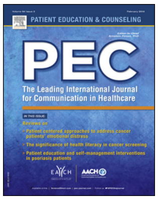
Patient Education and Counseling xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

Patient Education and Counseling

journal homepage: www.elsevier.com/locate/pateducou



Do medical images aid understanding and recall of medical information? An experimental study comparing the experience of viewing no image, a 2D medical image and a 3D medical image alongside a diagnosis

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ARTICLE INFO

Article history:
Received 31 August 2016
Received in revised form 6 December 2016
Accepted 29 December 2016

Keywords:
Doctor- patient communication
Patient understanding
Recall of medical information
Patient trust in medical information

ABSTRACT

Objective: This study compared the experience of viewing 3D medical images, 2D medical images and no image presented alongside a diagnosis.
Methods: We conducted two laboratory experiments, each with 126 healthy participants. Participants heard three diagnoses; one accompanied by 3D medical images, one accompanied by 2D medical images and one with no image. Participants completed a questionnaire after each diagnosis rating their experience. In Experiment 2, half of the participants were informed that image interpretation can be susceptible to errors.
Results: Participants preferred to view 3D images alongside a diagnosis ($p < 0.001$) and reported greater understanding ($p < 0.001$), perceived accuracy ($p < 0.001$) and increased trust ($p < 0.001$) when the diagnosis was accompanied by an image compared to no image. There was no significant difference in trust between participants who were informed of errors within image interpretation and those who were not.
Conclusion: When presented alongside a diagnosis, medical images may aid patient understanding, recall and trust in medical information.
Practical considerations: Medical images may be a powerful resource for patients that could be utilised by clinicians during consultations.

1. Introduction

During consultations with healthcare professionals, patients are frequently given large amounts of information [1], which can be important to make informed decisions about treatment. However, existing literature has found that understanding of medical information can be poor [2,3]. Research has shown that images including pictures, diagrams and 2D images may aid patient understanding [4,5] and increase patient satisfaction [6]. However, they may also cause anxiety [4,7]. Recent advances in technology have allowed the development of 3D medical images, reconstructed from the digital data of 2D scans. 3D images can be rotated for viewing from different angles and may benefit lay audiences as organs and structures are easily identifiable. The literature suggests there is interest in the specific potential of 3D images to have greater utility in communicating with patients, as such images are assumed to be easier to understand [8,9]. However, at present, research into the benefits of showing 3D images to people who do not have medical training is sparse.

The potential to use visual means to communicate in healthcare has emerged as an important area of research [10]. Diagnostic imaging, although inherently uncertain, is often described to provide certainty [11,12]. However, there have been several occasions where image interpretation has led to clinical errors in diagnosis [13]. Furthermore, sociologists argue that the portrayal of medical images as certain is problematic [14] and argue that it could lead to increasing demand for medical imaging

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http://dx.doi.org/10.1016/j.pec.2016.12.034
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tests from patients and clinicians or disregard for other forms of information [14].

The effects of communicating uncertainty within medicine are unclear [15,16]. Johnson and Slovic presented two alternative scenarios that could arise from sharing uncertainty. First, it could enhance credibility and trustworthiness or, second, it could cause confusion and decrease trust. They went on to find that communicating uncertainty about health risks led to perceptions of honesty in some participants but perceptions of incompetence in others [15].

Given that little is known about the impact of sharing 3D medical images with the public, this study investigates people's experiences with these images. Regardless of the sophistication of this technology if people do not see benefits of these images they will not be useful in a clinical setting. The two experiments in this paper ask participants to rate how viewing 3D images, 2D images or no image alongside a diagnosis affected their understanding, perceived accuracy, trust, satisfaction, feelings of vulnerability, uncomfortableness and anxiety. It is possible that viewing images alongside a diagnosis will lead to improved experience as the human brain is optimally structured to view and attend visual images [17–19]. Alternatively, viewing images alongside a diagnosis may have a cost as there is a limit to the amount of information we can process [20–23]. Given the complexity of 3D images it is important to make sure that presenting an image does not distract people from information in the diagnosis. We investigate this in Experiment 2 by asking participants to recall information across conditions where they viewed 3D or 2D images, or no image. In this experiment we 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. As described above, the perception of medical images as certain is argued by sociologists to be problematic. However, informing the public of the uncertainty inherent to medical imaging 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 to understand how the results from medical imaging tests can be better communicated to the public.

