and four examined the use of 3D images for hip conditions only while study three sought to understand the experience of viewing oncology as well as orthopaedic images. This thesis therefore reveals little about sharing 3D images with patients in other clinical contexts. The impact for patients of viewing their own 3D images may differ depending on the nature and severity of the condition. In order to overcome this limitation, participants were recruited to focus groups to gain an understanding of possible benefits or concerns of sharing medical images with patients with other conditions, such as cancer, as it was not possible to access patients with other conditions in a clinical setting.

Participants across all four studies were typically well educated, resulting in a sample that is unrepresentative of the general population. As highlighted in Chapter Six, previous research has shown that for patients with low literacy skills, pictures can improve health communication. It therefore may be the case that this research underestimates the benefits that patients gain from viewing their own 3D images. However, it is also possible that well educated patients will gain more from viewing their own imaging results. Medical images could be argued to be more complex than pictures and as a result patients with low literacy skills may not understand them. Bearing this is mind, care should be taken when generalising these findings to the wider population and a patient's educational level or ability to understand the image may need considering when medical images are used within clinical practice. Furthermore, an opportunistic sampling strategy was also employed across all four research studies which may have resulted in self-selection bias (as previously discussed in Chapters Five and Six). This again may have contributed to the sample being unrepresentative of the general population.

Although recall of medical information was assessed in study four relatively objectively as described in the strengths section above, much of the data collected through the psychology experiments still relied on self-report. Variables such as trust, perceived accuracy and satisfaction that were measured in the psychology experiments would be difficult if not impossible to collect in a more objective way.

The epistemological positions and theoretical perspectives upon which this thesis is grounded may also introduce some limitation. Studies one and three adopted a Heideggerian phenomenological approach. This approach acknowledges that individuals, including researchers, are unable to separate themselves from their social world and experiences. Therefore, the interpretation of data may have been influenced by the researcher's own experience. A post-positivist approach underpinning studies two and four proposes that the whole truth or reality can never be completely discovered. The approach also highlights the falsification of results from empirical research and argues that hypotheses should withstand multiple attempts at falsification before being interpreted with confidence. The results from these studies should therefore be interpreted with caution, as they have not been subjected to multiple attempts at falsification.

7.2.3. Reflection on the challenges encountered during the research project

Several challenges arose while collecting data within the case study clinic. First, there were less eligible participants attending the clinic than anticipated. This was because during some clinic sessions the majority of patients were either not having a CT scan, which is required to produce the 3D images, or were under the age of 18. Seven patients who were initially recruited for participation in studies one and two were also excluded as they were not shown a 3D image despite having a CT scan. Two patients only saw 2D images during their consultations even though they had undergone a CT scan from which 3D images can be produced. On reflection, it may have been beneficial to recruit patients who were not having a CT scan if they were having another imaging test. For example, the majority of patients attending the clinic had an X-ray. By recruiting patients who saw x-rays only to the study, a larger sample size would have been achieved for the RIAS analysis of patient centred consultations. Additionally, recruiting patients who had viewed 2D images (i.e. x-rays) only may have allowed differences in patients' experiences to be explored to an extent within a clinical context. Second, it was not possible to observe and video-record all consultations. Of the 14 afternoon consultations where the patients' diagnoses and imaging results were discussed, 10 were video or audio recorded and 13 were observed. For three consultations, the video-recording equipment failed. Third, it was planned that the 3D image would be available during the interview for patients to refer to. In practice, this was difficult to achieve. For patients interviewed within the clinic immediately after their consultation this was not possible as it took time to get a copy of the patients' images from the radiologist. During telephone and skype interviews, it was not possible for patients to view the image. This left two interviews conducted face to face several days after the consultation where patients did view their 3D image during the interview. The presence of the 3D image did not appear to aid data collection and was a distraction for one patient.

7.3. Evaluating the quality of qualitative research

Yardley (2000) proposed four criteria for the evaluation of qualitative research. These are sensitivity to context, commitment and rigour, transparency and coherence and impact and importance (Yardley, 2000). These will each be discussed in relation to the qualitative aspects of this study (studies 1 and 3) in turn.

Sensitivity to context was demonstrated throughout the analysis with the unique nature of the case study clinic discussed in relation to the findings. Additionally, the influence of the researcher on participants was also considered in discussing the results. Commitment refers to substantial engagement with the topic, the development of skills required for the methods used and immersion in the data. These have been demonstrated through the research process. Engagement with the topic was achieved through a thorough review of four relevant bodies of literature and through extensive observations within a radiology department and outpatient clinics. Development of the appropriate research skill was achieved through the completion of a Postgraduate Award in Social Science Research at the beginning of this research process, during which an improved understanding of the research theory, philosophies, methods and techniques was gained. Immersion in the data was accomplished by listening to audio recordings of interviews and focus groups, transcribing the audio recordings, reading through the transcripts thoroughly and repeatedly and by watching each video-recorded consultation at least twice.

Rigour is described by Yardley (2000) as the "completeness of data collection and analysis" (Yardley, 2000 p.221). According to Yardley, this includes an appropriate sample able to supply all the information required for analysis, in depth analysis and triangulation of data sources and methods. Rigour was also demonstrated within this project. Considering the constraints of recruitment within the case study clinic, a good sample size (14 patients) was achieved. Although not a necessity for thematic analysis, data saturation was achieved within this sample. This is a similar sample to other qualitative studies with Guest *et al.,* (2006) for example, concluding that sample sizes between six and 12 can be sufficient for meaningful interpretation (Guest *et al.*, 2006). However, some issues with the sample have been raised in the limitations section above, specifically the high educational level of the majority of the sample. The use of different data sources (i.e. patients, clinicians and lay participants) allowed the phenomena of interest, in this case the experience of viewing 3D images, to be understood from different perspectives. It also allowed the findings from one data source to be compared to that of another, increasing confidence in the findings. Similarly, the use of different data collection methods allowed a more complete data set to be achieved. For example, it is unlikely that patients and clinicians would be able to recall a consultation in the same level of detail that was achieved by video-recording consultations, while video-recording consultations alone would not have accessed patients' interpretations of their experiences.

Transparency was achieved by providing a clear and detailed description of the methods employed and through the inclusion of excerpts from the data alongside the analysis

Finally, this project sought to investigate a topic with importance to clinical practice. Research has identified that patients struggle to recall and comprehend medical information. The findings from this study suggest that the use of 3D images within clinical consultations may be an appropriate strategy to help overcome this.

7.4. Recommendation for future research

This exploratory research project has provided evidence to suggest viewing 3D images during a clinical consultation may be helpful to patients. Based on the findings of this project, five areas for further research are suggested. First, it would be beneficial to understand in which clinical contexts viewing 3D images is helpful to patients. Data collected through focus groups in study three suggested that some clinical contexts might be less suitable for sharing images with patients than others. Future research could investigate, for example, if they are certain health conditions for which viewing images is less appropriate or whether there are certain points within the patient pathway where images may be more or less helpful to patients. Patients whose treatment is monitored using imaging, for example, may be an interesting group to study as there is potential for these patients to see any change in their pathology by repeatedly viewing their images. It may, however, be difficult to find additional clinics that currently use or could realistically use 3D images to study. It may be worthwhile to consider the impact of viewing medical images more generally (i.e. 2D CT, X-ray and MRI images) within different clinical contexts.

