

Is Functionality All That Matters? Examining Everyday User Opinions of Augmented Reality Devices

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ABSTRACT

How users feel towards Augmented Reality (AR) is often shaped by the context of use. This paper reports from a study with 112 participants on how users experience AR in everyday situations. The respondents in an online survey were queried about comfort, aesthetics, functionality, privacy, and physical limitations. The responses revealed a range of opinions, from general enjoyment to key issues and features that users are concerned with, such as pain and tiredness, device size, social acceptance of AR devices, and accessibility. Considerations for future work regarding these issues are discussed. These include balancing functionality with appearance, involving a variety of users in the design process, and focusing on devices that the everyday person is likely to use. Overall users appear keen to see AR device improvements resulting in more practical and accessible devices.

Index Terms: Human-centered computing—User studies; Human-centered computing—Mixed / augmented reality;

1 INTRODUCTION

There has been extensive research on how users experience augmented reality (AR) applications [8, 12, 15], however there has yet to be a full exploration of how everyday users feel about the devices that these applications run on. Existing surveys on AR technology mainly focus on AR research and technical requirements [14], advances, and applications, with little focus on everyday user opinions of the devices used to experience AR.

A systematic review of AR usability studies [9] suggested that more user studies “that report on how people naturally use AR applications” are needed, and also noted that diversifying participant populations would be beneficial, as previous user study participants are mostly young and educated males. These suggestions become more relevant as the popularity and use cases of AR increase, so that research conclusions accurately reflect the population. It is important to note that the papers reviewed focused on specific applications and contexts, and while this is valuable work for the associated fields, the results cannot be applied to everyday AR users.

1.1 User Opinions

There have been several concerns with augmented reality expressed on social media and blogs, such as problems or concerns with user’s hair [2, 3] and makeup [4, 5], device cosmetics [3, 10], convenience [1], price [3, 10], field of view [10], privacy [10], discomfort [13], and injuries [7]. These concerns have not been explored in the previous research mentioned, which instead focus on the user experience of the applications. While currently unexplored with AR, online articles, and academic research [11], discuss how notifications can cause distractions and interruptions, even when they are

important. In order to design devices that everyday users will use, these obstacles should be fully researched and addressed.

2 SURVEY

While there are existing methods of evaluation for devices [6], these do not go into detail about the experiences and problems of everyday users. Therefore the previous user opinions mentioned were gathered, and a selection of questions surrounding these created. These questions focused on: device cost, the effect of wearing glasses while using a device, the effect of the device on hair styles and makeup, the device’s appearance and comfort, any injuries resulting from using the device, the device’s field of view (FoV), data collection, and notification use. A final question asked for any further comments regarding the device. Each question contained two parts: a 5-step Likert-scale to determine how much a participant had experienced any issues, from ‘Not at all’ to ‘Very much’, and an optional open question for participants to detail their experiences. Combining qualitative and quantitative parts in this way offers a deeper understanding of the overall user evaluations.

2.1 Structure

The survey began with an introduction, followed by demographic and AR usage questions. Demographics included: age, sex, country of residence, and if a participant wears glasses. The AR usage section asked what devices a participant had used for AR, split into the following sections: smartphone/tablet, headset, AR glasses, other, and no AR use. These answers determined what questions participants were shown for the remainder of the survey, in order to limit the length, e.g. participants who do not wear glasses were not shown glasses related questions. Participants were shown the mixture of Likert-scale and open questions previously discussed for each device they selected. If a participant said they had not used AR, they were instead shown a list of optional reasons for why they had not used it, with an additional open question for further clarity.

2.2 Dissemination

Users were encouraged to take part in the survey no matter their AR experience. Participants were informed that the survey would take between 10 and 30 minutes depending on the extent of their AR experience, and a prize draw of two £25 Amazon gift cards was used to encourage participation.

A recruitment message with the above information and the survey link was shared through a variety of channels in order to gain a broad picture of the different everyday users of AR devices. This included several social media platforms and mailing lists.

