Authors

D.M. Hudson [a,*],

C. Heales [b],

[a] InHealth Group, High Wycombe, UK

[b] Medical Imaging, Department of Health and Care Professions, Faculty of Health and Life Sciences, Exeter University, Exeter, UK

Background:

Scan associated anxiety is commonly experienced within various diagnostic imaging procedures[1], with patients undergoing Magnetic Resonance Imaging (MRI) particularly noting concern[2–4]. The expression of any anxiety in MRI most commonly presents as fear relating to the physical nature of the scanning procedure and the equipment itself[4–7]. The impact on patients ranges from an inability to attempt any scan at all, abandoning a scan midway through, or for those managing to cope there may be issues around reduced scan quality due to movement or shortening scan times[8–17]. This can adversely affect outcomes for patients through their poor experience of the diagnostic test[5,18], as well as hinder efficiency and throughput of departments[5,14,15,19,20].

Managing claustrophobia continues to present a challenge to imaging staff in practice[6,21], although incomplete examinations have most recently been shown to be less than 1%[10]. This is in part due to improvements in scanner design and acceleration technology[20,22–24], but focusing just on scan 'success' rates provides a limited view of the patient experience of MRI. A key influence for patients is their interactions with clinical staff[25,26]; how well informed they are beforehand, and throughout. A common barrier to providing effective support is time available to clinical staff; not having long enough coupled with pressure to do more[6].

The most common means of preparing patients for a scan so that they know what to expect are through information leaflets and videos[16,27–31]. However, effectiveness is variable[32] and how accurately they reflect what is involved can be limited[33,34]. Other approaches may be to visit a scanning unit ahead of an appointment or having additional time at the appointment[6]. Unfortunately taking time to explore the scan room and familiarise in this way impacts scanning lists.

An emerging solution to this longstanding issue is the use of Virtual Reality (VR) as a means of creating a virtual scan experience that patients can engage with[35] and experience ahead of time, although actual use within the context of MRI is currently low[21]. Immersive VR uses a head-mounted display (HMD) that displays a 3D computer-generated world into which someone is transported[36], allowing them to face their fears in a safe and controllable manner[37]. This allows patients to more accurately experience the sights and sounds involved, replicating a response similar to that in physical reality. Through this, patients could be better prepared and informed on what to expect, with opportunity to practice the experience as much as is needed away from the pressures of a regular scanning list.

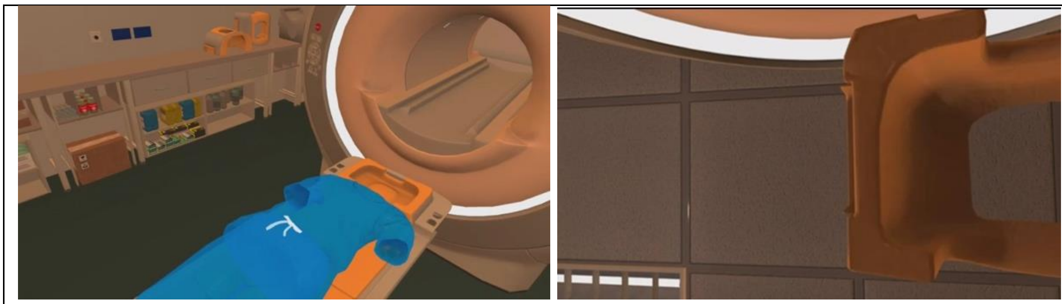
Use of VR within the healthcare setting is increasing dramatically[38], primarily due to advances in HMD technology and software which has helped make it more affordable and accessible[39,40]. Specific to diagnostic radiography, its use has mainly been within simulation-based teaching[41,42], with some use in therapeutic practice to support patient education[43,44]. However, as with opportunities within nursing[45], VR can be integrated into clinical practice to support patient experience and manage anxiety, specifically as a means of informing and educating[46].

How VR is being used specific to the context of MRI is outlined elsewhere[35,47], with a predominant focus on early development and efficacy, or its use within paediatric populations. Whilst current and emerging research focuses on the efficacy and outcomes of VR tools[38], it is important that practitioner views are also sought in order to support effective implementation into the clinical setting[48]. As VR becomes more commonplace its uses will increase, however being readily available is not enough in itself, its integration and ease of doing so into practice needs to be high[49]. Therefore, as part of a feasibility study looking at the use of a virtual scan experience for patients prior to MRI, this study sought the views of practitioners to explore how effective VR might be and how best to implement its use into clinical practice.