2. Methods

2.1. Participants

Two hundred and fifty-two participants (160 female, mean age = 21.2 years) participated, with 126 participants in each experiment. A power analysis showed, with a small effect size (0.15), that this number of participants would provide a power of at least 0.8 for each experiment. The majority of participants described themselves as Asian/Asian British (52.8%) and almost half (47.28%) had previously viewed their own medical imaging results. Participants were all English speaking and were recruited from the University of Warwick participant pool. Participants currently studying or who have previously studied medicine were not eligible to participate. All participants provided written consent and were paid for their time. Ethical approval was obtained from the University of Warwick, Department of Psychology Research Ethics Committee.

2.2. Apparatus and stimuli

The experiments used three different case-study diagnoses: (i) avascular necrosis (AN) (Diagnosis A) (ii) femoroacetabular impingement (FAI) (Diagnosis B) and (iii) slipped upper femoral epiphysis (SUFE) (Diagnosis C). These three medical conditions were selected to be appropriate for the typical age range of our sample population. Two of the conditions: SUFE and FAI occur in young adults 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 Figs. 1 and 2 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 firstly from a dorsal view followed by an anterior view.[1] For the no image condition participants heard the diagnosis alone with no image. The medical images were provided by RW and were shown to participants on a PC. During the no image condition the screen was black. EP developed the diagnosis scripts for these experiments with assistance from RW, a consultant radiologist, to ensure that the information given to participants was accurate.

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). In Experiment 1, 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 diagnoses 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.

In Experiment 2, information about medical image generation and interpretation was given to participants before the experiment. Half of the participants received information about miss errors and over diagnosis within image interpretation along with a small summary explaining how CT images are produced ('detailed information'- see Appendix A). The remaining half only received information about how CT images are produced ('basic information'). After each condition participants were given three statements asking participants to rate how well they thought they understood the diagnosis, how accurate they perceived the diagnosis to be and how much they trusted the diagnosis.[2] Participants were also asked to answer six multiple choice questions about each diagnosis after hearing it. Questions assessed participants' ability to recall the name, description, cause, symptoms and treatment of a diagnosis as well as which hip joint was affected. The total number of correct responses were calculated for each participant.

2.3. Procedure

The experiment was set up to replicate a clinician–patient consultation, with the researcher taking the role of the clinician and the participant the patient. The experiment was conducted on a 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 to participants orally, using scripts to ensure that all participants received identical information. Each script contained ten sentences which explained what the medical condition is as well as possible causes, symptoms and

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[1] Both of these images gave participants a front and a top view of the hips. We used the same image for the 3D case (in different orientations). However, by definition this was not possible for the 2D image, therefore different images were used.

[2] As we were primarily interested in how information given to the participant about the validity of the images affected their trust, understanding and perceived accuracy we did not include the other questions asked in Experiment 1.

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Fig. 1. (a) Axial 2D CT image of the hips with SUFE, (b) Coronal 2D CT image of the hips with SUFE.

Fig. 2. (a) Dorsal view of the 3D CT image of the hips with AN, (b) Anterior view of the 3D CT image of the hips with AN.

treatments (see Appendix B for an example script). Participants were presented with different image types (e.g. 2D, 3D or no image) for each diagnosis. The order that the diagnoses were presented in and the order of the image type were counterbalanced across participants to minimise order effects (see Supplementary material). After hearing all three conditions participants were asked to report which condition they preferred.

2.4. Data analysis

Kurtosis, Skew 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' experience of the three diagnoses were examined using repeated measures ANOVAS and *t*-tests. Analysis of the multiple *t*-tests were conducted using Bonferroni adjusted alpha levels of 0.016 per test (.05/3). A one sample Chi-Square test and McNemar's tests determined whether there was a difference in preference for the three conditions.

3. Results

3.1. The experience of viewing a 3D image, a 2D image and no image alongside a diagnosis

Figs. 3 and 4 show the mean scores for each question in Experiments 1 and 2, respectively. Table 1 shows the results of the repeated measures ANOVAs conducted on each question to see if there was a difference in mean ratings across the 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, satisfaction with the communication of the diagnosis and how uncomfortable participants felt during the diagnosis.