2.3 Participants

A total of 170 responses were recorded between May and November 2020, however only 112 were included in the analysis. Of the 58 excluded, 3 participants did not consent to taking part, 17 did not complete more than the demographics and background use sections, and 34 did not complete any further sections. Two responses were

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poor verbatim (containing incoherent text), and a further two responses were irrelevant (containing text that was not relevant to the topic).

The 112 participants consisted of 55 males and 57 females. Exactly half of the participants wore glasses (56), and the 112 were distributed across age groups as follows: 44 18-24, 36 25-34, 18 35-44, 9 45-54, and 5 55+. Participants lived in various countries, with 58 in the UK, 23 in North America, 16 in other European countries, 10 in Asia, 3 in Australia, and 2 in South America. Overall the participant demographics demonstrate a variety of everyday users.

3 RESULTS

Of the 112 participants, 39 (34.8%) had used more than one kind of device for AR, and 22 (19.64%) had never used AR before.

3.1 Smartphone/Tablet AR Users

Many of the participants (77, 68.8%) had used AR on a smartphone or tablet, where 44 (57.1%) of these wore glasses. Of these 44, 25 (56.8%) did not experience any issues with comfort when wearing glasses to use AR. The remainder experienced issues such as general discomfort, not being able to wear their glasses while using AR on the device, and experiencing discomfort or pain where a smartphone addition such as Google Cardboard added pressure on contact points (nose bridge, behind the ears). There were also minor concerns of glasses steaming up or damage to the glasses occurring while using AR.

The majority of participants had not experienced any makeup (66, 85.7%) or hair (55, 71.4%) related problems while using AR. Of those that did, one participant noted that they have seen makeup wearers *"refuse to use"* AR, and two others had noticed makeup transferring to the device in use. Problems with facial and hair recognition were noted, particularly with curly hair.

In terms of the appearance of the device, 14 participants said the size was important, where they would be unlikely to carry around a large and bulky device, such as a tablet, and enjoy that a smartphone is *"invisible"*, *"lightweight"*, and *"fits in [their] pocket"*. There were some concerns that *"Holding a device for AR use might attract attention of others and might not be socially acceptable in some environments"*. Three participants noted that *"Functionality matters more than appearance"*, where functionality referred to screen size, camera quality, and general ability to run AR applications.

When asked about discomfort while using AR, 38 (49.4%) participants stated that they had not experienced any. The discomfort issues noted by the other 39 participants discussed fatigue or tiredness (17 participants), that *"Holding out the phone is uncomfortable."* or *"awkward"* (7 participants), environment issues such as low light meaning the AR content does not *"manifest"*, busy areas, and slipping on poorly maintained pavements. Ten participants noted that the discomfort is due to the device being *"too heavy for long-time usage"*.

Nearly all participants had not incurred any injuries while using AR (70, 90.9%), however five participants noted they either found themselves *"running into things"* as *"concentration on what is in front of you can be an issue"*, or damaged their phone. One participant mentioned that *"a friend got mugged while playing pokemon go"*.

When describing the device's set up process for AR, 57 (74.0%) participants found it *"easy"* and *"intuitive"*, whereas some participants experienced calibration problems (3), battery problems (1), found it lengthy (4), or found installing apps inconvenient (3), while one participant found printing AR markers *"a total pain"*.

Participants had mixed views on this device's FoV. Nineteen participants noted it was limited to their phone screen, with five participants further explaining that this meant the AR *"didn't feel very immersive"*. Six participants explained that they had to move around a lot to see all of the AR content, one noted that *"it's easy*

to lose track of what's going on around you" when using AR, and seven felt that there were no problems with the FoV.

Privacy concerns for these participants were minimal, although 12 had concerns with how the data was collected and stored, who had access to this, and how advertisers may use it. Four participants felt that *"Sacrificing privacy seemed like the cost of entry"*, while 38 (49.35%) participants did not have any concerns.

