CON-FORMING BODIES: THE INTERPLAY OF MACHINES AND BODIES AND THE IMPLICATIONS OF AGENCY IN MEDICAL IMAGING

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ABSTRACT

In attending to the material discursive constructions of the patient body within cone beam computed tomography (CBCT) imaging in radiotherapy treatments, in this paper I describe how bodies and machines co-create images. Using an analytical framework inspired by Science and Technology Studies and Feminist Technoscience, I describe the interplay between machines and bodies and the implications of materialities and agency. I argue that patients' bodies play a part in producing scans within acceptable limits of machines as set out through organisational arrangements. In doing so I argue that bodies are fabricated into the order of work prescribed and embedded within and around the CBCT system, becoming, not only the subject of resulting images, but part of that image. The scan is not therefore a representation of a passive subject (a body) but co-produced by the work of practitioners and patients who actively control (and contort) and discipline their body according to protocols and instructions and the CBCT system. In this way I suggest they are '*con*-forming' the CBCT image.

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INTRODUCTION

The introduction of new technologies into medical practices presents dramatic changes to organisational and professional fields, as well as challenging patient agency. The introduction of cone beam CT systems provides an example of such changes. Rapidly being implemented across the UK, it involves the adaptation of a radiotherapy cancer treatment machine (linac) enabling it to produce CT-like images through cone beam CT (CBCT). The aim is to take a CT like scan on the linac immediately prior to each treatment. The high quality of the image allows staff to assess small changes in position and size of the target (tumour) area and surrounding soft tissue and either make small adjustments to the patient or machine's position, or alternatively, make daily adaptations to the treatment plan that has been prepared before start of the course of radiotherapy.

The role of the patient, and the patient body, in achieving these images is often overlooked and they are considered passive actors in imaging processes. Such a standpoint drives the portrayal of images as 'objective' (Beaulieu, 2001) and 'transparent' (Joyce, 2008) and smooths the path for incorporating imaging technologies into practices with unquestioned acceptance in the eyes of the public. Demonstrating how Magnetic Resonance Imaging (MRI) draws on cultural imagery relating to sight and technology, Joyce explored the way in which

medical images are the site of the 'transference of action' from human practitioner to machine (Joyce, 2008: 60). As a way of discussing the shifting of agency and the transfer of responsibility, Joyce argues that this transference of action is used to promote and ascribe meaning to the technological system, meanings that cohere with the demands of situated practices.

Within the theoretically informed analysis of two ethnographic cases, in this paper I show how patients and their bodies are active participants in the production of medical images. Drawing on the theoretical perspectives of bodily agency developed within Science and Technology Studies (Mol and Berg, 1998, Mol, 2002, Prentice, 2005a, Goodwin, 2009) and, more specifically, feminist technoscience (Haraway, 1997, Barad, 1998, 2007, Thompson, 2005, Sandell, 2010), I show how CBCT needs specific bodies and how those bodies, once they are conforming, co-produce acceptable CBCT images. As such, I examine how agency moves, and is distributed, between practitioners, the organisation, the machine and patient. Building on the discussion of bodily agency developed by (Pasveer, 1989, Burri, 2008 , Johnson, 2008), I go on to show how co-production of medical images is not just the consequence of governance; rather it is an effect of complex and dynamic shifts in agency. Using these perspectives, which have extended arguments of patient agency beyond subjectivity and control, I explore co-production as a reinterpretation of bodily agency in image production.

Throughout the paper, I use con-forming to stress the co-production of the images. In separating the pre-fix from the 'forming' part of the word I highlight that the actions presented in the following sections are not those of repressed subjects, forced to conform to a 'moral good' but that they are active participations of both practitioners and patients, investing in the technology (or medical authority) and that they have consented to all that may involve; a consent which is provided by the patients in the context of hope that they will be cured from cancer.

The argument builds on sociological literature on imaging technologies and imaging practices (for examples see Cartwright, 1995, Rapp, 1999, Beaulieu, 2001, Beaulieu, 2002, Joyce, 2008, Sandell, 2010, Roberts, 2012). It connects to contemporary studies from feminist technoscience and their arguments of embodiment, bodily agency, patient autonomy as well as highlighting the multiple entanglements of bodies, technologies and discourses that have developed surrounding medical image production. This builds on Barad's concept of intra-action, which is not meant as a more 'intense' form of acting between humans and machines, rather, intra-action moves from two entities coming together to something being an **effect** of that relationship (Barad, 2007). In focussing on the patient body and its role within the imaging phenomena, I discuss patients as part of the configurations and formations of conebeam imaging. I suggest that these bodies con-form i.e. work with the machine, in order to achieve an image that is acceptable within the machine parameters. What is important to remember here is that this co-production is not simply between body and machine. The parameters to which the patient is judged have their own contested social history as do the practitioners and organisations that are also implicated. The con-formation is therefore a sociocultural negotiation involving the lived body of the patient and the network of which it is a part.

The present paper is taken from a larger ethnographic project examining the emplacement of cone beam imaging in radiotherapy practice, critically reflecting on imaging practices and performances of images (Wood, 2012).