Tables 2 and 3 break the significant results down into individual *t*-tests for Experiments 1 and 2, respectively. In Experiment 1, participants rated their understanding of the diagnosis to be greater in the 2D condition and in the 3D condition compared to the no image condition. However, there was no significant difference in participants' understanding of the diagnosis between the 2D and the 3D image conditions. Similar findings were also found in Experiment 2. However, here participants also reported greater understanding of the diagnosis in the 3D condition compared to the 2D condition. Given the differences across results the data were pooled across experiments to increase experimental power. Overall the results showed that participants reported greater understanding when the diagnosis was accompanied by a 3D or 2D image compared to the no image condition ($t(251) = -9.38$, $p < 0.001$, $d = -0.59$ and $t(251) = -11.70$, $p < 0.001$, $d = -0.755$, respectively). However, they reported a greater level of understanding when the diagnosis was accompanied by a 3D image over the 2D image condition ($t(251) = -3.17$, $p = 0.002$, $d = -0.186$).

Examining participants perceived accuracy of the diagnoses, in Experiment 1 the results showed that participants perceived the diagnosis to be more accurate in the 2D and 3D condition compared to the no image condition. Additionally, participants perceived the diagnosis to be more accurate in the 3D condition compared to the 2D condition. In Experiment 2, participants perceived the diagnosis to be more accurate in the 3D condition compared to the no image condition. There was no difference in

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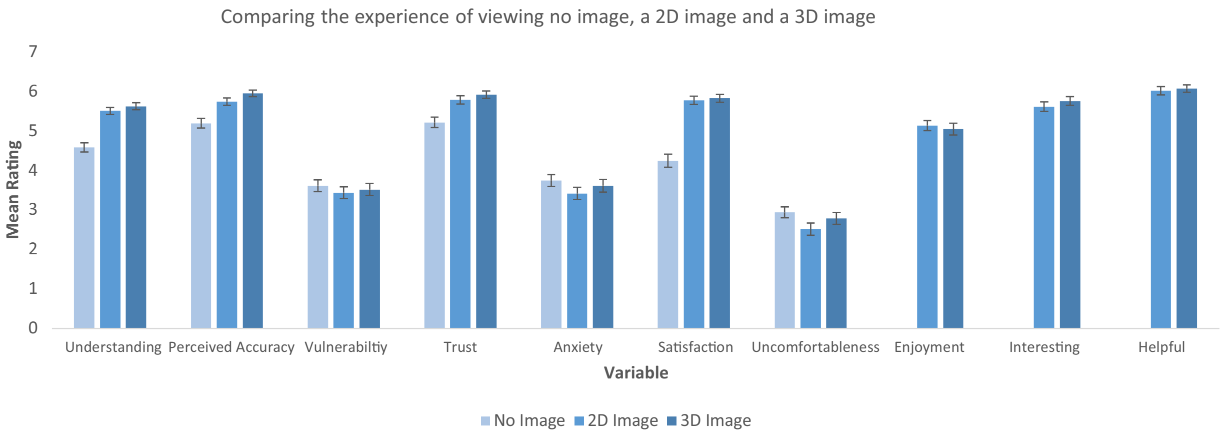

Fig. 3. Mean ratings for each question in Experiment 1 depending on image condition.

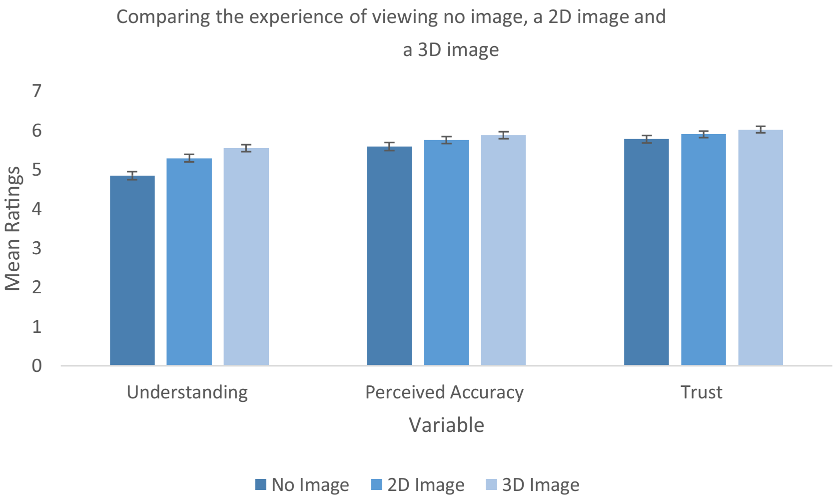

Fig. 4. Mean ratings for each question in Experiment 2 depending on image condition.