Method:

A convergent mixed methods study design was used[50]; comprising a short survey based on the Technology Acceptance Model (TAM)[51] and a semi-structured focus group. Quantitative data was obtained from the TAM survey providing structured scoring on aspects of acceptance, whilst qualitative data was acquired from the group discussions held enabling open responses. Internal approval was received from the lead author's employing organsiation, along with ethics approval from the University of [anonymized for review] Psychology Research Ethics Committee (approved 15 December 2021). Participants were coded to provide anonymity in the results obtained, with only background demographic information obtained (age, sex, area of work, years qualified and years of experience within MRI). Please see figure 1 for information on the virtual experience tool used.

Figure 1: screenshots taken from the virtual tool.



The VR tool studied was developed by Cineon training and based on an actual scanning suite in clinical use. It was developed for a 6 Degree of Freedom standalone VR system for greatest degree of immersion and accessibility, using an Oculus Quest VR headset, with the Unreal real-time render engine to create the software. Sound recordings of a real scanner were also added to enhance the realism of the experience.

Nine radiographers were purposively recruited from within the lead author's organisation, with the intention to recruit representatives from different service areas to capture opinion from a range of clinical settings. An email invitation with additional information was sent to all clinical imaging professionals, outlining the aims of the study and planned focus groups. The inclusion criteria were: employed as an MRI radiographer, aged 18years upwards, working clinically within the organisation, and 3 years plus experience within MRI.

The planned schedule for each focus group is outlined in figure 2. Focus groups were conducted in person at two separate locations lasting 2-3 hours in total. On attendance participants were able to undergo a virtual experience within the VR tool (figure 3) and participate in a discussion about its potential use in clinical practice. The focus group followed a semi-structured interview schedule aimed at encouraging discussion and debate around the VR tool presented, to elicit views on its acceptance, use, areas for improvement and challenges of implementation. The discussion component was recorded and transcribed verbatim. As well as the discussion, participants also completed a survey drawing on the TAM, along with some general feedback scoring based on their experience of the tool in action. The survey was piloted and reviewed by the study's patient and public involvement group to ensure understanding and ease of completion.

Figure 2: Schedule for focus groups.

- **The rationale behind the use of VR:** *provide a summary of context suggesting potential use of VR to support patients attending for MRI*
- **Overview of the tool and how it works:** *video of the tool and instructions on its use*
- **Demonstration of the VR tool:** *with opportunity for all participants to undergo a virtual experience*
- **Completion of questionnaire by practitioners:** *based on Technology Acceptance Model (TAM) along with other general user rating scales*
- **Facilitated group discussion:** *recorded and following the interview guide*

Figure 3: VR set-up

From the range of models and approaches used to look at acceptance in technology, the TAM as a well-established tool[52] was utilised. This was initially developed for software-based information systems[53] and explores the perceived usefulness (PU) ("the degree to which a person believes that using a particular system would enhance his or her job performance" (pg320)[51]) and perceived ease of use (PEU) ("the degree to which a person believes that using a particular system would be free of effort" (pg320)[51]) of a technology. These two constructs relate to the overall attitude towards the technology[54]), impacting on actual intention to use.

Recognised as a reliable tool and useful predictor for technology use and uptake[55], the TAM model has been applied both within the medical imaging field[56] and with VR technology[57]. For this study, personal innovativeness (PI) was also included. This has been shown to be a key factor that could influence perceptions around VR technology depending on one's openness to try out new innovations, having then been shown to directly influence both PU and PEU[57].

Feedback on 1) the degree of realism of the experience, and 2) any negative experience of side effects, such as cybersickness, was also recorded. These could also influence use of the technology[57] and highlight areas directly related to the VR tool itself that warrant improvement to support use. Therefore, for the purposes of this study, the simplicity of the original model[53,58] with the addition of PI and the VR specific constructs[57], was deemed sufficient to provide early insights on practitioner acceptance of the tool in question.

The transcript from the two focus groups underwent a process of thematic analysis[59]; first undergoing descriptive coding, followed by grouping of these codes into related patterns[60]. From this a series of themes and subthemes were generated to best summarise the feedback and views received. One participant from each focus group was then approached to review the themes and interpretations made to ensure they were considered representative of the discussions held.

The TAM survey provided scores for each construct and its component statements, which were summarised using mean and standard deviation in Microsoft Excel. Questions pertaining to realism and cybersickness were summed per participant. Assessment for any correlation between any of the scored constructs was performed using Spearman's Rank Correlation coefficient in SPSS (IBM Corp, v26).

Results:

The characteristics of the nine practitioners participating in the focus groups are summarised in table 1. Representation of both female and male participants was approximately equal (4:5 respectively), however the ratio within the first focus group was more skewed towards male participation due to the logistical issues around attendance. Over half of participants were aged between 35-44 years of age (n=5), with most being qualified over 10years (n=6), and all but one having worked in MRI for at least 6years.