SHIFTING AGENCY IN MEDICAL IMAGES: BODY AS OBJECT

The role of the patient body is widely discussed in medical ethnographies where physical connections between practitioner, patient and technologies are interconnected. Important literature of contemporary (feminist) Science and Technology Studies has been concerned with questions of embodiment, material/bodily agency, and patient autonomy (Thompson, 2005, Prentice, 2005b, Goodwin, 2009), as well as highlighting multiple entanglements of bodies, technologies, and discourses within the process of medical image production (e.g. medical ultrasonography) (Haraway, 1997, Rapp, 1999, Barad, 2007). Of note are the ethnographies of medical practices as typified by Rachel Prentice's work on how medical education provides the 'articulation' between the patient body and the surgeon body (Prentice, 2005). Drawing on Bruno Latour's notions of articulation describing how bodies come into being through sensory interactions in the world, Prentice describes how the patient and the surgeon shape each other through mutual articulations. The way in which the resistance of one body and the actions of another shape these sensory interactions moves away from the notion of 'docile' bodies during surgery (Poovey, 1987, Hirschauer, 1991). The passive nature of anaesthetised bodies is also convincingly challenged by Dawn Goodwin in the description of "anaesthesia's cyborgs" (Goodwin, 2009). Goodwin, through ethnographic studies of anaesthetic practices, describes how unconscious patients do indeed act, communicating through connections and pathways established in the union between patient and machine. Anaesthesia's silent bodies, Goodwin argues, still communicate through their augmentation: technologically mediated and organic communication. Bodies that do not always comply, or bodies that speak through 'augmentation', have what Goodwin terms, "agency without intentionality" (43). As such, agency is enacted through the relations of which the body is a part. For Suchman (2007), agency is "*an effect or outcome, generated through specific configurations of human and non-human entities*" (261). As such, entities do not precede their inclusion within configurations; rather they emerge from multiply distributed and contingent practices.

In this paper, I describe radiological imaging practices in order to acknowledge and describe the active role of the patient body in producing medical images. What follows is a description of the ways in which these theoretical concepts have previously been applied to (medical) imaging. In the empirical sections I go on to demonstrate how Goodwin's notion of "*agency without intentionality*" relates to this literature, widening the debate of agency in imaging beyond pre-natal screening to acknowledge and describe the role of patient bodies when co-producing diagnostic medical images.

In order to understand the entanglement of bodies, technologies and discourses surrounding medical images, it is necessary to pay attention to how actors are folded together through the actual and lived practices of forming those images. The politics of visualisation and contemporary biopolitics, driven by neoliberal, technology focussed healthcare, have shifted the clinical gaze to different points of scale typified by the

'molecular gaze' (Clarke et al., 2009). Through 'visual ordering' of bodies certain bodies and certain body parts are configured and what is included or excluded by the medical gaze is shaped (Cartwright, 1995). The patient is therefore 'distilled' into a representation, creating what Johnson terms "*a model of the essence of the patient rather than the whole*" (Johnson, 2008: 108). As a consequence, visualising technologies are invested with the ability to change the body and the matters of concern in view.

Within the domain of prenatal sonography, Rayna Rapp notes how the purpose of the sonogram is not to visualise inside the mother's body, but rather to make an image of a new body, the fetus. 'Giving flesh' to a fetus through the high technology of visualisation is how Donna Haraway describes fetal imaging in Modest_Witness@Second_Millennium (Haraway, 1997). What was previously unseen is now made visible through a technologically mediated experience and the potential 'danger within' is made present (Cartwright, 1995).

The body as object in fetal imaging is summarised more recently by Karen Barad, in taking an 'agential realist' approach to sonography, who states:

> *...the marks on the computer screen...refer to a phenomenon that is constituted in the intra-action of the "object" (commonly referred to as the "fetus") and the "agencies of observation.*
>
> (BARAD, 2007)

In this sense Barad moves the 'object' of the image, the fetus, from a passive bystander into an active participant in the phenomenon of image production. Barad suggests that ultrasound practices are a range of different practices involving "*material configurations and discursive formations*" (Barad, 2007: 204) hence the image is an effect of the coming together of the object and ways of seeing that object.

This goes someway in connecting visualising in prenatal sonography to other diagnostic imaging fields, however the stories of agency and objectivity in pre-natal sonographic imaging are different. Fetal imaging is not a reflection and representation of the scanned woman, "*…the computer screen is not a mirror, the foetus* [sic] *is not her double or her copy."* (Haraway, 1997: 184). The woman in pre-natal sonography is not the object of visualisation, the image gives agency (or gives flesh) to the unborn fetus in some way bypassing the woman's body.

However, the mother's body does play an active role in forming an 'acceptable' fetal image, determined by the 'status' of her body (a full bladder, for example), and thus gives agency to the fetal body. Using examples from early experiments with x-rays (and their consequences on test bodies), Cartwright (1995) suggests that the technician, the gaze, the patient and the object often merge. Here the radiographer generated knowledge by testing on their own body, as such, Cartwright argues, it is "*difficult to analyse the distinction among subjects, objects and agency in the cultural apparatus of radiography*" (Cartwright, 1995: 128).

In diagnostic imaging, it can be argued that the patient is presented with a representation of their inner self, even if bringing the previously unseen into the domain of the seen is not a representation many of us would recognise. In doing so, it blurs the distinctions between

public and private (Cartwright, 1995: 107).[1] And yet, the patient is not 'passive'. As I will go on to explain, there are requirements placed on them to control their bodily functions. The patient body is rendered active through the prerequisites they are asked to meet and through the ways in which they are required to discipline their own body. It is this conflict between involuntary, internal bodily movements and the requirements placed on patients to control and shape them that makes transference of action in image production visible.