how accurate participants perceived the diagnosis to be between the 2D and 3D image conditions and the 2D and no image conditions. Pooling the data across experiments showed that overall participants perceived the diagnosis to be more accurate when it was accompanied by a 3D or 2D image compared to no image ($t(251) = -5.65$, $p < 0.001$, $d = -0.317$ and $t(251) = -7.81$, $p < 0.001$, $d = -0.477$, respectively). However, they reported a greater level of perceived accuracy when the diagnosis was accompanied by a 3D over a 2D image ($t(251) = -3.18$, $p = 0.002$, $d = -0.173$).

Table 1
Results of repeated measures ANOVA's showing the overall difference in mean ratings across the three image conditions.

Variable	Test of significance
Understanding	$F(1.914,480.447) = 86.62$, $p < 0.001$, $\eta_p^2 = 0.257$
Perceived accuracy	$F(1.859,466.66) = 38.37$, $p < 0.001$, $\eta_p^2 = 0.133$
Vulnerability	$F(2,250) = 0.766$, $p = 0.47$, $\eta_p^2 = 0.006$
Trust	$F(1.699,424.76) = 30.55$, $p < 0.001$, $\eta_p^2 = 0.109$
Anxiety	$F(1.812,226.49) = 2.51$, $p = 0.089$, $\eta_p^2 = 0.053$
Satisfaction	$F(1.641,205.15) = 94.80$, $p < 0.001$, $\eta_p^2 = 0.431$
Uncomfortableness	$F(1.854,231.75) = 4.29$, $p = 0.017$, $\eta_p^2 = 0.033$

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

*Experiment 1 and 2 data combined for Understanding, Perceived accuracy and Trust.

Participants reported greater trust in the diagnosis in the 2D and 3D image conditions compared to the no image condition in Experiment 1. In Experiment 2, participants reported greater trust in the diagnosis in the 3D condition compared to the no image condition. In both experiments no significant difference in participants' trust were found between the 3D and the 2D conditions. Pooling the data across experiments showed that overall participants reported greater trust when the diagnosis was accompanied by a 2D or 3D image compared to the no image condition ($t(250) = -4.97$, $p < 0.001$, $d = -0.29$ and $t(250) = -7.08$, $p < 0.001$, $d = -0.401$, respectively). However, they reported a greater level of trust when the diagnosis was accompanied by a 3D image over the 2D image ($t(251) = -2.48$, $p = 0.015$, $d = -0.115$).

The data also showed that participants reported greater satisfaction with the way in which the diagnosis was communicated in the 2D and 3D image conditions of Experiment 1 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 2D and 3D image conditions.

Interestingly, participants reported feeling less discomfort during the 2D image condition compared to the no image condition. However, there were no significant differences in how uncomfortable participants felt between the no image and the 3D image conditions and the 2D and 3D image conditions.

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Table 2
Results from individual *t*-tests for each significant independent variable in Experiment 1.