Table 1: Characteristics of Participants

ID	Age Range	Sex	Area(s) of Work	Years Qualified	Years in MRI	VR[@]	PU		PEU		PI		Attitude		Intention to use	Realism	Cyber-sickness
							Mean	SD	Mean	SD	Mean	SD	Mean	SD	Score	Total	Total
VR1	25-34	M	Mobile/ Hospital	10-14	6-9	K	5.5	1.049	4.667	1.033	5.25	0.433	1.4	0.55	5	5	9
VR2	35-44	M	Community	6-9	2-5	K	5.333	1.033	5.5	0.548	5.75	0.433	1	0	7	7	0
VR3	35-44	F	Community	15+	10-14	K	6.333	0.516	6.833	0.408	5.5	1.118	1.6	0.89	7	5	1
VR4	25-34	M	Mobile	6-9	6-9	T	6.833	0.408	6.5	0.548	7	0	1	0	6	4	3
VR5	25-34	F	Community /Hospital	10-14	6-9	K	7	0	7	0	7	0	1	0	7	6	1
VR6	35-44	F	Community /Hospital	10-14	10-14	K	6.833	0.408	7	0	7	0	1	0	7	7	0
VR7	45-54	M	UpRight/ Hospital	6-9	15+[$]	T	5	1.265	4.833	0.983	7	0	1.2	0.45	7	7	1
VR8	35-44	M	Mobile	15+	10-14	K	5.833	0.983	6.333	0.816	5.75	1.09	1.2	0.45	3	6	6
VR9	35-44	F	UpRight	15+	15+	K	5.167	0.408	6.167	0.983	6.25	0.433	1.8	0.84	7	-[§]	-[§]
Averages Overall							5.98	0.78	6.09	0.89	6.44	0.73	1.24	0.3	6.22 *(SD 1.39)*	5.88 *(SD 1.13)*	2.63 *(SD 3.04)*

PU, PEU, PI, Attitude and Intention to use were assessed using 7-point Likert scales, with midpoint being neutrality or indifference. For all by Attitude, ratings were from negative to positive, and so higher scores are more positive in response.

- Realism was assessed by asking how realistic the experience felt and how consistent it appeared with the real-world experience, both on a 5-point Likert scale, measured from not at all to extremely.
- Cybersickness was measured using the simulator sickness questionnaire[61], comprising 16 items rated on a 4-point Likert scale, from not at all to extreme

[$] prior experience in support role within MRI pre-registration
[@] experience and use of VR: K = knows about it, T = has tried it
[§] remote participation and was not able to trial virtual experience

The mean TAM scores and their standard deviation for each participant are also summarised within table 1, with a breakdown for each item measured within each construct provided in table 2. These demonstrate that overall, all constructs scored positively from participants in their perceptions of the VR tool demonstrated, its realism and therefore its potential for use in clinical practice. Figure 4 provides a summary of the adapted TAM used with general feedback scores outlined in table 3.

Table 2: Model construct breakdown summary

Construct	**Items**	**Mean**	**SD**
Perceived Usefulness	The VR tool could enable me to scan patients more quickly	5.56	1.33
	The VR tool could improve my job performance	5.33	1.22
	The VR tool could help increase scan list productivity and throughout	6	1.12
	The VR tool could more effectively prepare patients for scan	6.44	0.73
	The VR tool could make it easier to do my job	6.22	0.67
	The VR tool could be useful in my job	6.33	0.71
	Total	5.98	0.78
Perceived Ease of Use	The VR tool appears easy to learn	6.56	0.73
	The VR tool appears easy to navigate around and control	6.11	1.17
	The VR tool instructions appear clear and understandable to follow	6.22	1.09
	The VR tool appears flexible and intuitive to interact with	5.56	1.42
	The VR tool would be easy for me to build up skill and experience in using	6.11	0.93
	The VR tool appears easy to use within clinical practice	6	1.00
	Total	6.09	0.89
Personal Innovativeness	If I heard about new technology*, I would look for ways to experiment with it	6.67	0.5
	Among my peers, I am usually the first to try out new technologies*	5.89	1.27
	In general, I am hesitant to try out new technologies*	6.44$	0.73
	I like to experiment with new technologies*	6.11	0.93
	Total	6.44	0.73
Attitude Scales	Good ----- Bad	1.22	0.44
	Wise ----- Foolish	1.67	0.87
	Favourable ----- Unfavourable	1.22	0.44
	Beneficial ----- Harmful	1.11	0.33
	Positive ----- Negative	1	0
	Total	1.24	0.3
Intention to Use	I predict that I will use it on a regular basis in the future: unlikely ----- likely	6.22	1.39