Advances in medical imaging have been argued to make visible truth whilst simultaneously challenging power and ethical relationships. The role imaging plays in material and bodily agency is well covered in the literature (Rapp, 1999, Johnson, 2008, Blaxter, 2009, Roberts, 2012) and arguably medical imaging, and its accepted practices of examining bodies and prescribing behaviours, demands compliance through an acceptance of intervention and control. Lisa Cartwright (1995) has provided a historical analysis of the status of the body as object under the medical gaze. Cartwright argues that the partiality of 'visual apparatus' leads to a 'double edged public gaze' that is surveillant but not a totalizing mode of institutional domination and control. As such, Cartwright rebukes claims that imaging is a tool of 'social control' (Cartwright, 1995: 169). The acceptance of norms within imaging encourages compliance. The practices involved in implementing these norms, for example, fasting before an image is taken or drinking a required amount of fluid, mean that enacting agency is something that individuals take on for themselves as part of their role in creating an image. This resonates with the position Cussins (1998) argues for with relation to fertility treatment: enacting forms of objectification (for example being forced to fast) is not antithetical to having agency and that accepting and complying with treatment procedures "*entails neither being helpless nor being a victim*" (Cussins, 1998: 167).

Previous research has used the analytical frame of biopower in medical imaging to explore ways in which imaging increases individuals' knowledge of their own body (Buchman et al., 2013) or acts as a way of empowering individuals to act through increased bodily knowledge (Johnson, 2008). In an exploration of "brain based self-help" literature, Johnson explores biopower in relation to neurological images. His analysis of texts relating to neuroimaging suggests that rendering the internal anatomy of the brain visible and thus in a 'calculable' form is surevillant but not totalizing control. It compels individuals to act to improve their health through techniques of self-government and self-management by demonstrating culturally constructed benefits and possibilities. I would argue beyond this and suggest that medical imaging makes the patient responsible for creating the image and, as such, I argue that the patient is participant in producing body images. This echoes Karen Barad's discussion on sonographic imaging, where the patient and their body are active participants in imaging.

Images are not simply situated but inseparable from the conditions of their acquisition and interpretation – they are, as Karen Barad would term it, materially and socially in intra-action (Barad, 2003). What is seen is a constructed image, the requirements the patient adheres to in order to comply with the imaging procedure, provide the conditions necessary to give meaning to the image. The image is therefore an assembled set of perspectives, or an agential cut (Barad, 1998). As such, compliance is produced through an enactment of a solution within multiple possibilities. The term 'agential' is used here specifically to indicate

that the image is not an objective version of reality, void of human input from a distant passive body, rather an image is **made** through the conditions of its production, through enactments of agency.

What follows is a detailed explanation of radiotherapy and the role of CBCT within this specialised domain of cancer treatment. This is presented to provide the reader with contextual information[2]. I then discuss the organisational protocols that stipulate the requirements to be met by patients prior to the imaging and treatment procedures. Through the analysis of two cases, I discuss how patients conform to these requirements in the co-production of CBCT images.

IMAGE GUIDED RADIOTHERAPY

Radiotherapy is the use of radiation to treat disease, mainly cancer, with the aim of treating tumour tissue whilst sparing or limiting doses to healthy tissue. In order to achieve the precision required for the targeting of diseased cells, treatment needs to be 'planned' or calculated before the X-rays can be delivered. For most radical (curative) treatments, planning processes involve the use of computed tomography (CT) scans or diagnostic strength X-rays to determine the area (target) to be treated. A margin is added to the target area, termed the planning target volume (PTV), to allow for motion during the treatment process. This can be both inter- and intra-fraction movement. Inter-fraction motion is a result of discrepancies in daily patient positioning. The intra-fraction motion is that which occurs whilst the patient is receiving the daily dose and occurs due to patient movement (including breathing) and also tumour movement (also from breathing but sometimes due to the position of the tumour).

Once the target has been defined, a plan for the treatment is designed by a radiographer, planning technician or physicist. Due to the time it takes to complete the planning process, the planning images or reference scans are taken one or more weeks prior to the commencement of radiotherapy treatment. Treatment verification, i.e. the process that enables practitioners to be certain the tumour is treated as planned, is then performed during the course of radiotherapy treatment. This involves comparing the treatment to be delivered to that planned for each individual patient.

The role of image guided radiotherapy (IGRT) is to improve the geometric verification of radiotherapy treatments by comparing information obtained during treatment delivery against that planned to confirm the location of the treatment. When 'IGRT' is discussed commonly what is meant is a recently developed system involving the **prospective** use (i.e. before treatment is given) of Computed Tomography (CT) scans to localize tumour volume. It involves the adaptation of a linear accelerator enabling it to produce CT-like images through cone beam CT (CBCT) imaging (so called because of the 'cone' shape of the radiation beam used). The resulting image is of CT-like quality, but unlike using a CT scanner, as the scan is taken with the facilities on the treatment machine, the patient is in the treatment position and therefore primed for treatment.

Once a CBCT image of a patient in the treatment position is taken, it is compared with the original planning image, on which a treatment plan was based. If the CBCT scan shows the target tissue volume is not going to receive the planned treatment, because the patient is in a different position for example, then the patient's position can be adjusted. This is done by remotely controlling the treatment couch (from outside the treatment room) rather than physically moving the patient. If the target anatomy is no longer where it was on the planning scan, or has changed shape or size, the treatment plan or treatment couch position can be modified.

METHODS AND MATERIAL

This paper is based on observations conducted at two National Health Service hospitals in the UK, the Gray Cancer Centre (GCC) and the Sieverts Hospital (SH).[3] At SH observations began with the installation of equipment and early usage of the system. These two departments of similar size were at different stages of a machine replacement programme. At GCC, new practices had been developed and implemented for over two years. At SH these were in their infancy. Rather than conducting a comparative appraisal about variations in practices, the observations across these two hospitals attended to the ways in which systems are materialised differently. Between the two sites there were different types of relationships and articulations forming the network around the CBCT system, as such the basis of the observations was illustrative, rather than evaluative, in order to show sociomaterial practices in action.