Second, it may be useful to explore the relationship between the benefits patients experienced as a result of viewing their 3D image and the perception of medical images as able to depict the truth and provide evidence about our bodies. Study four did examine this relationship to an extent, finding that informing participants about the uncertainty inherent to medical imaging did not negatively affect their trust in medical information. Better understanding of this, however, could help us to understand whether the benefits of the image would persist if patients and the public have a more accurate perception of medical images and medical imaging technology.

Third, the practical and ethical considerations of sharing medical images with patients in clinical practice as raised through this research should be considered further. For example, several participants argued that by using medical images to explain a diagnosis consultation times could be reduced, while others thought that this practice would increase consultation times. Understanding the resources and time required to share images with patients would provide a better understanding of whether sharing images with patients is feasible in clinical practice.

Fourth, the impact of viewing 3D images during a consultation on health outcomes should be considered. Patient activation, that is a patient's knowledge, skill and confidence in managing their own health, is one outcome that could be assessed (Hibbard & Gilburt, 2014). A clinical trial could be used to demonstrate whether the use of images in consultations results in patient activation. Patient activation (including adherence to treatments) is associated with better health outcomes across all specialities (Hibbard & Gilburt, 2014; Horwitz & Horwitz, 1993) and after hip surgery (Marker *et al.*, 2010). Marker *et al.,* (2010) found adherence to therapy after hip resurfacing is associated with better outcomes, namely higher levels of functionality and satisfaction. The impact of patient education on health outcomes has been considered. Giraudet-Le Quintrec *et al.,* (2003) found that patients undergoing hip surgery who received a patient education intervention reported less preoperative anxiety and pain than patients receiving standard care (Giraudet-Le Quintrec *et al.*, 2003). It may be that viewing medical images during a consultation has a similar impact to patient education interventions.

Finally, study two also highlighted the need for further research into patient centredness within orthopaedic surgical consultations. Future research should investigate the consequences of a biomedical, patient education focus within orthopaedic surgery consultations. This could be done by examining whether the positive outcomes associated with patient centred care in other specialities, such as patient satisfaction, are absent for patients attending consultations about orthopaedic surgery. A larger sample would be required in order to achieve sufficient statistical power to undertake this analysis and a broader range of orthopaedic surgery consultations should be included with several participating clinics and clinicians. This research is needed as in other specialities, such as general practice, patient centred approaches are favoured. It is therefore important to ascertain whether surgeons should also be encouraged to adopt a more patient centred approach or continue focusing on patient education. If a focus on patient education is more appropriate within surgical consultations, it is important that communication of biomedical information is effective. Exploring the relationship between outcomes such as patient satisfaction and patient understanding with the use of an image within a clinical consultation might reveal whether images may be appropriate tools to aid surgeons in educating their patients and increasing patient understanding.

7.5. Implications for clinical practice

This research used a multi-method approach to explore the impact of sharing 3D images with patients during a clinical consultation. From this research, implications for clinical practice have been identified. This section will first present implications for orthopaedic clinical consultations, before considering the implications for clinical consultations more generally. The section will conclude by outlining the implications for radiology that arise from the results of this research.

7.5.1. Implications for orthopaedic clinical consultations

3D images are a powerful and persuasive tool that can be utilised by clinicians during clinical consultations. When presented alongside a diagnosis about hip problems, 3D images may increase patient understanding, satisfaction, recall and trust in medical information. They also allow clinicians to explain complex information relating to orthopaedic diagnoses and treatments to patients without the use of jargon. This may enable patients to participate in shared decision-making and be more involved in their care. This is particularly important in consultations about orthopaedic surgery as they are typically biomedically focused, which results in patients being required to understand and recall large amounts of information.

Clinicians conducting consultations with patients in orthopaedic clinics could consider incorporating 3D images into discussions about diagnosis and treatment options.

Patients trust 3D images, with some patients considering them to be evidence of the information they are given, which can increase their confidence in their diagnosis, treatment and clinician. However, medical images are susceptible to interpretation errors. Consequently, clinicians should be careful when communicating with 3D images to avoid presenting them as certain. Results from study four suggest that informing patients of the potential for error within image interpretation may not have a negative impact on patient trust.

Clinicians incorporating 3D images into discussions should also consider two ethical issues raised in this thesis. First, they should consider whether to seek consent from patients before showing them their images. Second, if images are used during discussions about treatment, clinicians should be aware of whether or not they might be using the image to pressure patients into a treatment decision.

Finally, one practical implication for orthopaedic consultations was raised which does not relate to the use of 3D images within consultations. Study four found an increase in discussion of psychosocial issues during orthopaedic consultations in comparison to Levinson and Chaumeton's (1999) study. Furthermore, research by Fossum *et al.,* (1998) found that patients attending orthopaedic consultations would like greater discussion of psychosocial issues. Clinicians therefore should consider placing a greater emphasis on ensuring psychosocial issues are addressed during orthopaedic consultations.

7.5.2. Implications for clinical consultations in other specialities

This study found benefits for patients of viewing their own 3D images during orthopaedic consultations. Previous research has shown benefits for patients of viewing their own 2D images in other specialities (Carlin *et al.*, 2014; Wiener *et al.*, 2013). Clinicians consulting with patients in other clinical specialities should also consider whether viewing their own 3D images would be beneficial for their patients. This research has identified several factors that clinicians should consider when deciding whether to share images with patients. For example, they may need to consider when is the most appropriate time to show 3D images to patients and for which diagnoses and treatments the use of 3D images may be appropriate. They may also consider if there is any value in showing patients their medical images should there be no curative treatment.

7.5.3. Implications for radiology

Two implications for radiology were identified from the research findings. A concern raised within the existing literature and in study three of this thesis is the potential to overuse medical imaging in clinical practice. The perception of medical images as able to access authoritative knowledge about the body or provide proof of a condition, as described within the existing literature and in study one, could result in patients undergoing unnecessary imaging tests. Focus group participants expressed concern that clinicians may request more imaging tests if by showing patients their own imaging results they appear more patient friendly, or that patients may request 3D images if they know they are available. Radiology departments should be mindful of this concern when receiving requests for imaging tests.

The results of this study show that 3D images may be a useful tool for clinicians to show to orthopaedic patients during consultations in addition to assisting diagnosis and treatment planning. Chapter One described some of the current limitations of 3D images, particularly the difficulty in demonstrating soft tissues. With the demand for 3D images increasing, radiologists and scientists are continuing to develop 3D imaging. These 3D images may have potential to be shared with patients in the future.

7.6. Theoretical implications

In addition to the practical implications outlined above, two theoretical implications have also been identified from the results of this research.

First, the findings from study two (as presented in Chapter Four) and from the existing literature (Levinson & Chaumeton, 1999), suggest that the usual criteria for assessing patient centred consultations within primary care and oncology may be inappropriate for consultations about orthopaedic surgery. As discussed in Chapter Four, an equal discussion of biomedical and psychosocial issues may not be optimal for consultations about orthopaedic surgery, with further research to understand what a patient centred consultation about orthopaedic surgery should consist of needed. Care should therefore be taken when applying the results of research into patient centred consultations across specialities.

Second, this study found that medical images are susceptible to inattentional blindness from lay participants in addition to radiologists, as identified within the existing literature. Furthermore, the results of this study showed that participants who were informed of the ability to manipulate medical images and the potential for error when interpreting medical images showed greater inattentional blindness than those who were not given this information. This result furthers current understanding of inattentional blindness by demonstrating that information about the fallibility of a visual stimulus can affect what is objectively perceived by viewers.