When asked about any movement limitations they may have experienced, nine participants mentioned using AR with a smartphone or tablet limited the use of their hands, and five said that the battery limitations meant that you *"need to stay within range of somewhere you can recharge your device"*, or carry a power pack, however 46 participants (59.7%) did not experience any movement limitations.

Participants again had varying experiences with notification disruptions, where 41 participants (53.3%) either received no notifications, or felt they didn't impact the AR experience. Other participants found that notifications disrupted or covered the AR (6), caused them to click off the AR accidentally (1), or were distracting (2). Four participants would manually block notifications or turn their phone on do not disturb to avoid any disruptions while using AR.

When asked for any further comments, one participant noted that they *"don't think phones are a very good way to experience immersion, but they do make it very accessible."* A further five participants shared that this is an accessible and affordable way to experience AR, with four mentioning they did not find it immersive.

3.2 AR Headset Users

A third of the participants (37, 33.0%) had used AR on a headset, such as the Magic Leap, Hololens, and Oculus headsets, where 21 (56.8%) of these wore glasses. Of these 21, only 3 (14.3%) did not find that wearing glasses affected their comfort when using an AR headset. Issues described by participants included being unable to wear glasses with the headset, the headset not fitting properly over glasses, and experiencing an increase in discomfort or pain on pressure points such as the nose and head.

Of the 37 participants who had used a headset for AR, 20 (54.1%) did not own one. All of these participants said the headset cost would limit their use of AR headsets, with comments such as *"the cost of the headset should not be above limits of an ordinary people"*, *"I prefer cheap devices"* and general comments on being unable to afford expensive headsets.

When asked about hair and makeup, 25 participants (67.6%) had experienced no issues with makeup, and 17 (46.0%) had no hair related problems. Those who did experience problems described the headsets becoming dirty with makeup transfer and/or the headset disturbing their makeup, while some detailed that they cannot wear makeup if using the headset, or experienced discomfort when their eyelashes touched the headset lenses. Those who had hair problems with a headset described difficulties with putting the headset on with certain hair styles such as ponytails, buns, and clips, and found they would need to fix their hair after using the headset. Some participants wore specific hair styles to avoid this if they knew they would be using a headset, while one participant felt they *"look extra silly with the device on"*.

The appearance of a headset ranged in importance among participants, where 10 (27.0%) felt the appearance would not limit their use of a headset. Six of the participants suggested that a headset *"is always attracting unwanted attention"* or is *"Kinda silly looking"*, however two suggested that the headset appearance would depend on the use purpose and surrounding environment: *"For example if it was to be used indoors then the bulkiness doesn't matter so much but if used outdoors then perhaps as a wearable device it would be important to have something more streamlined to the face"*. Eight felt that the weight of the device was particularly important, and four felt that comfort while wearing the device was important.

Thirteen (35.1%) of these participants experienced various kinds of pain and/or strain while using a headset that they felt may limit future use of the device, in places like the neck, eyes, head, shoulder, arm, and ears, however 12 (32.4%) participants did not experience any such discomfort. The majority of these 37 had not received any injuries while using a headset for AR (31, 83.8%), and those that did were only minor injuries such as hitting a wall or the headset weight causing their nose to bruise.

The set up process of a headset for AR was found to be too long by five participants, while others found it too complicated or had never set a headset up themselves. Eleven (29.7%) participants did not have any problems with setting a headset up for AR. Ten participants found the FoV too small or limiting on a headset, while others felt it was *"pretty good"*. Many (22, 59.5%) users did not have any privacy concerns about using a headset, though three had concerns *"that it may be looking at my surroundings via the cameras"*. One participant took precautions to limit what of their background could be seen by the cameras.

There were several movement limitations experienced by participants when using a headset, such as wires causing trips and needing to *"look down explicitly to carefully watch my step"*. One participant who had used the Magic Leap explained that *"If you're a woman then you often don't have pockets for the device to rest on and things start to get awkward"*, while another mentioned that they cannot use their headset outdoors.