A 12 month period of fieldwork yielded 322 hours of observations including observations of what was being done by clinical and non-clinical staff working with the system. This ethnographic method replicates others deployed in Science and Technology Studies focussing on the processes, policies and people associated with technologies in order to reveal continuous, multi-faceted relationships which are embedded within socio-technical networks. This particular methodological approach *"…reveals how things might have been otherwise..."* (Michael, 1996: 49).

By focussing on the mundane practices around installing and working with the XVI technology, the interplay between machine and human was revealed. Observations also took place at a variety of locations and settings to explore the way organizational frames shape, and are shaped by, the technologies they are associated with. The ethnographic approach allowed the assembly of the ethnographic object to be explored, and hence disentangled, in the multi-sitedness and multi-temporality of the field.

The research was approved by the NHS Main Research Ethics Committee and at each of the two sites by the local Trust Research and Development committees. Written consent was obtained from all staff participants for the observations and patients were informed of the research via posters in the department waiting rooms. Members of staff approached each patient about the observations prior to each treatment session.

PATIENT BODIES

BACKGROUND TO RADIOTHERAPY PREPARATION

In patients receiving radiotherapy treatment for prostate cancer, the problem of movement of the prostate gland, within the bony anatomy of the pelvis, has been known about for some time. However, at the GCC, daily CBCT scans have confirmed the extent to which this resulted in 'geographic misses' of the radiation treatment.

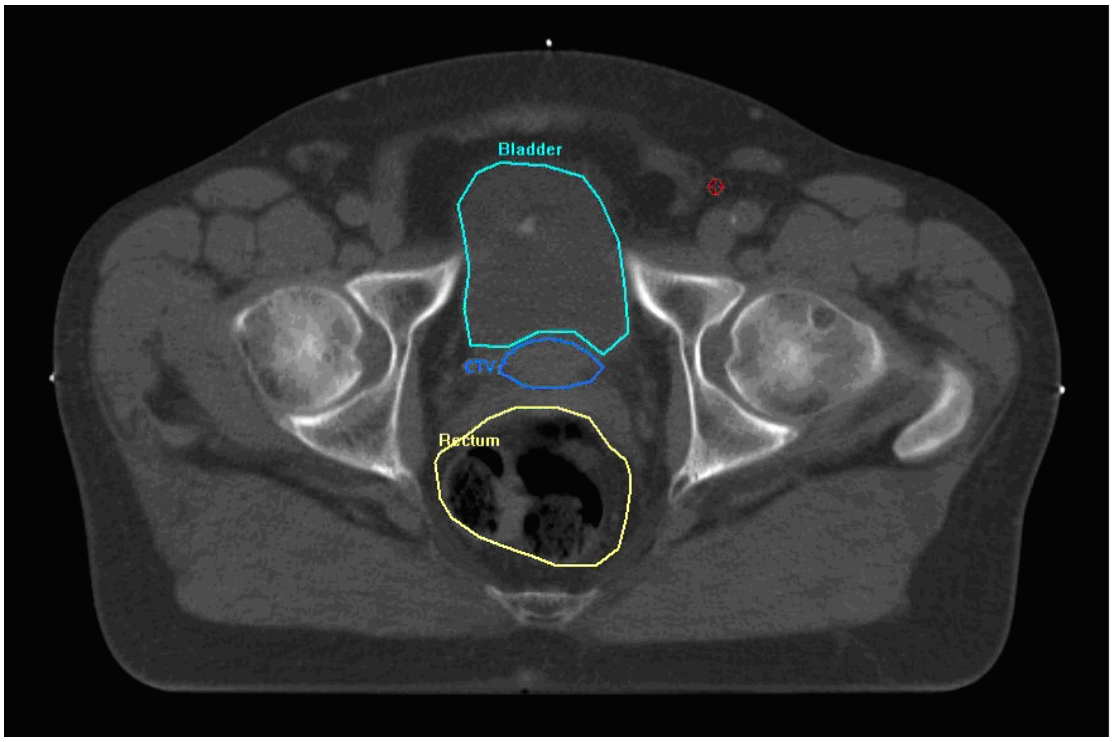

Figure 1. CT scan image showing the position of the prostate (CTV, marked in darker blue) in relation to the bladder and rectum. Permission to reproduce this image was granted from medical physicists at the Gray Cancer Centre.

The variable volume of the rectum and bladder makes precise localisation of the prostate gland more complicated. Many radiotherapy departments have in place bladder filling and rectum preparation procedures that aim to 'control' the volume of these structures. In the department described in this paper, it is believed that an empty rectum[4] plus a '*comfortably*' full bladder is the most reproducible status in order to reduce prostate motion. Patients are therefore given instructions on how to achieve this. The patients are encouraged to 'practise' these requirements prior to the planning scan appointment so that they have rehearsed achieving the full bladder, empty rectum status. After some days during which the patient is expected to practice these requirements, the reference scan is taken. This is the scan on which the radiotherapy treatment is planned and to which all future CBCT images are compared.

REQUIREMENTS OF TREATMENT

The requirements at the GCC state that patients take 25ml of 'Milk of Magnesia' (magnesium hydroxide), once a day in the morning, starting seven days before the planning

scan is taken. Patients are asked to continue to take this medicine up to the day of the final radiotherapy session. The Milk of Magnesia acts as a mild laxative that stimulates bowel movement and thus encourages the empty rectum status required.

In order to ensure what is locally considered a full bladder, patients are asked to empty their bladder and bowels and then drink two and a half cups of water (approximately 400ml) one hour before their appointment time. They are then asked not to empty their bladder until after the treatment has been delivered. At this point it is important to point out that some of the main side effects of prostate cancer are the inability to hold large amounts of urine, urinary frequency, along with incomplete emptying of the bladder. The patients, therefore, constantly feel the urge to urinate. If the patient cannot hold this amount of fluid, that which is deemed to be '*comfortable*', and they have to empty their bladder, they are asked to recommence the bladder preparation.