7.7. Conclusions

Medical images may be a valuable resource for patients when shown during a clinical consultation. For the majority of patients, viewing their own 3D images was a positive experience, which aided their understanding of their condition and treatment. 3D images may also aid patients' recall of medical information, influence decision-making, increase patient trust and satisfaction and improve clinical communication.

Several participants recruited to this research project described 3D images to depict the truth and provide certainty. This finding reveals that the perception of medical images as truthful and authoritative is not unique to MRI. Concerns resulting from this perception have been identified within the literature. These highlight the need for patients and the public to better understand the uncertainty associated with medical imaging. Results from this research project suggest that highlighting the occurrence of errors within diagnostic imaging to give patients a more realistic understanding of their medical imaging results may not negatively affect patient trust.

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Appendices

Appendix 1: Invitation letter

Text for letter

Clinic headed notepaper

Dear X

During your clinic appointment on X/X/X, a researcher will be in the clinic. The clinic staff and the researcher invite you to take part in a study whilst you are at the clinic and shortly afterwards. I have enclosed/attached some further information about the research project. Please read it and decide if you would like to take part. If you do not wish to take part, that is fine.

We look forward to seeing you in clinic on X/X/X.

Yours sincerely,

XXXXX

Clinic Lead

XXXXX Clinic

XXXXX Trust

Appendix 2: Information sheet (patients)

Warwick Medical School
University Hospitals Coventry and Warwickshire NHS Trust

The impact on patients and their health related decision making of viewing their own medical imaging results in the form of 3D accessible images.

Information about the study

We would like you to help us with this research study. Before you decide whether you want to take part or not, we would like to give you a clear picture about why we think this research is important and what being involved will mean for you.

Please take time to read the following information carefully and feel free to discuss it with someone you trust, whether that be with your family or friends, or your Doctor or Nurse. Please get in touch if anything is unclear or if you would like more information. My name is Emma Phelps and you can contact me on *(email)* or *(phone* number).

What's the purpose of this study?

The purpose of this study is to understand whether using 3D medical images during clinic visits is helpful to patients. We also want to understand what benefits or problems showing these images could cause to patients, health professionals and the NHS as a whole.

Why me?

This study will focus on adults (18 years and above) attending outpatient clinics at University Hospital Coventry and Warwickshire. Your hospital clinic has agreed to be one of the case studies in our research project. These clinics have been chosen because of how they use 3D images at the moment.

What will it involve?

If you agree to take part in the study, your visit with the doctor will be observed by the researcher. **During your visit you will be shown your own 3D medical imaging results. You will be interviewed by the researcher face to face after your visit or over Skype, whichever you prefer.** The interview will also be conducted in English so a good understanding of the language is required. It should last no longer than one hour. We would also like to video record your consultation with the doctor. (Physical examinations will not be recorded). You will still be able to take part in the rest of the study if you choose not to have your consultation video recorded.

Please note that:

- You can decide to stop the data collection at any point.
- In the interview, you do not have to answer any of the questions if you do not want to.
- Your data will be kept confidential to the research team.
- Reports from this study will not include any identifiers of participants.

What will happen to my video recording?

The video recording will be used to look at the way the doctor speaks to you and answers your questions and how the image is used in the consultation. At the end of the study, the video recording will be deleted.

What will happen to the information from my interview?
The interview will be recorded for audio, and later put into text form. At the end of the study, the recorded interviews will be deleted. As part of the presentation of results, extracts of your own words may be used in text.
A summary of the results will be offered to all participants.

Do I have to take part?
No, you do not have to take part. However your participation will help us understand how medical images can be used to benefit patients. Declining to take part or withdrawing at any time, requires no reason and will have no effect on the standard of care that you receive. If you do decide to withdraw all your information will be removed and destroyed. If you do decide to take part you can still withdraw during the interview or any time up until 01 September 2015 without giving a reason.
Withdrawal is only possible up to 01 September 2015.

So, what happens next?
If you do decide to take part you can let us know by sending an email to E.E.Phelps@warwick.ac.uk or by returning the expression of interest form enclosed using the stamped addressed envelope provided. You can also tell the clinic staff when you arrive. You will be given this information sheet to keep and be asked to sign a consent form. If you would like a copy of the final study report, we'd be happy to supply it to you.

Who is organising and funding this research?
The research is being lead by The University of Warwick in collaboration and University Hospitals of Coventry and Warwickshire. The study has been funded by the Economic and Social Research Council.

If this study has harmed you in any way you can contact Jo Horsburgh, Deputy Registrar at The University of Warwick or The Patient Advice and Liaison Service (PALS) at UHCW using the details below for further advice and information:

Contacts for further information

Jo Horsburgh
Deputy Registrar
Deputy Registrar's Office
University of Warwick
Coventry CV4 8UW
Email: J.Horsburgh@warwick.ac.uk
Tel: 024 765 22706

Patient Advice and Liaison Service
University Hospitals Coventry and Warwickshire NHS Trust
Clifford Bridge Road
Coventry
CV2 2DX
Email: complaints@uhcw.nhs.uk
Freephone: 0800 028 4203

Thank you

This study has been reviewed by the West Midlands (Solihull) National Research Ethics Service and approved on 28/05/14.

Appendix 3: Information sheet (clinicians)

Warwick Medical School   University Hospitals Coventry and Warwickshire NHS Trust

The impact on patients and their health related decision making of viewing their own medical imaging results in the form of 3D accessible images.

Information about the study

We would like you to help us with this research study. Before you decide whether you want to take part or not, we would like to give you a clear picture about why we think this research is important and what being involved will mean for you.

Please take time to read the following information carefully and feel free to discuss it with someone you trust. Please get in touch if anything is unclear or if you would like more information. My name is Emma Phelps and you can contact me on *(email)* or *(phone number)*.

What's the purpose of this study?

The purpose of this study is to understand whether using 3D medical images during clinic visits is helpful to patients. We also want to understand what benefits or problems showing these images could cause to patients, health professionals and the NHS as a whole.

Why me?

This study will focus on adults (18 years and above) attending outpatient clinics at University Hospital Coventry and Warwickshire. Both the patient and their clinician are invited to participate in the study to in order to gain an understanding of the use of images from both perspectives. Your clinic has agreed to be one of the case studies in our research project. These clinics have been chosen because of how they use images at the moment.

What will it involve?

If you agree to take part in the study, your consultations with participating patients will be observed by the researcher who will be spending a few days in your hospital clinic. You will be interviewed by the researcher too. This can be done face-to-face after the clinic sessions. It should last no more than one hour.

We would also like to video record the consultations. However, you and your patients will still be able to take part in the rest of the study even if you choose not to have your consultation video recorded. The recording will not be invasive and will not record any physical examinations.

Please note that:

- You can decide to stop the data collection at any point.
- In the interviews, you do not have to answer any of the questions if you do not want to.
- Your data will be kept confidential to the study team.
- Reports from this study will not include any identifiers of participants.

What will happen to the video recordings?
The video recording will be used to look at communication and the way in which the patient's 3D image is integrated into the consultation. At the end of the study, the video recording will be deleted.

What will happen to the information from my interview?
The interview will be recorded for audio, and later put into text form. The recorded interviews will be deleted at the end of the study. As part of the presentation of results, extracts of your own words may be used in text.
A summary of the results will be offered to all participants.

Do I have to take part?
No, you do not have to take part. However your participation will help us understand how medical images can be used to benefit patients. Declining to take part of withdrawing at any time, requires no reason and will have no affect your professional standing. If you do decide to withdraw all your information will be removed and destroyed. If you do decide to take part you can still withdraw during the interview or any time up until 01 September 2015 without giving a reason.
Withdrawal is only possible up to 01 September 2015.