Variable	Conditions Compared	Test of significance
Understanding	No Image, 2D Image	$t(125) = -8.88,\ p < 0.001,\ d = -0.796$
	No Image, 3D Image	$t(125) = -9.26,\ p < 0.001,\ d = -0.881$
	2D Image, 3D Image	$t(125) = 1.480,\ p = 0.141,\ d = 0.122$
Perceived accuracy	No Image, 2D Image	$t(125) = -5.35,\ p < 0.001,\ d = -0.456$
	No Image, 3D Image	$t(125) = -7.39,\ p < 0.001,\ d = -0.655$
	2D Image, 3D Image	$t(125) = 2.79,\ p = 0.006,\ d = 0.215$
Trust	No Image, 2D Image	$t(124) = -4.83,\ p < 0.001,\ d = -0.44$
	No Image, 3D Image	$t(124) = -6.46,\ p < 0.001,\ d = -0.549$
	2D Image, 3D Image	$t(125) = 1.480,\ p = 0.141,\ d = -0.118$
Satisfaction	No Image, 2D Image	$t(125) = -10.70,\ p < 0.001,\ d = -1.004$
	No Image, 3D Image	$t(125) = -10.77,\ p < 0.001,\ d = -1.063$
	2D Image, 3D Image	$t(125) = -0.584,\ p = 0.560,\ d = 0.045$
Uncomfortableness	No Image, 2D Image	$t(125) = 2.89,\ p = 0.005,\ d = 0.272$
	No Image, 3D Image	$t(125) = 0.91,\ p = 0.364,\ d = 0.094$
	2D Image, 3D Image	$t(125) = 2.15,\ p = 0.034,\ d = 0.168$

Table 3
Results from individual *t*-tests for each significant independent variable in Experiment 2.

Variable	Conditions Compared	Test of significance
Understanding	No Image, 2D Image	$t(125) = -4.52,\ p < 0.001,\ d = -0.387$
	No Image, 3D Image	$t(125) = -7.34,\ p < 0.001,\ d = -0.629$
	2D Image, 3D Image	$t(125) = -3.00,\ p = 0.003,\ d = -0.249$
Perceived accuracy	No Image, 2D Image	$t(125) = -2.39,\ p = 0.018,\ d = -0.162$
	No Image, 3D Image	$t(125) = -3.58,\ p < 0.001,\ d = -0.278$
	2D Image, 3D Image	$t(125) = -1.68,\ p = 0.096,\ d = -0.122$
Trust	No Image, 2D Image	$t(125) = -1.78,\ p = 0.077,\ d = -0.115$
	No Image, 3D Image	$t(125) = -3.37,\ p = 0.001,\ d = -0.235$
	2D Image, 3D Image	$t(125) = -2.00,\ p = 0.047,\ d = -0.124$

No significant differences in participants' ratings of enjoyment, interest and helpfulness were found between viewing 2D or 3D images (all $ts \leq 1.44$, $ps \geq 0.153$).

3.2. Preference

In Experiment 1, 63.5% of participants reported that they preferred the 3D image condition, 34.9% reported that they preferred the 2D image and 1.6% preferred the no image condition. A chi square test revealed that the difference in preference across all three conditions was significant, χ^2 (2, $N = 126) = 72.571$, $p < 0.001$. Furthermore, when comparing preference across the individual conditions, the results showed that participants preferred the 3D image over the 2D image, χ^2 (1, $N = 126) = 9.879$, $p = 0.002$ and the no image condition, χ^2 (1, $N = 126) = 72.305$, $p < 0.001$. Viewing 2D images alongside a diagnosis was preferred to viewing no image, χ^2 (1, $N = 126) = 36.543$, $p < 0.001$.