On the basis of knowledge regarding the movement of the prostate gland with varying bladder and bowel volumes, patients are asked to adhere to these preparation instructions in departments where IGRT techniques are not used. However, when CBCT scans are performed daily, before treatment is given, as at GCC, the demands on the patients become more visible; visible for me, the ethnographer, and visible for the radiographer via the scans.

At GCC scanning the patient before each treatment session enables adjustments to be made before the radiotherapy is given, however, these adjustments, according to the protocol, can only be made if the discrepancy is less than one centimetre. If the discrepancy between the planned treatment location and that seen on the scan is greater than one centimetre, then some intervention has to be made, followed by a re-scan of the patient. In order to keep the displacement within the one centimetre tolerance, and hence reduce the number of re-scans performed, the rectal volume and bladder filling protocols are applied.

'THE PROBLEMATIC GAS MAN'

The normative and culturally loaded notions that an acceptable body is that with a 'comfortably full' bladder and an empty rectum is used to act on the patients, anything else is unacceptable. The men practice what the practitioners term 'their drinking' so that they can meet these norms when they attend for planning and subsequently, when they attend for treatment. A decision is made that 400mls of water results in a 'comfortably full' bladder for these patients. It is not an arbitrary figure as it is an amount of fluid that will stretch the bladder far enough out of the treatment field and purportedly ensure the correct positioning of the prostate gland. It is, however, a further normative step to say that all patients will be comfortable with this amount of fluid in their bladders for the period before and during their radiotherapy treatment. The issue of 'for whose comfort' is of concern here. Is it the comfort of the patients or the comfort of what works for the system?

On each day of the treatment they climb aboard the treatment couch, having prepared their internal self, and the practitioners then confirm if this interior re-shaping has been adequate by relaying the displacement results they acquire from matching the CBCT to the planning scan. In this way, the patients are being asked to replicate a moment in their own bodily

history. Their compliance in this process is a reflection of the patient taking on their own role in the imaging process. They are well informed (having attended planning / training sessions) and, as such, compliance in the meeting the requirements is secured.

To illustrate this point, I will present the story of 'The Problematic Gas Man'.[5] The following scenes involve multiple radiographers, an assistant practitioner, a student radiographer and Mr. London. Mr. London is a short, rotund gentleman who walks with two sticks for support. He is a jovial man, probably in his 70s. On this particular day, Dave, a senior Radiographer, acquires the scan and, after the registration process where the CBCT is compared to the reference image, Hannah, another radiographer, says "*This doesn't look so hopeful. That's out, that's out and that's out*" (she is referring to the three measurements given by the automatic registration process which matches the CBCT scan to the reference scan). Dave confirms "*It's all out*". Mr. London's prostate is not lying in the desired position for treatment and therefore they are unable to deliver the treatment until there has been some kind of intervention (usually the patient is asked to empty his bowels). When Hannah has another look at Mr. London's scan, before he is asked to leave the treatment room, she says she does not think his bladder is full enough either. Mr. London comes out of the treatment room and says he will be back. Hannah asks "*Do you want to look at your scan?*" He replies "*When I come back.*" Hannah tells him to take his time and that there is no rush. They also check if Mr. London is taking his Milk of Magnesia medication and he says he is. Hannah suggests that Mr. London should maybe go and have some lunch which might "*stimulate something*." She says, "*We don't want to get him back on unless he's had a significant movement*." They send in another patient while Mr. London walks around the main waiting room in an attempt to prompt the *significant movement*.

After 20 minutes have passed since Mr. London left the treatment room, the radiographers discuss their workload; they are getting tenser as time progresses. There are 10 minutes left until lunch time and two patients to treat in that time. At two minutes before one o'clock, lunchtime, Susan suggests they could just do another scan and see if the gas "*moves itself*" and if not "*just send him home.*" When Mr. London returns he tells the radiographers that it does not seem like much has changed. They discuss the problem with this situation: if they do another scan today and nothing has changed, they would not be able to take a third scan as the hospital protocol states that the number of scans should not exceed two in one day. Hannah and Dave go back into the corridor to talk to Mr. London about any bowel movements he has had in the period of time between the two scans. I hear Mr. London say he is "*willing to wait all day if he has to*." He takes his role as a con-forming patient seriously, adopting a sense of vocation and assuming his role as participant. This mirrors the discussion by Fox (1998) relating to patient roles in clinical trials.

The radiographers decide to scan him. The scan is acceptable and they finish at half past one for lunch when Mr. London goes home. It later transpires that Mr. London has been taking painkillers for the pain in his legs. These painkillers have made him constipated; that, Hannah concludes, is the issue. Therefore we see how, despite the bladder and bowel filling control procedures, other issues, such as pain relief for Mr. London's arthritis, also plays a part in the acquisition of an 'acceptable' image. It is, of course, a longstanding critique of procedure driven medicine that important individual circumstances, and thus context, is lost

or not accounted for in the drive for standardization (Berg, 1997, Mol and Berg, 1998, Mol, 2002). In Mr. London's case, other aspects of his health and his ability to interpret the information highlight jolts or breaks in the performance of compliance. For example: *"Eileen, a radiographer, is looking through his* [Mr. London] *notes. She says "oh, this is the guy who thought he needed an empty stomach not an empty rectum, he wasn't having his breakfast and was feeling faint."* (from fieldnotes).