Figure 4: The Technology Acceptance Model and mean scores obtained for each construct

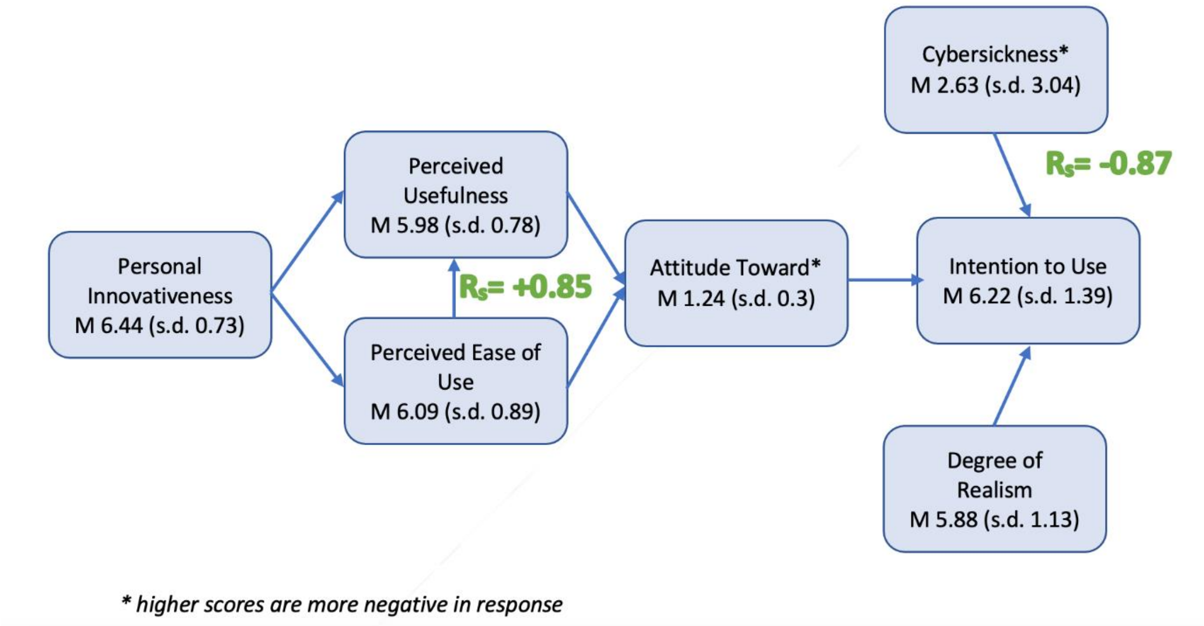


Table 3: Feedback scores

Feedback Question (5-point Likert scales)	**Mean**	**SD**
How realistic was the experience? §	3.125	0.83
How much do you think the experience in the virtual world is consistent with real-world experience? §	2.75	0.46
How safe did you feel using it?	3.75	0.46
How well were you able to tolerate the virtual experience?	3.5	0.46
Movements within the virtual environment were smooth and felt in time with my actual movements	3.625	0.74
The head mounted device was comfortable to wear	3.875	0.35
The head mounted device itself elicited feelings of claustrophobia	0	0
The sound quality added to the experience	3.125	0.64
Overall, I can see the experience being positive and beneficial	3.75	0.46

§*combined to provide the score of perceived realism*

In order to look for any potential correlations or relationships between the assessed constructs in the model, preliminary analysis showed relationships to be monotonic as assessed visually by scatterplots. Therefore, along with being ordinal data, Spearman's Rank Correlation Coefficients were calculated and summarised in table 4.

Table 4: Correlation between variables

	2 - PEU	3 – PI	4 – Attitude	5 - Intention	6 – Realism$	7 – Cybersickness$
1 – PU	**0.845***	0.258	-0.536	-0.085	-0.373	-0.056
2 – PEU		0.294	-0.395	0.288	-0.006	-0.006

3 – PI			-0.549	0.237	0.250	0.250
4 – Attitude				-0.062	-0.331	0.500
5 - Intention					0.524	**-0.872***
6 - Realism						-0.701**

*Significant correlation (p<0.01)
**Neared significance p<0.05 (p=0.053)
$N=8 due to remote participation of one practitioner

Analysis showed there to be two statistically significant correlations; a strong positive correlation between PU and PEU (r_s=0.845, p<0.01) and a strong negative correlation between cybersickness and intention to use (r_s= -0.872, p<0.01). No other significant correlations were noted, although the negative correlational relationship between cybersickness and realism neared significance (r_s= -0.701, p=0.053). Moderate negative correlations are also suggested between PU and PI with that of attitude (r_s= > -0.5).