Most participants (29, 78.4%) did not have any notifications disrupt their AR experience, however a small number described *"Messaging and alerts interrupted the immersive experience"*, or that they found the notifications received helpful, such as *"friends inviting me to games or games finishing downloads"*.

When asked for further comments, participants mentioned *"Hygiene concerns when sharing the headset or viewing demos"*, that they thought the designs should be improved for mainstream use, and that current devices are *"not good enough for any practical purposes"*. Two participants noted that they found the headset format fun and would recommend it to others.

3.3 AR Glasses Users

Ten participants (8.9%) had used AR glasses, such as the Google Glass, Vuzix Blade, and Bose Frames. Half of these participants wear standard glasses daily, and all noted comfort issues. Participants needed to remove their standard glasses to use the AR glasses, leading to blurry vision. One participant explained that the AR glasses could not be adjusted, where *"They were too big for my head and the distance between the lenses/glasses for each eye was not suiting my eyes"*.

Six of those who had used AR glasses did not own any, and expressed that they were too expensive for the functions available, or did not last long enough to be worth the cost. One participant pointed out that they *"would be willing to pay a lot more for AR glasses than for a headset. But they would need to work with my current prescription and not need to be replaced when that prescription changes"*.

None of these participants experienced any makeup related problems, and only one participant expressed concerns when having a specific hairstyle that some AR glasses may have difficulty with. When thinking about the appearance of AR glasses, some participants thought *"They would need to look almost like normal glasses"*, while one participant was only concerned with the weight of the device and how this affected long-time use.

In terms of discomfort, one participant experienced arm ache, while another experienced *"buggy"* glasses that resulted in them needing to turn their head a lot. Eight participants did not have any injuries while using AR glasses, while the remaining two did not detail their experiences.

The set up process for AR glasses did not work for one participant,

however four had no problems, while the remaining participants did not detail their experiences. For the glasses FoV, three participants found it limited and difficult to see all of the AR content at once, while four participants had no issues. Eight participants had no privacy concerns with the AR glasses, while the remaining two did not comment on their concerns.

Participants had mixed opinions on movement limitations, with three experiencing no limitations, but only one detailing that they *"had to hold them sometimes in order to not let them fall"*. Seven participants did not have any disruptions from notifications, while one participant found the devices tutorial tips frustrating. When asked for further comments, one participant stated that the AR glasses needed a head strap, and another noted that *"a lot of improvement needs to be done in order for people to use them"*.

3.4 Other AR Device Users

Four participants (3.8%) had used other kinds of AR devices. Due to the low participant number, all comments from the questions asked have been gathered together. One of these participants experienced a headache and nose pain while using a laptop related AR device. Another participant who has used AR on a Nintendo DS had concerns about the device's fragility if *"moving about and not paying too much attention to my real surroundings"*.

3.5 Users with no AR experience

The reasons that the 22 participants gave for not using AR are outlined in Table 1. The further comment detailed that the participant finds AR *"too clunky, or too distracting"*, but that they would be more open to using AR *"if it becomes more streamlined and subtle in the future"*.

Table 1: Reasons participants selected for no previous AR use

Please select all of the following that you believe has prevented you from experiencing augmented reality:	N
I do not have access to augmented reality devices or applications	13
The cost of the device(s) is too much	10
Augmented Reality looks uncomfortable	2
I do not want to experience augmented reality	3
I have not had the chance to experience augmented reality but would like to in the future	13
Further comments	1

4 DISCUSSION

When considering the quantitative answers, summarised and compared in Figures 1, 2, 3, 4, and 5, we find that participants' main concerns are around comfort when wearing glasses while using AR, the appearance of the AR device, general discomfort, the FoV for AR content, and to a lesser extent, movement limitations, although the concerns do vary with each device. Participants expressed less concerns with hair and makeup problems, injuries while using an AR device, how their data was used, and notification disruption. The qualitative answers allow us to gain insight into these differences, and understand how common a problem may be in everyday activities. Overall the results demonstrate a range of everyday problems encountered when using AR, with some suggestions from users on how further AR adoption for everyday use can be encouraged.