What this vignette shows is the shifts in agency when Mr. London is asked and tries to adjust his internal positioning as a consequence of the image registration process performed by the CBCT scanning software. He paces in the waiting room in attempts to have the 'significant movement' required for him to receive his treatment and is 'willing to wait all day' if he has to. The onus to replicate the position of the prostate gland is with Mr. London; he has agency but without intentionality. That is to say, he has the capacity to act, but he does not necessarily have the ability to act as making his body comply with the requirements is beyond his own control. Mr. London takes multiple trips to the toilet during the time between the two scans and tells the radiographers he has had a bowel movement but that he does not think much has changed. The delivery of the treatment, and the radiographers' lunch break, depends on Mr. London's bowel movement. The requirement to re-arrange his body in order for the service to continue makes him active in forming the image and a part of generating the conditions of acceptance or rejection.

In this case we see how Mr London's body is stripped back to its basic functions. The work of producing his body to behave in a way that meets the socio-cultural demands of the imaging process contributes to the efficiency of the department, the smooth running of the workload and the staff lunch break. The CBCT scan affords an examination of the body and habits and practices are brought into public in order to assess concordance. The radiographers proceed with the scan and the scan confirms the movement was adequate to move the prostate gland within the required one centimetre of the planning scan. In this respect the CBCT technology, and those working with it, become the experts in the status of the patient's body; subordinating the position of the patient in their knowledge of their own body whilst compelling the patient to attend to their body to meet expectations. These expectations are shaped by culturally specific notions of what is ideal. The making of any ideal representation is an exercise in a culturally bound aesthetic (Laqueur, 1990). The radiographers, the technology, the whole CBCT assemblage, manipulate the body based upon an aesthetic judgement to meet the 'standards' that have been culturally determined.

Through his bodily involvement in the imaging process, Mr. London's own embodied and subjective agency in that situation was further weakened by the creation of the image (although it is important to note that Mr. London's agency is already weakened by his consent to treatment and all that it involves). There is a contrast here between the bodily awareness a patient needs to have to adhere to the bladder and bowel preparation protocols, and the awareness required from a patient in response to a scan. In the latter, the bodily awareness of the patient can be overridden by the practitioners' knowledge gained from performing the scan. It could be argued that the body is involuntarily acting when a comfortably full bladder and empty rectum are not observed. Despite faecal movement through the bowel being considered an involuntary process, the patient is expected to take

control over these actions through disciplining the body when it becomes 'unruly'. In the case of the patients with full rectums they are shown the image and told that a change needs to be made but translating what is 'enough' or an adequate bowel movement is unattainable.

The patients speak to the radiographers through verbal communication and 'organic' communication; the latter 'augmented' mode being given a higher status in demonstrating the bodily arrangement. Individuals are enrolled in the imaging process. Increasing a patient's knowledge of their own body draws them into the expectation that they will con-form the CBCT image. Once an image has been taken and the practitioner (in action with the CBCT system) decides it is not acceptable, a cut is made and responsibility for producing an acceptable image is transferred and difficult to achieve.

The body is ordered; accepted behaviours are prescribed onto it via the departmental norms and the body is dismantled into the parts that interfere with the production of an acceptable scan image where both the process and the image serve to examine, and thus intra-actively create, the patient. The imaging process aids compliance and ensures that any contravention of order is exposed. Prior to the pre-treatment visualization, faecal matter would have been in place in the patient's rectum. Now, not only is it considered out of place, there is a conversation that has to be had between practitioner and patient and action to be taken by the patient. The progress of this action is monitored verbally by the practitioners as the patients attempt to have 'significant[6] movements', and then examined visually by the CBCT image and resulting registration process.

The image, and the patient's active part in creating it, compels the individual to act and improve their own scan, their own bodily arrangement, through self-government or self-management. The patients' take ownership of their responsibilities to conform (and con-form) and concede of their own accord. Despite the patient's co-constitutive role in producing the CBCT image, the resultant image is also a technical mediation between practitioner, machine and the patient's internal self. Presenting the image to the patient reinforces their role in its production and confronts them with techno expectations that are hard to fulfil. If the patient does not act there will be no treatment for that patient today.

There is a sociocultural contestation in getting bodies to conform to the dictates of the accepted practices in order to produce an actionable image. In the case of the CBCT, the extent to which the patients can interfere with processes and actively participate is limited, as the CBCT images will always be used to 'check' on patients' bodies and their abilities to adhere to the requirements. The CBCT images can therefore be seen as a means for checking the patients have met the requirements determined by the introduction of CBCT imaging. As such, we can see how the image registration process qualifies and classifies the patient's body using this image. As failure results in the cancellation of that day's treatment the patients are constantly under this threat of not receiving treatment. Therefore the practitioner, by showing the patient what they see on the image, transfers their knowledge of the patient's internal anatomy and draws in the patient by putting them 'in the know'.

Alternatively, in a readily conforming or unproblematic body, the image, as a result of the registration process, may be accepted, meaning the patient has achieved the replication of

the previous bodily state required of them. The following vignette is taken from field notes during one of these cases where the unproblematic body's role in producing the image is not made visible. However, this does not mean that contestation hasn't taken place prior to their coming together with the imaging system.

> *The radiographers get the next patient in. Eileen … performs the scan. Dave is looking on the computer used to manage the patient appointment times and Hannah reads the research information sheet I gave her. Eileen sings as she takes the scan. Hannah briefly glances over as Eileen does the scan. She says something and Eileen laughs. Eileen scrolls through the images of the scan and says, "Yeah, it's all beautiful." Hannah says, "You can sit down for the next Mr Fleetwood scan [a repeat scan for a patient seen earlier]. You may have the vibes! You never know." Eileen laughs and says, "Over to you sir." Alan rotates the gantry and starts the treatment. Eileen continues singing.*

In such cases treatment can continue without the patient ever seeing their images or discussing at length the status of their bowel and bladder. The images, by remaining invisible to the patient and only visible to the practitioner, serve an alternative purpose of **preserving** modesty, yet the patient's role in con-forming remains.