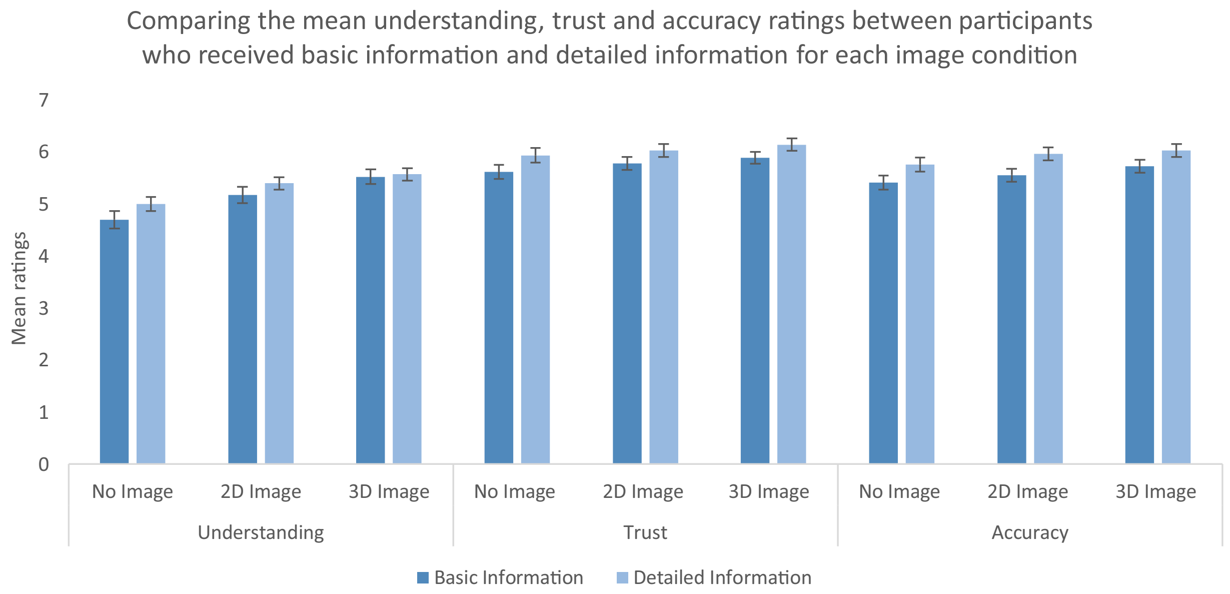

Fig. 5. Mean ratings by information type for each image condition in Experiment 2.

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

Fig. 5 shows the mean ratings for participants who received detailed information about medical image production and interpretation compared to participants who received basic information. No significant difference in ratings for understanding, perceived accuracy or trust scores were found between these groups.

3.4. Recall of medical information

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 recall of medical information, F (2,250) = 5.13, p = 0.007, $\eta_p^2 = 0.039$. Participants showed better recall of the medical information when it was accompanied by either 3D or 2D images compared to no image (t (125) = −2.98, p = 0.003, d = −0.339 and t (125) = −2.44, p = 0.016, d = −0.264, respectively). No difference in participant's ability to recall information was found between the 2D and the 3D image conditions. However, recall rates differed depending on the question type. Participants showed better recall for which hip had been affected when presented with a 2D or 3D image compared to the no image condition (χ^2 (1, N = 126) = 10.105, p = 0.001 and χ^2 (1, N = 126) = 18.618, $p < 0.001$, respectively). However, there was no difference in recall across condition for the other five questions.

4. Discussions and conclusions

4.1. Discussion

Although 2D and 3D images can be used to communicate information to patients in a clinical setting there has been little research directly comparing the benefits of these image types. Our study is one of the first to show that when a diagnosis was accompanied by a medical image (either 2D or 3D), participants reported increased satisfaction, understanding, and trust and they perceived the diagnosis to be more accurate compared to when there was no image. More importantly, the combined results of Experiment 1 and 2 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. The results also found that participants preferred to receive a diagnosis accompanied by a 3D image compared to a 2D image or no image. These findings suggest that although there are benefits of viewing both 2D and 3D images alongside a diagnosis, the benefit may be slightly greater for 3D than 2D images.

There was no significant difference in anxiety ratings between viewing 3D medical images, 2D medical images and no image alongside a diagnosis. This is in contrast to previous research [4,7]. Ogden et al. found women who viewed the screen during their hysteroscopy procedure reported greater anxiety than those who did not. While, Carlin et al. found that some patients reported feeling anxious after viewing their own 2D medical images during a clinical consultation. Our results may have differed from these existing findings for several reasons. First, the context in which the images were shown in Ogden et al.'s study (i.e. viewing the screen during a hysteroscopy) differs from the type of consultation imitated within our experiments. Second, Carlin et al. did not compare the experience of viewing an image to hearing a diagnosis alone. Patients who are not shown their images may be equally or potentially more anxious than those who are shown their own images. Finally, our results could be due to our use of healthy subjects as opposed to patients.

We did not find a difference in understanding, perceived accuracy or trust in the diagnosis between participants who were given detailed information about image interpretation and those who were not. These findings are important as they suggest that being open about the uncertainties inherent in medical imaging may not be damaging to patient's confidence in medical information.

Participants also showed better recall for information if a diagnosis was presented with a 2D or 3D image, demonstrating that viewing an image did not distract participants from the information contained within a diagnosis. However, this effect seemed driven by better recall of which hip was affected. One difference between this question and the others was that people could visually identify the hip in the image. This might have implications for other visual information presented to patients in images. For example, viewing the size of abnormality, could be important for patients [20]. Further research is needed to investigate this.