4.1 Users Who Wear Glasses

Of the participants who wore glasses (50%), many had experienced some kind of discomfort while using AR. Smartphone users had the least issues, while AR glasses users understandably had the most. The common concerns of pain on contact points, and being unable to wear their glasses, suggests that future designs should pay particular attention to the pressure that a device applies, or offer prescription lens options that would then avoid any pressure on contact points.

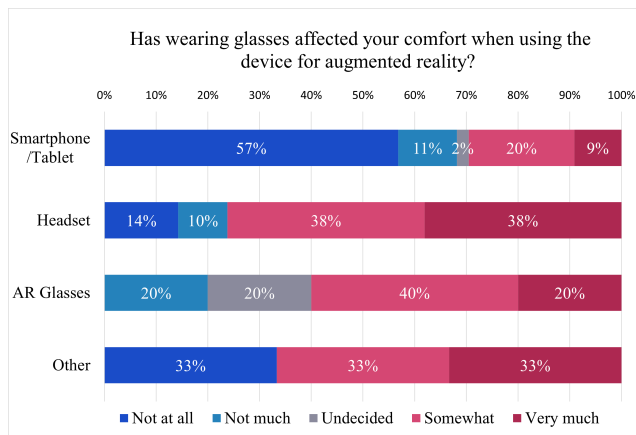


Figure 1: Comparison of the comfort Likert-scale ratings for those who wear glasses across the four device sections.

4.2 Hair and makeup

Concerns for hair and makeup were mostly observed in headset users, although the voiced concerns remained the same across all device categories. The transfer of makeup to the device on contact, which therefore disturbs the makeup style, and problems with wearing a device or the device's recognition due to various hair styles, can be difficult to address. One of the further comments on hygiene

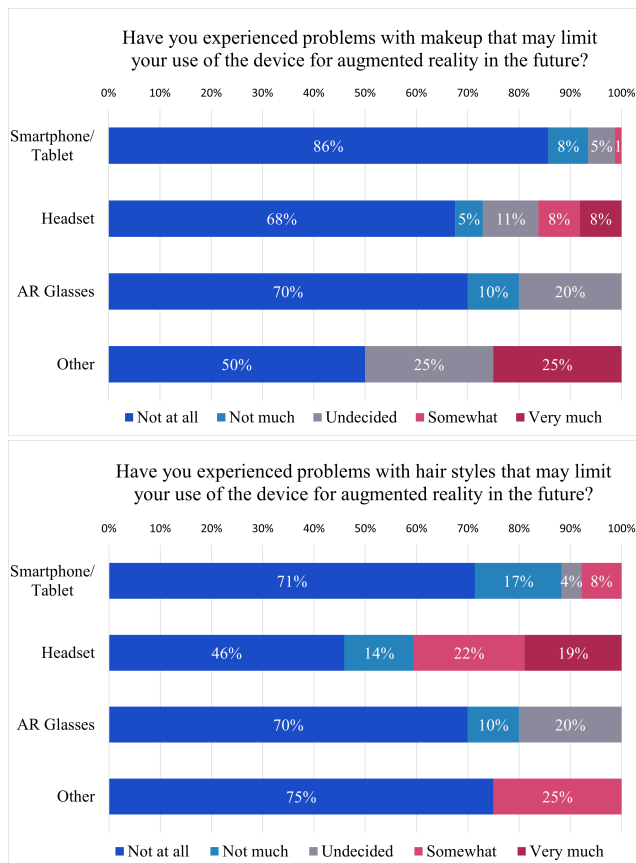


Figure 2: Comparison of the hair and makeup Likert-scale ratings across the four device sections.

concerns when sharing a headset also belongs here. Some partici-

pants find it reasonable to adjust their style and clean the headset after use, while others find this undesirable. An AR device that does not touch the head might be suitable for these users, although the small amount of smartphone concerns in this area suggests further research is needed on how to incorporate a users individual style into a device.