Finally, as well as quantifying acceptance through the aforementioned survey, the focus group discussions provided opportunity to explore perceptions and views of participants more freely and in more depth. Figure 5 provides a thematic map summarising outputs from both focus groups, with table 5 providing a summary of the thematic interpretations. The resultant themes align strongly with the constructs of the TAM applied, helping to provide context to the scorings provided. Overall discussion was in support of such a VR tool, highlighting areas of strength and weakness, as well as real opportunity for use in clinical practice to help tackle common operational issues and provide enhanced support for those patients needing it.

Figure 5: Thematic map

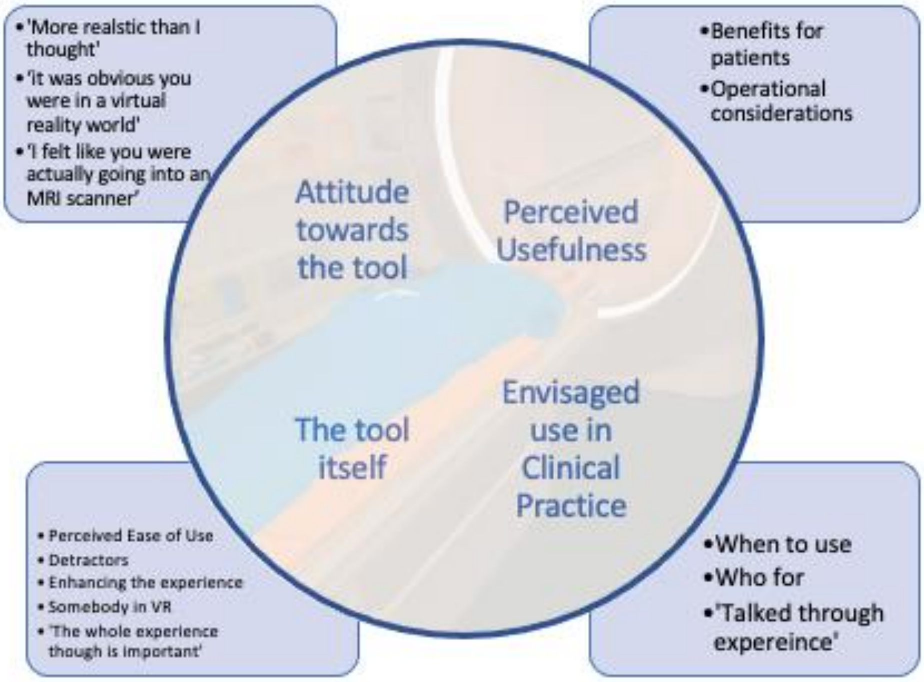


Table 5: Thematic interpretation summaries

Category	Sub-category	Description/interpretive summary
Attitude towards the tool	***'More realistic than I thought'***	Comments from participants were positive and complementary around how similar the virtual experience was to that of a real scan.
	'It was obvious you were in a virtual reality world'	Participants noted that some elements of the experience were clearly not real, but that this didn't really detract from it. *VR3 – I don't think it really matters if they don't think its realistic. I think the important thing is they you get the sensation going into the scanner. The important thing is the feeling in the scanner, isn't it really?*
	'I felt like you were actually going into an MRI scanner'	The overwhelming response from participants was around the sensations felt as a result of the virtual experience, and how they felt embodied and totally immersed within the experience. *VR1 – once you're actually in it, you don't really pay much attention, probably because it's that enveloping*
	Benefits for patients	The perceived benefits for patients were around how the tool provides an alternative means of preparation which can only be positive in being able to cope with a real scan.