4.1.1. Study strengths and limitations

Using a laboratory study afforded many advantages over a clinical setting. First, using a within participants design allowed us to compare the experience of viewing 3D images, 2D images and no images directly. This information would be difficult to ascertain 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, it allowed participants to make an informed choice of which image they preferred having been exposed to all of the different image types. Again this would not have been able to be investigated in a clinical setting. Third this design minimised the effect of individual differences between participants (e.g. first language or previous patient experience). However, although we endeavoured to imitate, as close as possible, a real world setting there are several limitations of this study. For example, participants were unable to ask questions about the diagnoses. This protocol was needed to ensure experimental control, however, we realise it does not reflect typical clinical practice.

Furthermore, we used healthy volunteers within our experiments, whose responses may differ from that of real patients and therefore our study may lack ecological validity. However, almost half of our participants had viewed their own medical images and been patients themselves. All participants were instructed to take on the role of a patient and the diagnoses were chosen to be appropriate for this population (as it is easier for young adults to envisage having hip pain than a more severe or life-limiting condition). Our sample was made up of young well-educated participants. Thus, our sample is unrepresentative of the general population and of patients attending orthopaedic consultations. We also used an opportunistic sampling strategy so there may be a degree of self-selection bias. Consequently, our results may not be generalizable to the wider population. Despite this previous research has shown that the role of pictures is important in improving health communication, especially for patients who have low literacy skills [5]. As our sample was made up of well-educated participants, it may have underestimated the benefits of presenting an image alongside a diagnosis. Future research is needed to investigate this but at present our research is the first to show that within these boundaries there are advantages for showing people 3D images alongside a diagnosis.

4.1.2. Future research

Future research should investigate whether the benefit of showing patients their medical images alongside a diagnosis,

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occurs in a clinical setting. Furthermore, the effect of showing patients their medical images in different clinical contexts should be studied. For example, looking at different conditions such as cancer, where there is potential for patients to experience greater distress, would enable us to consider whether the use of images in other contexts is appropriate.

4.2. Conclusions

Medical images may be a powerful resource for patients when shown during a clinical consultation. They may aid patient understanding of medical information and may increase patient trust and satisfaction, with the benefits of 3D images slightly stronger than that of 2D images. Highlighting the occurrence of errors within diagnostic imaging to give patients a more realistic understanding of their medical imaging results had little effect on patient trust.

4.3. Practical implications

Clinical practice is currently inconsistent, with some patients shown 3D images, some shown 2D images and some not shown their images. Our findings suggest when presented alongside a diagnosis, 2D and 3D images may increase patient understanding, satisfaction, and trust in medical information. If these findings are replicated in clinical practice, these images could be utilised by clinicians during consultations.

Funding

The study was funded by the Economic and Social Research Council (grant number ES/J500203/1) and University Hospitals Coventry and Warwickshire NHS Trust as part of a Ph.D. studentship.

Conflict of interest

No conflicts of interest have been identified.

Acknowledgments

I confirm all patient/personal identifiers have been removed or disguised so the patient/person(s) described are not identifiable and cannot be identified through the details of the story.

Appendix A. Text for detailed information condition

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

Appendix B. Example diagnosis script

The hip is a ball socket joint. On your right hip the shape of the ball which is called the femoral head is slightly abnormal. It has a slight bulge (here/towards the bottom of the ball where the ball meets the top of the femur – the bone between your hip and knee).

Upon movement this bulge impinges upon your hip socket called the acetabulum so it hits the socket earlier than it would if it were a smooth normal shape. This condition is called femoral acetabular impingement. It is not known why your hip is this shape but it is thought that your hip probably grew this way during puberty.

The impingement can damage the joint and the cartilage (which are the soft tissues within the joint (just here)) and can cause symptoms such as pain and limited movement of the hip. Abnormal shape hips are common but they only become a problem for some of the population depending upon how you use your hip so the activities you do.

Treatment is initially pain relief or physiotherapy to strengthen the muscles around this hip. Surgery to remove the lump reducing the impingement is also performed. This can give good relief of symptoms.

Appendix C. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.pec.2016.12.034.

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