4.3 Discomfort, Injuries, and Movement Limitations

At least 50% of participants for each device experienced some form of discomfort, while the number of movement limitations varied, and the number of injuries while using AR with any device was low. Common discomfort issues included tiredness and pain related to

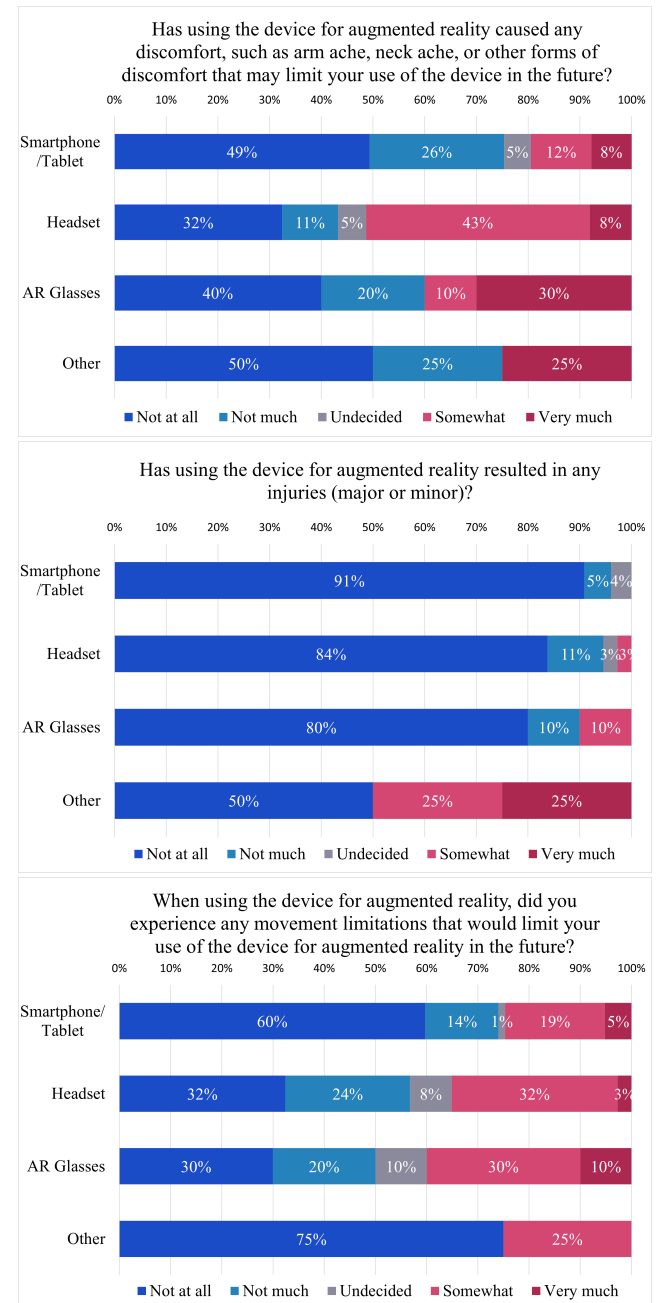


Figure 3: Comparison of the discomfort, injuries, and movement limitations Likert-scale ratings across the four device sections.

holding or wearing a heavy device, with some cases of eye strain. This suggests that current AR is not suitable to use for more than a short usage time in everyday situations, as everyday users are not adjusted to the prolonged use of technologies.

Movement limitations included limited use of hands with large devices, reduced areas that participants could travel with the device in due to battery limitations, and participants that need to take care where they walk due to device wires and hazards in the surrounding environment. Although some AR software address these issues, e.g. Pokemon Go has hazard notifications and warnings, and wireless devices are becoming increasingly common, perhaps these can be considered in more depth in future device designs.