So, what happens next?
I will be at your clinic from 12/09/14. If you decide to take part I will ask you to complete a consent form before the start of the clinic. You can keep this information sheet. If you would like a copy of the final study report, we'd be happy to supply it to you.

Who is organising and funding this research?
The research is being lead by The University of Warwick in collaboration and University Hospitals of Coventry and Warwickshire. The study has been funded by the Economic and Social Research Council.

If this study has harmed you in any way you can contact Jo Horsburgh, Deputy Registrar at The University of Warwick or The Patient Advice and Liaison Service (PALS) at UHCW using the details below for further advice and information:

Contacts for further information

Jo Horsburgh
Deputy Registrar
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Deputy Registrar's Office
University of Warwick
Coventry CV4 8UW
Email: J.Horsburgh@warwick.ac.uk
Tel: 024 765 22706

Patient Advice and Liaison Service
University Hospitals Coventry and Warwickshire
Clifford Bridge Road
Coventry
CV2 2DX
Email: complaints@uhcw.nhs.uk
Freephone: 0800 028 4203

Thank you

This study has been reviewed by the West Midlands (Solihull) National Research Ethics Service and approved on 28/05/14.

Appendix 4: Consent form (patients)

Declaration of Informed Consent for Participants (Version 1, Date: 25/03/2014)

Warwick Medical School University Hospitals Coventry and Warwickshire NHS Trust NHS

Declaration of Informed Consent for Participants

The impact on patients and their health related decision making of viewing their own medical imaging in the form of 3D accessible images

Please tick

1. I have read and understand the Information Sheet (Ref XXXX)		☐
2. I understand what the project is about		☐
3. I have asked all the questions I want		☐
4. I have had my questions answered in a way I understand		☐
5. I understand that I can stop taking part at any time		☐
6. I understand that my data will be identified by an ID number and/or by a pseudonym in the study		☐
7. I am happy for my visit with the doctor to be video recorded.	Yes	☐
	No	☐

If you are happy to take part in this study and give informed consent to do so please fill in the section below:

Print name____

Address and telephone number________________________________

____

Sign __________________ Date __________________

To be filled in by researcher:

Sign __________________ Date __________________

(Copy to patient, clinic and researcher)

Appendix 5: Consent form (clinicians)

Declaration of Informed Consent for Participants (Version 1, Date: 25/03/2014)

Warwick Medical School   University Hospitals Coventry and Warwickshire NHS Trust

Declaration of Informed Consent for Participants

The impact on patients and their health related decision making of viewing their own medical imaging in the form of 3D accessible images

Please tick

1. I have read and understand the Information Sheet (Ref XXXX) ☐

2. I understand what the project is about ☐

3. I have asked all the questions I want ☐

4. I have had my questions answered in a way I understand ☐

5. I understand that I can stop taking part at any time ☐

6. I understand that my data will be identified by an ID number and/or by a pseudonym in the study ☐

7. I am happy for my consultations to be video recorded.

Yes ☐

No ☐

If you are happy to take part in this study and give informed consent to do so please fill in the section below:

Print name____

Address and telephone number____________________________

____

Sign ________________   Date ________________

To be filled in by researcher:

Sign ________________   Date ________________

(Copy to patient, clinic and researcher)

Appendix 6: Observation template

Observation Template

Context	
Use of image in explanation of condition • How • When	
Patients response to the image	
Patient involvement in the discussion about the image	
Patient ask questions about image	
Reflections	

Appendix 7: Patient interview guide

Opening

Thank you for agreeing to participate. Firstly we will talk about you and your condition and then I would like to discuss your consultation with Dr________ and the images you saw today. Let me know if you wish to stop at any point.

Tell me about yourself?

Occupation

Activities

Family

Tell me about the health condition that bought you to the clinic?

How long have you experienced this?

What impact does it have on your life?

Have you seen other doctors/treatments?

Before today, had you seen any medical images? Your own?

Tell me about your visit with Dr _________ last week?

How did you find the doctor?

How did you find the way he communicated with you?

Image

During your consultation you saw ________ images?

Can you tell me about your experience of viewing the images? And the 3D CT image?

What did you see?

How was it explained?

How did you feel looking at the image?

Did it change anything for you?

What about your understanding of your condition?

What about your understanding of your treatment?

Did it make a difference to the consultation?

To communication?

Did it make a difference to how you feel about the doctor?

Trust?

Did it make a difference to how you feel about your diagnosis?

Fear?

Now if we could talk about your treatment plan?

Can you tell me about the treatment you will have?

How did you come to this decision?

Were the images important to you in deciding upon treatment?

Is there anything else that could have helped you?

Is there anything else you would have liked today to help you understand your condition/treatment?

Concluding Questions

Is there anything else you would like to add?

Do you have any questions you would like to ask me?

Appendix 8: Clinician interview guide

Opening Remarks

Thank you for allowing me to observe your consultations.

Just to remind you about the study – I am looking at the use of 3D medical images within patient consultations. For this interview we will begin by discussing the use of the 3D images within the clinic and then move on to discuss the one/two consultations that I observed today. Let me know if you wish to stop at any point

General

Why do you use images in this clinic?

- Do/Have you always used these images?

From your perspective, how do patients find this?

Image

Tell me about your consultation with____________________?

- From your perspective how well do you think he/she understands his/her condition?
- How well do your think he/she understands his/her treatment options?
- Did he/she play a role in decision making?

Tell me about the use of the 3D image within _______ consultation?

Did the 3D image change anything?

- Anything else?
- How about…
    - his/her understanding of condition?
    - his/her understanding of treatment?
    - his/her role in decision making?
    - how you communicated with him/her?
    - the patients trust?

And now can you tell me about the use of the other images within the consultation?

Is there anything else you would like to add about the consultation?

Repeat for each consultation

Concluding Questions

Are you aware of any other clinics or doctors who use 3D images in this way?

- Who?
- What do they do?
- How well does it work?
- How long have they done this?

Is there anything else you would like to add?

Do you have any questions you would like to ask me?

Additional Questions

How long have you been in your current role?

When did you graduate from Medical School (if applicable)?

Appendix 9: Table to show themes by participant

Participants	Positive emotional impact	Aided understanding	Aided communication	Aided decision-making	Increased trust/ confidence	Image had little impact
P1	Yes	Yes	-	Yes	Yes	No
P2	Yes	Yes	Yes	-	Yes	No
P3	Yes	Yes	-	-	-	No
P4	Yes	Yes	Yes	N/A	-	No
P5	No	Yes* & No	-	N/A	-	Yes (image showed no abnormality)
P6	Yes	Yes	-	Yes	Yes	No
P7	Yes	Yes	-	No	-	Yes (already had good knowledge of condition)
P8	Yes	Yes	Yes	Yes & No	Yes	No
P9	Yes	Yes	-	-	-	Yes (did not see a 3D image)
P10	Yes & No	Yes	-	N/A	-	No
P11	Yes	Yes	Yes	No	Yes	No
P12	Yes	No	-	No	Yes	Yes (only saw 2D images which she did not understand)
P13	Yes	Yes	Yes	Yes	Yes	No
P14	Yes	Yes	Yes	Yes	Yes	No
C1	Yes	Yes	Yes	Yes	Yes	N/A
C2	Yes	Yes	-	-	-	N/A
C3	Yes	Yes	Yes	No	Yes & No	N/A
C4	Yes &No	Yes	Yes	Yes	Yes	N/A