Perceived usefulness		*VR3 – patients are really keen to try other options because some patients really don't want medication*
	Operational considerations	Participants highlighted the current challenges seen in practice due to patients who experience claustrophobia and anxiety. They conversely discussed how use of such a tool could help balance some of these issues, but also things to think about for implementation. *VR5 – it seems you guys doesn't have time to spend with us anymore*
Envisaged use in Clinical Practice	***When to use***	Consensus was around use of the tool within a clinic setting in preparation for a scan, either several days before or on the day. The portability of such a tool for use on wards or within someone's home was highlighted as useful, although supported use with a practitioner was considered a requirement as opposed to using alone. Use at country fayres to raise awareness and demystify the scan process was also noted. *VR8 – the whole idea behind VR I would like to think is to try and get someone mentally prepared that this is going to happen*
	Who for	As a tool, it was agreed that it wouldn't be for everyone as not all patients would need it or benefit from it. Discussion was around targeted used and how best to select patients, be that through alerts on referrals or some form of pre questioning to stratify suitability. Whether for those patients with a fear of the unknown or experiencing claustrophobia, or for both scenarios. Specific patient groups that were thought to benefit were paediatrics and those with learning difficulties. It was thought that older patients less familiar with technology may be more hesitant, although as awareness and use of technology continues to increase each generation this will become less of a barrier over time.
	'Talked through experience'	This theme was around how best to use the tool in practice. It was well acknowledged by participants how much the relationship between practitioner and patient was important. Supported use and being guided through the process was considered essential, but this didn't necessarily need to be by a radiographer. Any support worker with suitable knowledge and the right skills could do this. The importance of the role was seen as being around coaching, forming connection, and where possible providing some continuity between the virtual experience and real world one. The virtual tool

		was really seen as a conduit through which patients were prepared and informed, providing opportunity to build rapport and trust with a practitioner in advance of their scan. This would be in a safe place and with time away from pressurised scanning lists, where patients could be listened to and discuss their concerns and methods of coping. *VR7 – have a good radiographer who can talk to the patient*
The tool itself	***Perceived Ease of Use***	Use of the tool was deemed to be easy.
	Detractors	These were aspects of the virtual experience that practitioners criticised.
	Noise	The noise produced during the experience was considered too quiet compared to that experienced in physical reality. Use of headphones would have better replicated the experience and could have been used to increase the noise and be spoken through, as with what happens in practice.
	Motion	Both motion of the scan table and coil placement were considered too fast. A pause in between the table moving up and then in would be useful, plus being able to control table speed to ease patients into position. Similarly, the coil moved very quickly which was thought to be disorientating and again something that happens slower in practice, particularly with those anxious. Being able to control these would be important and allow adaptability to the individual patient.
	Appearance	Due to the way the tool was used, the presence of a headless avatar on the scan table was off putting. The contents of the scan room with bottles and other items lying around were also considered to perhaps be off putting to patients.
	Enhancing the experience	Suggestions made for improvements were primarily around additional components that would add to the experience through more closely replicating what happens in the physical world; such as the use of music, an open scan room door as a means of escape, and a mirror on the coil to see out with. Having an option tailored to the mobile scan environment was also raised due to the additional space constraints in this setting which can add to that feeling of claustrophobia.
	Somebody in VR	It was noted how having someone with you in VR was important, linking in part back to being 'talked through the experience'. In particular having someone place the coil on and perhaps directing the experience from

		within VR. Being able to personalise who that person was could also provide a means of added control for patients or a sense of continuity with who may be seeing them in the physical world. *VR4 – someone directing it as if it was a normal examination would be really nice*
	'The whole experience though is important'	Acknowledgement of the importance of the wider patient journey was made by participants. Not necessarily to experience in the same way, but maybe with additional video or 360° video footage of waiting areas and changing cubicles to help further familiarise them with the process not just the scan. *VR3 – I kind of think sometimes like the who experience though is important*

Discussion:

Feedback from this particular group of participants was overall extremely positive towards the VR tool presented and how it could be of benefit in clinical practice for patients undergoing MRI. Those involved in the study were experienced practitioners with many years of clinical practice between them. They therefore understood the challenges faced and coming from a range of clinical settings added to the different perspectives obtained.

All participants were aware of VR, but only two had used it before, and this was for recreational use (gaming). Despite low actual use of VR technology, the PI of participants was high, which likely reflects a common characteristic trait of those becoming radiographers. With imaging being heavily reliant on technology within daily practice, its use plays an essential part for radiographers and is something they need to be comfortable engaging with whilst delivering care[62]. Indeed within imaging, introduction of new technologies is a continual process which is generally well accepted when it is shown to improve practice and reduce examination times[63,64]. Whilst not found to be significant, PI and attitude did show potential correlation between the two attributes, with a more positive attitude correlating with increased PI, which in turn should support actual use.

Following opportunity to try the experience for themselves, participants thought the technology was more realistic than perhaps anticipated, with any limitations over perceived realism seemingly outweighed by the actual sensations; they felt as if they were actually having a scan. This is counter to reports in the literature of clinical practitioners having raised concerns about other VR applications in terms of the level of realism and whether it is able to replicate a response[65], as well as whether the virtual experience translates across to that in the physical world[49].