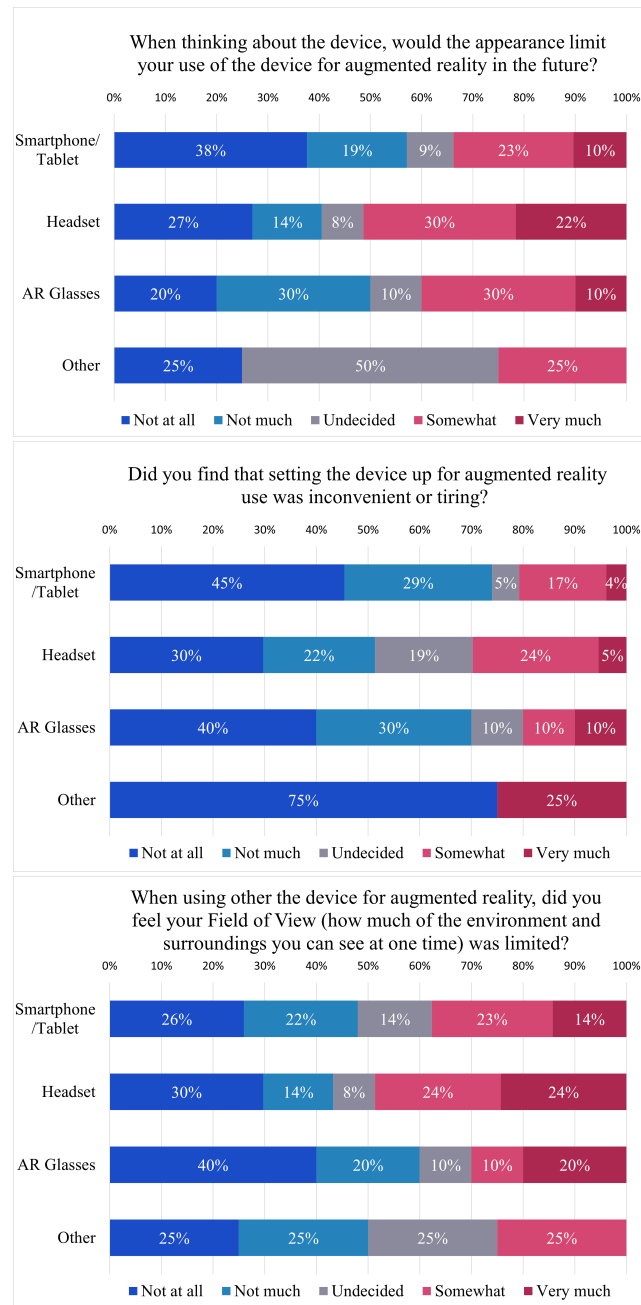


Figure 4: Comparison of the device appearance, set-up process, and field of view Likert-scale ratings across the four device sections.

4.4 Device Appearance, Set Up Process, and Field of View

The appearance of the device appears quite important to users. Frequent comments included participants preferring smaller and lightweight devices, as bulky and heavy ones are taxing to carry and wear. The device appearance is also important in terms of social acceptability, as users do not want to draw attention to themselves.

This is a particularly important concern for future device designs, as it is clear that while an AR device can function well, it will not be used a great deal in society if it doesn't fit in to everyday attire. Some participants did not hold this opinion, preferring functionality over appearance, however these were not in the majority.

The set up process and FoV for each of the devices had varying opinions. Calibration problems and complaints of lengthy processes were reported, with small field of views that limit how much content you can see at once also acknowledged. These concerns will hopefully be alleviated as technology progresses.

4.5 Privacy and Notifications

There were not many privacy concerns with any of the devices, yet a number of participants were worried about the collection and use of their data. These may be able to be addressed with a boost in transparency from companies that make these devices, however the majority of users appear to accept that their data will be used.

Notification disruptions appear to be a minor concern, and understandably appears mostly on smartphones. Although this is a software issue, it appears that a number of users would welcome a feature that automatically paused notifications while using AR.