* Images could aid understanding in patients who do have an abnormality

Appendix 10: Example illustrate the process of data analysis

Decision-Making	**Patient**	**Clinician**	**Video-Recoding**
P1	• I would say to me it was conclusive to me In understanding what my situation was and what my possibilities were • When I say they were conclusive in me understanding that I might as well get on…get on the waiting list and get it done, they clearly erm display the fact that my hip is defunct • So… yes but they... that's a good question, did they aid my decision… in my decision making process yes completely		C you can look on the resurfacing options but it is something that you will probably have to look for a specific surgeon to do that because… not because there are a lot of surgeons who have being doing them for a long time but because they had some problems…. P I have come here. I am form (place) and I have come here because I have done a lot of research looking for a clinic… C … Someone who is doing resurfacing P No that is working on young people and so I am already of a mind to take your, this clinics opinion or your opinion on it
P2	• And they also explained that they don't know which one is the better one so which probably helps me because I probably wouldn't have decided either way I would have flipped a coin to see which one I would have done So by doing the study as well they chose it for me so that's not too bad		
P6	• I think I decided it could be an option but I think the image does help because you then you can actually see the structure you can actually see the extra bone, the bony ridge on the femoral neck and then you can actually then put it into relation of why your erm you can understand it a lot more so I think does, it does help you then decide this is potentially probably what I need • Because then obviously how er how C2 explained it is obviously then obviously the bony ridge is causing the disruption erm and then you then think actually once that goes then that will potentially help my symptoms and help me improve so I think it does, I think it just confirms erm it confirmed what I was feeling and it confirmed the fact that I did need to go ahead with the surgery		
P7	• No I always I always knew that sitting and waiting wasn't an option. I need to get something done, erm you know if it does go bad you know I'd cross that bridge when we come to it but hopefully you know it will work but no I don't think it swayed me either way on the decision-making • It aided it aided, it didn't help me you know I know what a shape hip looks like erm from being in the physio and they have got a physical however it's obviously a model you know looking at my hip you know it won't make any massive decisions but		

	however it did help me you know visualise what is going on inside my hip and why these things are going wrong with it		
P8	• Yes the erm… it was down to my motivations for being there which were to identify if there was a problem and if surgery would be of any benefit and then but most of all it was because, because I can live with the pain now there is no real driving force for me to have surgery right now • They didn't affect the decision. They helped explain what work was going to be and they it probably… where the images came in was that they either saved time because it would have taken a lot longer to explain to me what the problem was or it meant that I understood properly the problem because they wouldn't have explained it in the first place. So it was the speed of my understanding coupled with the fact that I may not have understood at all if they had not been there. It didn't change the decision • I thought I was going to be told its secondary effects from your first operation nothing is going to change off you go erm so when he actually said surgery I was a little bit shocked because it wasn't what I'd been expecting but because the imagery I very rapidly it didn't take me anytime at all to um align with the suggestion		P My main concern was if by waiting I missed my opportunity to put it right. To think I wouldn't have the same chance of success further down the line. C So I am glad you are here because I think that could be the case. P Ok
P9	• I am nervous obviously about it erm it's not something I am looking forward to but I understand that it's something I have got to do to try and get it better back to where I was before. I want to get better I want to be able to get fitter and stronger and at the moment my body won't let me do that • That's (football) a very big part of it. The other part is that I want to get back to fitness myself for my own wellbeing erm I suffer from diabetes as well so carrying a lot of weight isn't exactly helping me erm so I would like to be able to get a lot fitter than I am because of the diabetes and also look at my long term future.	• I don't think so he came in, he had a lot of faith in us as clinicians, he knew that we were trying to help him so my impression of it was that he was trusting our judgement from the history examination and discussion of the images that we knew exactly what we were telling him about the course of treatment so I think it would have been good in educating him and having him participate more in his care but it would have had a great deal on either the outcome or what he thought we should do for his hip.	
P11		• I don't think it will change anything for the patient because patients come and they expect us as their clinicians to make the correct decisions about what to do so for him maybe not erm I could have told him anything but us as clinicians that does because x-ray alone we are thinking we are not quite sure what we are going to do but basically this CT scan now we know that there is some identifiable organic pathology that we can treat and that will make him better so I guess for him maybe it will come across as increased confidence on the clinician's part in being able to assist which does make patients better or makes them feel more positive that they will have a good outcome.	
P12	• I suppose it was obviously it was good for you guys to have the information. Its new isn't it it's only been known about for the last ten years so obviously if I can benefit anybody then that's going to be a good thing also my husbands in education, my daughters in education so I can see the sort of benefit you know for teaching		

	purposes. Why that would be obviously be a good thing you know I guess that's a personal thing • Yea no they (the images) didn't make any difference		
P13	• When we looked at the 3D sort of scan it was erm it became very apparent what the issues were and then straight away it gave me a lot of confidence in you know what I wanted to do and where I was going to… my next move so it was quite rewarding to come and see the guys • Only in that it made my mind up more or less on the spot of um I knew what I wanted to have done in that I have it operated on and erm if I hadn't of had my leg in plaster the decision would have still been the same but I mean they said it would be a few months before I have it done I would have been pushing could it be done sooner to allow me to sort of heal		
P14	• Because they could use lots of technical jargon and be very eminent in their field clearly they are but they made me understand it by using the pictures so that you don't feel that you are not empowered to make your decisions properly yourself and that's the critical for thing for me is that I understand what's going on I am not daft but I have not got a degree in human biology		
C3		• I think it's important that patients er participate in their treatment, they get a much better conceptual understanding of what's wrong with them and feel more empowered when they can see the pathology, they have had the scan as (too unclear) treatment so for example hip degeneration you show them what a normal hip looks like if their contralateral hip, the opposite hip is normal and then you show them the pathological hip and they feel well educated and well a part of the management process. I think also it improves their hospital experience.	
C4		• I think it does when they actually see something there that probably shouldn't be there I think that's the thing, if the images showed nothing at all then you it (unclear) there's nothing wrong when they can actually see something I think it sort of tips them towards that • Oh yes definitely because originally she was didn't want it done but preferably in the school holidays and then she was oh no oh no I'll just have it done. You can always tell you know when people are more keen to have it done yea • Well yea I do I think it makes people erm more confident because they have confidence that you know what you are doing, you know what the problem is rather than taking… it takes guess work out of it so they think oh I can see that it's been explained to me so they tend to accept it better	

Appendix 11: Information sheet (focus groups)

Warwick Medical School   University Hospitals Coventry and Warwickshire NHS Trust

The impact on patients and their health related decision making of viewing their own medical imaging results in the form of 3D accessible images.

Information about the study

We would like you to help us with this research study. Before you decide whether you want to take part or not, we would like to give you a clearer picture about why we think this research is important and what being involved will mean for you.

Please take time to read the following information carefully and feel free to discuss it with someone you trust, whether that be with your family or friends, or your Doctor or Nurse. Please get in touch if anything is unclear or if you would like more information. My name is Emma Phelps and you can contact me on *(email)* or *(phone number)*.

What's the purpose of this study?

The purpose of this study is to understand how individuals experience viewing medical images and whether using 3D medical images during clinic visits could be helpful to patients. We also want to understand what benefits or problems showing these images could cause to patients, health professionals and the NHS as a whole.

Why me?
This study will focus on adults (18 years and above) who are members of a local (Coventry/ West Midlands) based patient or public group.