By not conforming to the protocols, in the usual usage of 'conforming', or by conforming to the protocols but not achieving the correct bodily arrangement, the patient is culpable. This dual culpability, of not conforming and not making their body conform, is set in the highly emotive domain of cancer treatment. If these patients cannot meet the required standards of normativity they do not get their treatment.

DISCUSSION

This paper has two main arguments: firstly, that patients are active participants in the creation of the images and secondly, through this participation, the images are drawn into the patients' framework compelling them to shape their body in order to achieve the desired image. I have discussed how patient bodies are successfully inscribed into the medico-technical network so as to con-form to produce an actionable scan. I have shown how conforming or nonconforming bodies are reduced down to their functioning parts and how the observed body is judged and governed through the application of goals and norms (based upon distinctly physiological ways of seeing the body). As such, patient, machine and practitioners and the wider sociocultural frames, con-form the image. In the processes of con-forming, individuals are compelled to do the work on themselves, on aspects of bodily function which are either within or outside of their control, to produce acceptable patient bodies together with the technologies. The subject is therefore turned into an active participant within a patient body that is simultaneously objectified and responsible for conforming. Compelled by their role in producing the first image and the assimilation of tasks prescribed to be a 'good patient', the patient strives to adjust in order to achieve subsequent images. The image is adjusted or re-taken, to assist in achieving the desired outcome, permeating the physical (and culturally accepted) boundaries of patient bodies making the patient party to image creation.

The imaging assemblage is designed to make responsibility (seem to) lie with the patient. As each CBCT image is compared with their own body, the patient is disciplined by comparison with earlier inscriptions of themselves. This is an exemplar of an "encounter at the interface" (Suchman, 2007: 284) and as such highlights the materialities and agencies that are required in order for imaging to make sense. These encounters bring together contexts, people, places and ongoing activities to con-form and inform future paths. It is an example of how conditions for action and possibilities for intervention are located within this seemingly mundane sociomaterial assemblage of patient, practitioner, imaging system and healthcare context. 'Agential cuts' within this assemblage reveal con-forming bodies.

The political cut that places responsibility with the patient is not naturally given (it could have been otherwise) but it is constructed in this way and, as such, has particular social (and material) consequences. Understanding the effect of this cut, and thus revealing con-formation (and associated agencies), enables subjects, objects and the relations between them to be made visible. The vignettes in this paper show how the image is the materio-technical manifestation of intra-action. The resultant image is con-formed from the recursive relationship and entanglements between the body and the machine and the input of the practitioners. The patient bodies, adapting in order to produce scans that are within the reasonable limits of the machine, animate and execute the function of the machine, providing the circumstances for the production of medical images.

The paper has provided an insight into the role that the biophysical materiality of patients' bodies plays in the co-production of medical imaging. As Joyce notes, "*the image becomes a core participant in the production of* knowledge" (Joyce, 2005: 43). This paper has shown how the image, the patient and the patient body are all core participants, coming together in con-forming CBCT scanning. It has provided a detailed elucidation of the sociomaterial context of image production, showing how responsibility for achieving an acceptable body configuration is distributed over the patient, practices, image technology network. Where the cuts are made in this intra-action is where responsibility and agency are assigned. As these examples have demonstrated, within the contestation and struggle to meet expectations through introducing CBCT imaging, the responsibility for achieving 'accurate' treatment is shifted from the practitioner and the hospital onto the individual. This prompts the question, what would happen to the unruly patient? The patient who can't conform or refuses to conform? Is this agent position possible? How would their treatment be adapted or declined and to what extent do the consequences of these actions shape patients decisions to fulfil the expectations? Whose responsibility is the unruly patient?

This paper has considered shifting agency, and also the shared and relational agency that produces the transference of action and co-production in medical imaging from human practitioner, machine and patient. The embodied subjects and their struggle with disciplining the body to the dictates of the CBCT system needs further explication. The study was designed to focus on the introduction of cone beam CT within radiotherapy practices. As such, data collected thus far undoubtedly privileges the machine, the staff, the organisations and their connections. As this paper has shown, the radiotherapy patient receiving CBCT scans are not unproblematic, readily conforming bodies. Further research should be performed that explores the 'active participation' of these patients, other

instances of shifting embodied agency within the domains of cancer treatment and how this is exercised.

BIBLIOGRAPHY

BARAD, K. 1998. Getting real: Technoscientific practices and the materialization of reality. *A Journal of Feminist Cultural Studies,* 10**,** 87-128.

BARAD, K. 2007. *Meeting the Universe Halfway: Quantum Physics and the Entanglement of matter and Meaning,* Durham & London, Duke University Press.

BEAULIEU, A. 2001. Voxels in the brain: Neuroscience, informatics and changing notions of objectivity. *Social Studies of Science,* 31**,** 635-680.

BEAULIEU, A. 2002. Images are not the (only) truth: Brain mapping, visual knowledge, and Iconoclasm. . *Science, Technology and Human Values* 27**,** 53-86.

BERG, M. 1997. Problems and Promises of the Protocol. *Social Science and Medicine,* 44**,** 1081-1088.

BLAXTER, M. 2009. The case of the vanishing patient? Image and experience. *Sociology of Health and Illness,* 31**,** 1-17.

BUCHMAN, D. Z., BORGELT, E. L., WHITELEY, L. & ILLES, J. 2013. Neurobiological narratives: experiences of mood disorder through the lens of neuroimaging. *Sociol Health Illness,* 35**,** 66-81.