Through having their own virtual experiences within the tool, participants raised some important areas which could inform further development – see table 6. Many of these were related to attributes of the virtual experience that either varied from, or did not reflect, what was seen in their own areas of practice. Whilst the tool was based on an actual working clinical department, there is of course variation in design and setting, and between scanner manufacturers and age, which make one universal tool a challenge to achieve. These feedback themes all have merit and provide opportunity for the VR development team to further enhance their tool.

Table 6: Open feedback summary

- The speed at which the scan table moved, and head coil was placed on, were both considered too fast, which in turn could be a cause of concern or exacerbate any fears for anxious patients.
- Avatar – having an avatar radiographer in the scan room explaining the procedure was raised, perhaps most notably around when coil placed and it not just appearing, which was also noted as being too fast.
- Mirror on coil to be able to see out or give the impression of seeing out.
- Noise was most commented on aspect which reduced realism – possible use of headphones would get around this. Whether different scanner sounds could be introduced.
- Appearance of the headless body on the table when needed and not always there.
- Being able to observe a patient avatar go through the process.
- Usefulness of being able to observe entry to scan room before then lying down.
- General appearance of scan room and scanner being cluttered, clinical and dark. Opportunity to improve and make it feel less alien.
- Having scan room door open helps patients in VR feel like there is an escape.
- Inclusion of some breathing or mindfulness relaxation techniques incorporated over noises when in scanner to teach a coping strategy.
- Opportunity to develop a version within a virtual mobile scanner setting where space is less and can be more claustrophobic.

One aspect that appeared to detract from any perceived realism, and was shown to negatively impact on intended use, was that of potential cybersickness symptoms. Two of the three respondents noting elevated scores wore glasses, which were taken off when using the tool due to the constraints of the HMD. This could therefore be the cause or exacerbation of cybersickness symptoms. That said, as a practitioner, use of the virtual tool would be more as a bystander whilst a patient is immersed into the virtual world.

The tool itself was considered easy to use with the lowest scoring construct still being over five, concerning its flexibility and intuitiveness of interaction. Within the TAM, PEU was found to strongly correlate with PU, which is something that underpins the model with PEU often influencing PU[53]. Whilst participants were able to take control of each other's interaction with the virtual tool, the overall set-up had been done in advance and so their experience of this was limited which might reflect the views noted.

An important aspect that was highlighted was around the headless virtual body on the scan table. This was a result of how the tool was used compared to its intended design, with participants entering through the scan room door in order to experience the full journey to the table rather than just entering on the scan table where the body would be. This modification in use was in recognition of the importance of the whole patient journey and wider triggers of anxiety, not just coil placement or positioning into the scanner itself. The intention of the avatar on the table is to be able to enhance the feelings of immersion and presence within the virtual world, so that those in the experience feel embodied within it. In other studies, not being able to see your own body has been noted as a factor for reducing this[66].

As well as having their own body in VR, the importance of having a radiographer present within the VR environment was also raised as important in terms of replicating normal practice. Again, there is a video exert of a radiographer explaining the procedure behind the scan window within the tool, but this was viewed as insufficient. It was felt that having some form of avatar within the actual scan room would be better, in particular when it came to lying down and placement of the coil. This is supported by other findings in the use of VR specific to claustrophobia, highlighting the importance of virtual humans within the environment which could even be personalized by the individual[67].This then offers the patient some control over their experience.

The PU of the tool was also high and whilst only a significant correlation with PEU was found, has been shown to be a significant predicator of intended use[55]. The highest scoring PU construct was around the tool an effective means of preparing patients prior to a scan. This was also supported in the structured interviews where participants noted the benefits for patients as a more effective means of helping them to cope with a real scan. Use of VR as a means of informing patients about what to expect has been shown to improve understanding and in turn satisfaction, whilst also reducing anxiety[46,68,69]. It also supports patients by being able to experience what a scan is like beforehand, with the tool realistically replicating the sensations of a scan and awareness of the environment, which can appear alien[68]. In practice, being able to acclimatise to the scan environment and try positioning beforehand is considered effective but is currently underutilised due to time constraints[6]. Unfortunately, this lack of time in practice to be able to provide person centered care is a common barrier[25], with one participant in particular noting patients often commenting that *it seems you guys doesn't have time to spend with us anymore* (VR5).

Therefore, the use of a virtual experience was seen as a means of being able to spend time preparing patients away from busy scanning lists, where they could be talked through the experience and given the time needed. The importance of the practitioner-patient relationship was a particularly strong theme throughout both discussions, with the need for connection, building rapport and trust noted. Both groups confirmed that this did not necessarily need to be with a radiographer, but a well-trained imaging support worker, who already often prepare patients in practice, would be suitable. It could be argued though, that it is key that there is some continuity for patients, so that whoever supports the virtual experience is perhaps also present for their experience in the physical world.