What will it involve?
If you agree to take part in the study, you will participate in a focus group (a discussion about medical images with other adults and the researcher. No knowledge or previous experience of viewing medical images is required. During the discussion you will be shown a number of different medical images including 3D medical images. These images may include images of cancer but will predominately be images of bones. We would like to know your opinion of these images. The focus group will be conducted in English so a good understanding of the language is required. It should last up to one hour. There will be a maximum of 8 participants per focus group.

Please note that:

- You can decide to stop the data collection at any point.
- You don't have to any of the answer questions if you don't want to.
- Your data will be kept confidential to the research team.
- Reports from this study will not include any identifiers of participants.

What will happen to the information from my focus group?

The focus group will be recorded for audio, and later put into text form. At the end of the study, the recordings will be deleted. As part of the presentation of results, extracts of your own words may be used in text.

A summary of the results will be offered to all participants

Do I have to take part?

No, you do not have to take part. However your participation will help us understand how medical images can be used to benefit patients. If you do decide to take part you can still withdraw during the interview or any time up until 01 September 2015 without giving a reason. If you pull out, all your information will be withdrawn and destroyed. Withdrawal is only possible until 01 September 2015

So, what happens next?

If you do decide to take part you can let us know by sending an email to *(email)* or by phoning *(number)*. You will be given this information sheet to keep and be asked to sign a consent form. If you would like a copy of the final study report, we'd be happy to supply it to you.

Who is organising and funding this research?

The research is being lead by The University of Warwick in collaboration and University Hospitals of Coventry and Warwickshire. The study has been funded by the Economic and Social Research Council.

If this study has harmed you in any way you can contact the Director of Delivery Assurance Deputy Registrar at The University of Warwick or The Patient Advice and Liaison Service (PALS) at UHCW using the details below for further advice and information:

Contacts for further information

Director of Delivery Assurance
Registrar's Office
University House
University of Warwick
Coventry CV4 8UW
Email: complaints@warwick.ac.uk
Tel: 024 765 22706

Patient Advice and Liaison Service
University Hospitals Coventry and Warwickshire
Clifford Bridge Road
Coventry
CV2 2DX
Email: complaints@uhcw.nhs.uk
Freephone: 0800 028 4203

Thank you

This study has been reviewed by the West Midlands (Solihull) National Research Ethics Service approved on 09/02/15

Appendix 12: Consent form (focus groups)

Declaration of Informed Consent for Focus Group Participants (Version 2, Date: 19/12/2014)

Warwick Medical School | University Hospitals Coventry and Warwickshire NHS Trust

Declaration of Informed Consent for Participants

The impact on patients and their health related decision making of viewing their own medical imaging in the form of 3D accessible images

Please tick

1. I have read and understand the Information Sheet ☐
2. I understand what the project is about ☐
3. I have asked all the questions I want ☐
4. I have had my questions answered in a way I understand ☐
5. I understand that I can stop taking part at any time ☐
6. I understand that my data will be identified by an ID in the study ☐

If you are happy to take part in this study and give informed consent to do so please fill in the section below:

Print name____

Address and telephone number______________________________

____

Sign ________________ Date ________________

To be filled in by researcher:

Sign ________________ Date ________________

(Copy to participant and researcher)

Appendix 13: Focus group guide

Opening

Introduction

- Researcher background
- Explain aims of the focus group (to gain feedback on a variety of medical images)
- Explains format of the focus group (we will start by introducing ourselves; it is a discussion not a question-and-answer session; the discussion will be video recorded; confidentiality will also be discussed).

Participant Introductions

- Name and a little bit about themselves

Previous Imaging Experience

- The group will be asked if they have seen medical images before – either their own or someone else's

  Prompts

  - How did they find this experience?
  - What did they see?

Viewing Images

- The group will then be shown the first set of images (each set will show up to six images of one condition. For example the first set will show hips and will include an X-ray image, 2D CT image and 3D image
- The images will be explained by the researcher
- Patients will be asked for feedback after each set of images and the researcher will go back and forth between the images within the set for participants to discuss and compare
- Participants will be asked to consider how they would feel viewing these images in a consultation

  Prompts

  - How did they participants find seeing these images
  - Did they have a preference, why?
  - Did they see what they were shown in the images
  - Are there/ what are the limitations of showing these images to patients

Concluding Questions

Is there anything else you would like to add?

Do you have any questions you would like to ask me?

Appendix 14: Table to show themes by focus groups

Focus Group	Aid Understanding	Aid Communication	Aid Decision-Making/ encourage behaviour change	Discussion of resources	Discussion of keeping a copy of the image	Discussion of patient consent to view image	Overuse of imaging and pressuring patients
P1	Yes	Yes	Yes	Yes	-	-	-
P2	Yes	Yes	-	-	-	-	-
P3	Yes	Yes	Yes	Yes	Yes	Yes	-
P4	Yes	Yes	-	Yes	Yes	-	Yes
P5	Yes	Yes	-	Yes	Ye	Yes	-
P6	Yes	Yes	Yes	Yes	Yes	Yes	-

* Images could aid understanding in patients who do have an abnormality

Appendix 15: Example to illustrate the process of data analysis

Focus Group	Communication		
	Importance of (skilful explanation)	Aids Communication	Jargon
FG1	• I think as long as its explained properly what the issue is because I know that people that are in the hospital might panic or something but if it's really thoroughly explained so that they don't get carried away thinking oh what's that kind of thing	• so you could tell them the problem or the proportion the number it is difficult for them to understand but if you show them the picture they can see the proportion of the area being affected	• It might help if the patient seems to not understand or if they are asking a lot of questions instead of the doctor using more complicated terminology and things • It might be easier to just point at in and just kind of explain it then rather because I think you don't usually see images like that especially if you are just a regular person so if they start describing it they might not be able to imagine it in their head they are not really going to know where to start whereas if you showed that then they'd it might help them a little bit more
FG2	• I'd say as long as you point out what bit I then its fine but if you just show the picture without any explanation then that's dangerous	• And that's what extent if somebody can say this is the dark patch, that's a big dark patch and that's bad a little patch might be… it qualifies it in some ways • But it would be difficult for someone to explain it without	
FG3	• I think if you are going to tell someone what the issue is the first two both the still and the rotating one were helpful in understanding exactly what it… although your fist statement was that should be curved – that's side should be curved like that side and that was actually the most useful bit of information (too unclear) and this one (2d) isn't nearly as helpful as the first one • It wouldn't be helpful on its own (to a lay person?) but it would be helpful with the man standing there saying here is the problem, so the image is fine but it needs an explanation at a push written explanation in the absence of a man but I'd much rather have the man there • You couldn't have a written explanation because it couldn't be written easily in non-technical		• Yes, but you couldn't explain it without an image I don't think …because you'd need to use some technical language, one consultant could explain to another consultant what the problem was but to a lay person you couldn't, you need an image to show what's wrong