BURRI, R. V. 2008 Doing distinctions: Boundary work and symbolic capital in radiology. *Social Studies of Science* 38**,** 35-62.

CARTWRIGHT, L. 1995. *Screening the Body: Tracing Medicines Visual Culture,* Minnesota, University of Minnesota Press.

CLARKE, A. E., SHIM, J. K., MAMO, L., FOSKET, J. R. & FISHMAN, J. R. 2009. Biomedicalization: A theoretical and substantive introduction. *In:* CLARKE, A. E., MAMO, L., FOSKET, J. R., FISHMAN, J. R. & SHIM, J. K. (eds.) *Biomedicalization: Technoscience, health and Illness in the U.S.*: Duke University Press.

CUSSINS, C. 1998. Ontological choreography: Agency for women patients in an infertility clinic *In:* BERG, M. & MOL, A. (eds.) *Differences in Medicine: Unraveling(sic) Practices, Techniques, and Bodies.* London: Duke University Press.

FOX, R. 1998. *Experiment Periolous: Physicians and Patients Facing the Unknown,* New Brunswick, New Jersey, Transaction.

GOODWIN, D. 2009. *Acting in Anaesthesia: Ethnographic Encounters with Patients, Practitioners and Medical Technologies,* Cambridge, UK, Cambridge University Press.

HARAWAY, D. J. 1997. *Modest_Witness@Second_Millennium. FemaleMan_Meets_OncoMouse™,* New York, Routledge.

HIRSCHAUER, S. 1991. The manufacture of bodies in surgery. *Social Studies of Science,* 21**,** 279-319.

JOHNSON, D. 2008. "How do you know unless you look?": brain imaging, biopower and practical neuroscience. *J Med Humanit,* 29**,** 147-61.

JORDANOVA, L. 1989. *Sexual Visions,* London, Harvester Wheatsheaf.

JOYCE, K. A. 2008. *Magnetic Appeal: MRI and the Myth of Transparency,* London., Cornell University Press.

LAQUEUR, T. 1990. *Making Sex: Body and Gender from the Greeks to Freud,* London, Harvard University Press.

MICHAEL, M. 1996. *Constructing Identities: The Social, the Nonhuman and Change,* London, Sage Publications.

MOL, A.-M. 2002. *The Body Multiple: Ontology in Medical Practice,* London, Duke University Press.

MOL, A.-M. & BERG, M. 1998. Differences in medicine: An introduction. *In:* MOL, A.-M. & BERG, M. (eds.) *Differences in Medicine.* Durham, North Carolina: Duke University Press.

MOL, A. & MESMAN, J. 1996. Neonatal food and the politics of Theory: Some questions of method. *Social Studies of Science,* 26**,** 419-444.

PASVEER, B. 1989. Knowledge of shadows: the introduction of X-ray images in medicine. *Sociology of Health and Illness,* 11**,** 360-381.

POOVEY, M. 1987. "Scenes of an indelicate character": The medical "treatment" of Victorian women. *In:* GALLAGHER, C. & LACQUEUR, T. (eds.) *The making of the modern body: Sexuality and society in the nineteenth century.* Berkeley: University of California Press.

PRENTICE, R. 2005a. The anatomy of a surgical simulation: The mutual articulation of bodies in and through the machine. *Social Studies of Science,* 35**,** 837-866.

PRENTICE, R. 2005b. The anatomy of a surgical simulation: The mutual articulation of bodies in and through the machine. *Social Studies of Science,* 35**,** 837-866.

RAPP, R. 1999. *Testing Women, Testing The Fetus,* New York, Routledge.

ROBERTS, J. 2012. 'Wakey wakey baby': narrating four-dimensional (4D) bonding scans. *Sociology of Health and Illness,* 34**,** 299-314.

SANDELL, K. 2010. Learning to produce, see and say the (ab)normal: Professional vision in ultrasound scanning during pregnancy. *In:* JOHNSON, E. & BERNER, B. (eds.) *Technology and Medical Practice: Blood, Guts and Machines.* Farnham, Surry: Ashgate.

SUCHMAN, L. A. 2007. *Human-Machine Reconfigurations: Plans and Situated Actions,* New York, Cambridge University Press.

THOMPSON, C. 2005. *Making Parents: The Ontological Choreography of Reproductive Technologies,* Cambridge, MA, MIT Press.

WOOD, L. A. 2012. *The Ray of Hope: Hidden Work and the Pursuit of Accuracy.* Unpublished PhD Thesis.

[1] Although, of course, what is 'public' and what us 'private' is embedded within wider cultural belief systems and ideologies JORDANOVA, L. 1989. *Sexual Visions,* London, Harvester Wheatsheaf..

[2] For a sociological critique of Image Guidance and imaging in radiotherapy see WOOD, L. A. 2012. *The Ray of Hope: Hidden Work and the Pursuit of Accuracy.* Unpublished PhD Thesis., specifically Chapters One, Three, Five and Eight.

[3] The names of the departments and practitioners used in the paper are pseudonyms.

[4] Referring to a rectum empty of both solid faecal matter and bowel gas – The patient in Figure 1 has both in their rectum.

[5] A phrase used by one of the radiographers, Susan.

[6] The use of the term 'significant' demonstrates the ordering within this context. It invokes a judgemental order onto the action but is also a verbalisation of a great deal of work that has been done by humans and machines to define what could be considered significant and what action may be required. It calls on practices that have been created as part of the 'normative ordering' of the assemblage created by, for example, the work, the texts, the technologies and the people in that assemblage MOL, A. & MESMAN, J. 1996. Neonatal food and the politics of Theory: Some questions of method. *Social Studies of Science,* 26**,** 419-444.