As well as these benefits for patients, another aspect considered beneficial operationally was related to productivity and throughout. There was a view that having patients better prepared would help scanning lists run efficiently as less time would be needed to explain the procedure and provide reassurance. Nevertheless, it is important to note that some level of emotional support will always be needed depending on the individual. Where a 360^{o} virtual experience has been used[68,69] it has been found that patients had less questions and more successful examinations, which in turn helped support efficient running of scans which kept appointments to time.

An important consideration raised in discussion was related to when to use VR and for which patient group(s). Predominantly it was felt that use within a clinical setting would be most advantageous, although with the HMD being portable and containing the required software, it could be that use at home, or even on the ward was possible. As for whether it was a tool for every patient, it was agreed that not every patient would need or benefit from it. Therefore, some means of identifying those patients who may find it beneficial would be needed, perhaps from alerts by referrers or as an alternative to those requesting anxiolytic medication. Other patient groups who may benefit from such a tool were also identified, with use of similar VR experiences in paediatrics being well reported[70–73], as well as offering potential use for autistic patients where undergoing MRI has been highlighted to be of particular challenge[74]. Use of such technology in elderly patients was considered to be less accepted, although as awareness increases within the general public and over each generation, this will become less of a barrier as public acceptance of the technology in general increases[65].

One final area of potential use of such VR simulations is in clinical training[66,75]. Such use would provide those new to working in the modality opportunity to experience the scan environment and sensations of having a scan. This could in turn enhance empathy as they better understand the perspective of their patients. VR for supporting empathic communication skills within MRI has already been shown to improve staff interactions[76]. If coupled with a virtual in-scan room experience, together this could form a powerful tool for improving staff performance, already well acknowledged as critical for MRI exam success[15,77–79].

Finally, whilst responses in this study were predominantly positive towards use of VR within MRI, there are important wider barriers that have been raised in other studies that warrant consideration. Concerns over cost and lack of clinical efficacy have been cited as barriers to VR use in clinical practice[37,67]. However, with the ongoing development and affordability of consumer VR technology, concerns over cost and technical use are less than they once were[49]. Likewise, as VR becomes more commonplace, lack of skill or experience in being able to use VR technologies will become less of a barrier within practice[65]. Perhaps the main limiting factor at the moment remains the space required in which to use VR[66,67], as clinical space within imaging departments is typically at a premium.

Limitations & Strengths

The main limitation with this study is the small numbers of participant views sampled which impacts on the relevance of any statistical analysis and generalisability of the findings. It is also important to consider that this is feedback on one particular VR tool, and not all comments will be representative of other similar interventions. Those volunteering to participate may also have a natural interest in both use of technology and in provision of patient centered care, thereby potentially providing a biased view that may not be representative across the wider profession.

Due to logistical issues at the time of the focus groups, the first session lacked the intended representation from specialist UpRight scanner services, as well as a disproportionate split between male and female representation. This could have influenced the discussion held within the group. The overall gender split was also misrepresentative of the radiographic workforce as a whole[80] which is a consideration and may impact wider views on uptake.

Whilst presence and immersion are both important aspects of any VR tool, this was not measured directly as part of the feedback or as a construct within the TAM used in this case. Nevertheless, through the thematic analysis it would appear that this was considered high by participants.

Conclusion:

With the ongoing introduction of technology within healthcare, and specifically accelerated evolution within medical imaging, the views of those using such technology are essential for its effective implementation and integration into practice. The key consideration from those working in imaging is that any new technology should be patient focused, with its use helping to improve care[62]. But also, in this particular context 'acceptance of VR depends on each person's characteristics and perception and attitude toward VR use' (pg3)[45].

Results from this study were in overall support of a VR tool that helped prepare patients prior to undergoing an MRI scan. The tool was considered realistic, representative and easy to use, with some areas highlighted for improvement. In particular, access to such a virtual experience was regarded to be of use to better prepare and inform those patients needing extra support beforehand. There was strong acknowledgment on how important building connection with patients was and how this was hindered in practice by not having enough time to discuss patient concerns. Therefore, use of such a VR tool could be a conduit through which trust and rapport are built in advance away from busy scanning lists, thereby not impacting on operational throughput and hindering efficiency.

Is it perhaps a good example of how technology could be used to positively improve the building of human connection within healthcare. Nevertheless, such technology is not something needed by all patients and so a means of suitable selection would be needed to ensure the intervention is targeted to those most in need and likely to benefit. Feedback obtained from practitioners will hopefully support development of the VR tool itself, as well as guide how it may begin to be implemented into practice.

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