	English could you…. it's the combination of sorry (unclear) isn't it • The explanation is just as important as the image itself		
FG4	• If I was the patient I would find these enormously helpful if they were explained properly but if it was part of a rather unskilful presentation on part of the medical team I might find it rather frightening • But if you had an unskilful team who didn't tell you that the technique makes the bone you know that cut of end of bone • They might thing oh my god I have got something degenerative (mumbled) it may look like that. I depends on the skill of the doctor • I think rather like the point I made a minute ago if that were my hip and I was having pain erm again depending on how it was presented I might get upset and depressed about that • I think it comes back to what we were saying earlier about the skill of the clinicians in explaining what's normal, what is not normal	• I have had to take her word for it but these are sort of very powerfully obvious we are all looking at the same thing erm I am less convinced that that would be of use but I think I am talking personally erm I think your explanation of what the problem was erm I could see what you were pointing at and talking about in the first couple of images erm yea a bit but then if you have got experience of seeing such things might find it more useful than I could • It's drawing out two purposes of these images perhaps, one is for the diagnosis and the second is for the communication • I think you are right I think you are saying using the image to persuade but I think using the image to give you confidence they know what it is you can see what it is I mean you say a picture is worth 1000 words but at least as you say it gives you confidence that yes we know what the problem is and we can move on to what are the options for treatment what are the pros and cons of the options. It does crystallise what the problem	
FG5		• Well there would be somebody there explaining it to them wouldn't there like you see all those little dots those very faint shades I am actually looking at this but you have pointed out the pointers what we are interested in and the knowledge that you have and for the patient would be talking to the patient and saying this little area here because if he were to just hand me that I'd be thinking what am I really looking at I know its the liver what we are looking at but what part am I really looking at • To me, I find that encouraging because you are bonding with the person that is helping to support you you know and I just thing it is good but that needs to be put	

		into ask the question, the gp, surgeon or whoever has got the power in their hands to, they know this does this patient like to know and understand more about it because in the long term it not only saves time it saves money doesn't it you know and so the patient can be just moved on and so far I think we are quite encouraged with the 2 options here with this and I find it quite clear because its been explained what it is	
FG6			• Just being told you are going to have it.. not really.. and they just say it's going to be this, you don't really understand they are doing medical terms when you can see the picture I think that's better

Appendix 16: Information sheet (experiment one)

THE UNIVERSITY OF WARWICK

Researcher: Emma Phelps
Date: 08.09.15
Project Title: Comparing the impact of 2D images, 3D images or no images alongside a diagnosis in simulated orthopaedic clinical consultations

Information Sheet for the Consent Form

In this experiment we are interested in how people experience receiving a medical diagnosis. The experiment will be conducted as a mock doctor – patient consultation, with the researcher acting as the doctor and you will be the patient. You will hear three medical diagnoses about hip conditions. During two of the diagnoses you will be shown medical images of the hip including 2D CT images and 3D CT images. The images will be shown on the computer. After each diagnosis you will be asked to complete a brief questionnaire on paper. The experiment should last for approximately 30 minutes. You will receive another questionnaire by email 2 weeks after the experiment.

Participants may withdraw from the experiment and have the right to withdraw their data at any stage. All data will remain anonymous and confidential. You will be compensated £3 for your time.

By signing the consent form you agree that you have read the above text and that you give your consent to participate in this experiment with the knowledge that you may withdraw at any point in the study without being disadvantaged or penalized in any way.

If you have any further questions about the study please feel free to contact Emma Phelps (contact details below).

Ms Emma Phelps
Department of Psychology, University of Warwick, Coventry, CV4 7AL
E mail: E.E.Phelps@warwick.ac.uk)
Tel: 02476 522133

Should anyone have any complaints relating to a study conducted at the University or by Warwick University's employees or students, the complainant should be advised to contact the Director of Delivery Assurance, details as below:

Director of Delivery Assurance
Registrar's Office
University House
University of Warwick
Coventry
CV4 8UW
Telephone: 024 7657 4774
Email: complaints@warwick.ac.uk

Appendix 17: Consent form (experiment one)

THE UNIVERSITY OF WARWICK

Participant identification number

CONSENT FORM

Project Title:

Contact Details of Researcher and Department:	Ms Emma Phelps Department of Psychology, University of Warwick, Coventry, CV4 7AL E mail: E.E.Phelps@warwick.ac.uk
Name of Researcher: (to be completed by participant)	
I confirm that I have read and understood the information sheet dated	**DATE: On Information Sheet**

For the above project which I may keep for my records and have had the opportunity to ask any questions I may have.

I agree to take part in the above study and am willing to:

Participate in a simulated doctor - patient consultation about hip problems. I will listen to three diagnoses and view four medical images which will be shown during two of the diagnosis. After listening to each diagnosis I will complete a brief questionnaire.

I understand that my information will be held and processed for the following purposes:

Your responses to the questionnaires will be anonymously analysed and written up for dissemination in journal articles and conferences. All data will remain anonymous and confidential.

I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason without being penalised or disadvantaged in any way.

____________________	____________	____________________
Name of Participant	**Date**	**Signature**
____________________	____________	____________________
Name of person taking consent if different from Researcher	**Date**	**Signature**

Appendix 18: Example diagnosis script (experiments one and two)

In your femurs (these bones here/ the bones between your knee and your hip) there are 2 growth plates one near the top of the bone and one near the bottom.

During childhood growth occurs around these plates.

The top growth plate which is just below the ball and socket of your hips (here) has slipped, on both sides. This has caused the balls which is called the femoral heads to slip of the femurs in a backward direction. This is often caused because the growth plates are weak. This would have occurred during a period of growth shortly after the onset of puberty for example. This is called slipped upper femoral epiphysis.

This causes hip pain, a reduction in your range of movement and pain upon movement. The legs are usually turned outwards so they are not straight. You may be unable to bare weight on your legs and struggle to walk.

If treatment is sought early the bone can be screwed back in to place. In your case treatment was not initiated early so a hip replacement is required. This should result in good recovery. Until then the pain could be managed with medication.

Appendix 19: Questionnaire (experiment one)

Participant Number.................

Condition: A ☐ B ☐ C ☐

Type of Image Viewed: No Image ☐ 2D ☐ 3D ☐

Please respond to each of the following statements by ticking the box for the number which best represents your opinion of the statement.

	Not at all 1	2	3	4	5	6	Completely 7
Did you understand the information you were given in the diagnosis?							
Did you think the information you heard in the diagnosis was accurate?							
Did you feel vulnerable during the diagnosis?							
Did you trust the information you were given in the diagnosis?							
Did you feel anxious during the diagnosis?							
Did you feel satisfied with the way in which the information was delivered?							
Did you feel uncomfortable during the diagnosis?							

Please respond to each of the following statements by ticking the box for the number which best represents your opinion of the statement. If you did not see an image please tick the box N/A

	Not at all 1	2	3	4	5	6	Completely 7	N/A I did not see an image
Did you enjoy viewing the medical images?								
Did you find viewing the medical images interesting?								
Did you find the medical images helpful?								

Appendix 20: Debrief sheet (experiment one)

THE UNIVERSITY OF WARWICK

Researcher: Emma Phelps
Date
Project Title: Comparing

Debrief Sheet for Participants

Thank you for participating in this study.

This study aimed to compare whether there is a difference between viewing a medical image alongside a diagnosis and hearing a medical diagnosis alone and if so which type of image (a 3D image or a 2D image) is preferred.

If you have any further questions about the study please feel free to contact Emma Phelps (contact details below).

Ms Emma Phelps
Department of Psychology, University of Warwick, Coventry, CV4 7AL
E mail: E.E.Phelps@warwick.ac.uk)

Should anyone have any complaints relating to a study conducted at the University or by Warwick University's employees or students, the complainant should be advised to contact the Director of Delivery Assurance, details as below:

Director of Delivery Assurance
Registrar's Office
University House
University of Warwick
Coventry
CV4 8UW
Telephone: 024 7657 4774
Email: complaints@warwick.ac.uk

Appendix 21: Information sheet (experiment two)

THE UNIVERSITY OF WARWICK

Researcher: Emma Phelps
Date: 27.01.15
Project Title: Comparing the impact of 2D images, 3D images or no images alongside a diagnosis in simulated orthopaedic clinical consultations

Information Sheet for the Consent Form

In this experiment we are interested in people's memory for medical information. The experiment is made up of three brief tasks. The experiment should last for approximately 30 minutes.