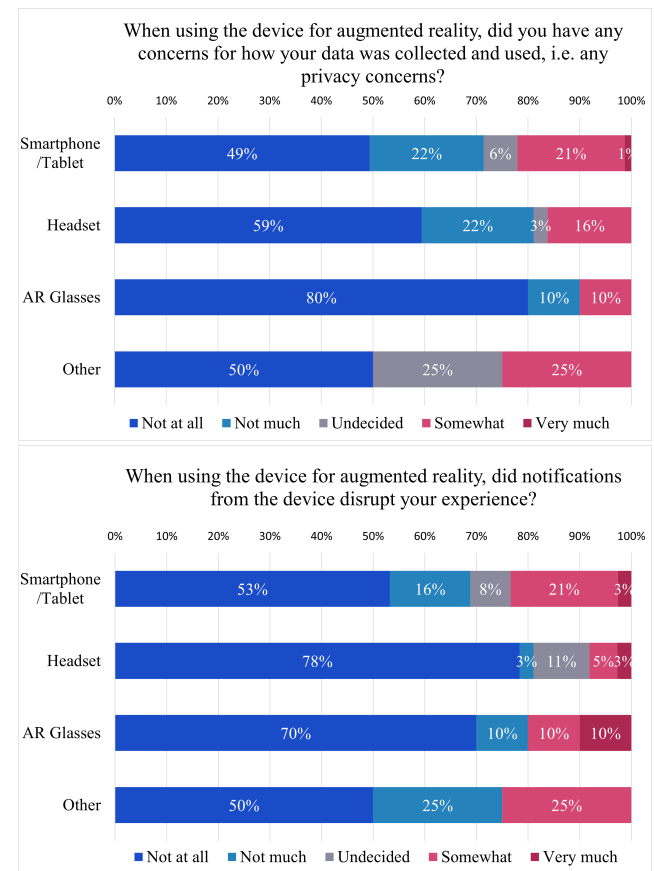


Figure 5: Comparison of the privacy and notifications Likert-scale ratings across the four device sections.

4.6 Users with no AR Experience

The answers given by participants for why they have not used AR suggests that there is hope for a future increase in adoption. Only a few participants had no desire to use AR, with more than half expressing that they would like to experience AR. As prices for AR devices decrease in the future, and become more socially acceptable to use in public spaces, the opportunities to access AR will increase.

5 FUTURE WORK AND CONCLUSIONS

The survey used in this study gives a brief overview of everyday user opinions on AR devices. It may be advantageous for future opinion studies to narrow down the focus to a specific user concern, in order to limit the study length and therefore gain more in depth opinions and experiences from participants. This would allow more detailed questions to be asked, in order to limit different interpretations and gain more exact opinions on a specific issue, however the broader questions in this study were favourable to gain a wide overview of these fairly new concerns. From the results of this survey, a focus on users who wear glasses, general discomfort and movement limitations, and/or device appearance would be beneficial, as these were the areas with the most noted concerns. Moving forward it would be valuable to construct a standardised questionnaire that considers these everyday occurrences, that could then be used alongside existing measures during various AR user studies. This would provide a useful way to determine if well-functioning AR devices are suitable for day-to-day use. Ensuring that these studies contain a diverse participant population is crucial to gain an accurate sample of the assorted opinions of everyday users.

Although minor differences were observed between groups in this overview, such as styled hair and makeup problems seen more among females than males, and those who wear glasses experiencing more problems with comfort and general use, further analysis to determine any differences between age groups and countries should be performed. It would also be advantageous to gain more opinions from AR glasses users, however the device user distribution does reflect on how commonly each device type is used in everyday life. From the comments offered in the survey, it is clear that users are looking forward to improvements in everyday devices used to experience AR, so that they are more practical and accessible for all. It can only be assumed that these improvements may lead to wider adoption of AR, which can alleviate concerns around the social acceptability of these devices, however it is important to continue investigating why some do not use AR. The divided opinions on how much the appearance of a device matters as opposed to its functionality suggests that these aspects should hold equal importance in future designs and research. Lastly, the range of opinions expressed in this survey demonstrates that a diverse set of users should be involved in future research and the design process of AR devices, as they can provide unique everyday experiences that can improve the overall designs of AR devices.

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