Task 1: At the beginning of the experiment you will be asked to read some information about medical imaging. The experiment will be conducted as a mock doctor –patient consultation, with the researcher acting as the doctor and you will be the patient. You will hear three medical diagnoses about hip conditions. During two of the diagnoses you will be shown medical images of the hip including 2D CT images and 3D CT images. The images will be shown on the computer. After each diagnosis you will be asked to complete a brief questionnaire on paper.
Task 2: You will then be shown a selection of 2D and 3D images to see if you can identify the images you were shown during the diagnosis.
Task 3: The last task is a counting task where you will be asked to count the number of bones you can see within a medical image.

Participants may withdraw from the experiment and have the right to withdraw their data at any stage. All data will remain anonymous and confidential. You will be compensated £3 for your time.

By signing the consent form you agree that you have read the above text and that you give your consent to participate in this experiment with the knowledge that you may withdraw at any point in the study without being disadvantaged or penalized in any way.

If you have any further questions about the study please feel free to contact Emma Phelps (contact details below).

Ms Emma Phelps
Department of Psychology, University of Warwick, Coventry, CV4 7AL
E mail: E.E.Phelps@warwick.ac.uk)
Tel: 02476 522133

Should anyone have any complaints relating to a study conducted at the University or by University's employees or students, the complainant should be advised to contact the Deputy Registrar (contact details below).

Director of Delivery Assurance
Registrar's Office, University House
University of Warwick
Coventry, CV4 8UW
Telephone: 024 7657 4774
Email: complaints@warwick.ac.uk

Appendix 22: Consent form (experiment two)

THE UNIVERSITY OF WARWICK

Participant identification number:

CONSENT FORM

Project Title:	Comparing the impact of 2D images, 3D images or no images alongside a diagnosis in simulated orthopaedic clinical consultations
Contact Details of Researcher and Department:	Ms Emma Phelps Department of Psychology, University of Warwick, Coventry, CV4 7AL E mail: E.E.Phelps@warwick.ac.uk
Name of Researcher: (to be completed by participant)	
I confirm that I have read and understood the information sheet dated	**DATE:** **On Information Sheet**

For the above project which I may keep for my records and have had the opportunity to ask any questions I may have.

I agree to take part in the above study and am willing to:

Participate in a simulated doctor - patient consultation about hip problems. I will listen to three diagnoses and view four medical images which will be shown during two of the diagnoses. After listening to each diagnosis I will complete a brief questionnaire. I will also view a selection of images to see if I can recall the images I was shown and participate in a counting task.

I understand that my information will be held and processed for the following purposes:

Responses to the questionnaires will be anonymously analysed and written up for dissemination in journal articles and conferences. All data will remain anonymous and confidential.

I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason without being penalised or disadvantaged in any way.

________________	____________	________________
Name of Participant	**Date**	**Signature**
________________	____________	________________
Name of person taking consent if different from Researcher	**Date**	**Signature**

Appendix 23: Detailed and basic information (experiment two)

Detailed information condition

Information for the beginning of experiment

Today you will be shown 2D and 3D CT images of the hips and pelvis. A CT image is created by taking numerous X-rays at different cross sections of the structure of interest, in this case the hip. X-rays measure the density of the area of the body that they are passing through. The individual X-ray images, are stacked together to provide an extremely detailed picture.

Medical images including CT images are often perceived as facts or evidence which can reveal the truth about the body. However, examining and interpreting medical images is a specialist task which can be difficult. Miss error rates: when the physician does not detect the abnormality, are estimated to be approximately 30%. Miss errors can occur for the following three reasons:

- the radiologist never directs their gaze to the specific area on the image in which the abnormality is located
- the radiologist directs their gaze upon the abnormality but it may not be strong enough to be identified as suspicious
- the radiologist directs their gaze upon the abnormality, it is strong enough for the radiologist to notice it and examine it but the radiologist may incorrectly conclude that it is a normal structure

Over-diagnosis: when the radiologist interprets an image to be abnormal when it is not can also occur

Information for inattentional blindness task

We hypothesis that there may be some issues with 3D images

- Firstly, 3D images can be easily edited and manipulated.
- Secondly, the 3D images do not show division between the different bones making them appear as one bone.

Basic information condition

Information for the beginning of experiment

Today you will be shown 2D and 3D CT images of the hips and pelvis. A CT image is created by taking numerous X-rays at different cross sections of the structure of interest, in this case the hip. X-rays measure the density of the area of the body that they are passing through. The individual X-ray images, are stacked together to provide an extremely detailed picture

Information for inattentional blindness task

We hypothesis that there may be some issues with 3D images

- The 3D images do not show division between the different bones making them appear as one bone.

Appendix 24: Example questionnaire (experiment two)

Participant Number……………..

Type of Image Viewed: No Image ☐ 2D ☐ 3D ☐

Please respond to each of the following statements by ticking the box for the number which best represents your opinion of the statement.

	Not at all 1	2	3	4	5	6	Completely 7
Did you understand the information you were given in the diagnosis?							
Did you think the information you heard in the diagnosis was accurate?							
Did you trust the information you were given in the diagnosis?							

Please answer the following question by answer A, B, C or D.

Q1. What is the name of the condition described?
A: Acetabular lip injury
B: Avascular Necrosis
C: Osteoporosis
D: Don't know

Q.2 Which of these statements best describes the condition?
A: The ball of the hip joint has collapsed due to a fracture
B: The ball of the hip joint has fractured due to loss of blood supply
C: The ball of the hip joint has collapsed due to loss of blood supply
D: Don't Know

Q3.In which hip did the problem occur?
A: Right
B: Left
C: Both
D: Don't know

Q4. What caused this condition?
A: Trauma (e.g. a very bad fall)
B: The hip was abnormal from birth
C: The cause is unknown
D: Don't Know

Q5. Which of the following was described as a symptom of this condition?
A: Inability to stand up straight
B: Pain at rest
C: Locking of the hip joint
D: Don't know

Q6.What is the treatment for this condition?
A: Hip replacement
B: Physiotherapy
C: Keyhole hip surgery
D: Don't know

Appendix 25: Debrief sheet (experiment two)

Researcher: Emma Phelps
Date
Project Title: Comparing the impact of 2D images, 3D images or no images alongside a diagnosis in simulated orthopaedic clinical consultations

THE UNIVERSITY OF WARWICK

Debrief Sheet for Participants

Thank you for participating in this study.

This study aimed to compare whether viewing a medical image alongside a diagnosis versus hearing a medical diagnosis alone effects recall of the information delivered. Additionally, we also aimed to find out the following:

- Can participants identify the image they were shown from a selection of four images
- Does providing participants information about medical image production and interpretation effect their trust in the information accompanied by the image (Half of participants were provided with this information and half weren't)
- Do participants notice when an image (a monkey) has been added to the medical images

If you have any further questions about the study please feel free to contact Emma Phelps (contact details below).

Ms Emma Phelps
Department of Psychology, University of Warwick, Coventry, CV4 7AL
E mail: E.E.Phelps@warwick.ac.uk)

Should anyone have any complaints relating to a study conducted at the University or by Warwick University's employees or students, the complainant should be advised to contact the Director of Delivery Assurance, details as below:

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