# Perceptions of Colour Pickers in Virtual Reality Art-Making

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## ABSTRACT

Virtual reality art is reshaping digital art experiences, especially with the recent release of multiplayer 3D art applications, but may elicit different first impressions across different age groups which can impact their uptake. In particular, popular colour pickers based on HSV colour spaces may appeal differently to younger and older adults. We investigate first impressions of colour selection when shown with a discrete picker or a continuous HSV picker via an online survey with 63 adults and 24 older adults. We found that the discrete picker was seen as having more positive hedonic qualities overall; there were no differences between perceptions of adults and older adults. We discuss the implications of our findings for colour selection tools in virtual reality art-making.

## Keywords

Colour selection, Colour picker, Colour palette, Virtual reality, VR art, Creativity tools

## 1 INTRODUCTION

First impressions are crucial in determining the likeability and thus adoption of a design [Gro16]. Given that a tool's aesthetics influences the user's perception of its utility and formation of the user's persistent attitude towards the tool [HT06, JWTY16, YKW22], it is critical to understand how features impact users' understanding, emotions, and expectations the first moment they are perceived. While there is a substantial body of research on virtual reality (VR) and its use for art making [HBM23], there are limited studies that explore factors that influence the first-impressions of VR art experiences.

Virtual reality can provide rich visual experiences and transferable skills [WFS97] as well as control over dynamic environments and measurements of responses [SR01]. Thus, it has been utilised for art and performance in hobbyist and therapeutic contexts, across age groups [Uge21]. A core function in digital painting is selecting a colour from a colour palette.

Most colour pickers in digital painting combine continuous and discretised subsets of 3D colour spaces such as HSV (Hue, Saturation, Value) and RGB (Red, Green, Blue). Novel colour pickers such as Brushwork's 2021 application [Sun22] offer discretised colours that can be mixed. A study of older artists found that some had reservations in engaging with VR art, and when they did, they had a passion for selecting the 'right' colour but had challenges in using the HSV picker to do so [AWL21]. It is not yet known how initial perceptions of discretised and HSV pickers impact impressions of VR art, in particular across age groups.

In this study, we investigated the first impressions of VR art colour pickers. We expand on preliminary results previously published as a conference poster [AWL22]. Our research question is:

> *What are perceptions of a discretised colour picker and HSV colour picker for adults (<60 years) and older adults (60+ years)?*

## 2 RELATED WORK

### 2.1 Colour Selection in VR

Virtual reality art applications tend to feature colour pickers using different representations of the HSV colour space (Figure 1). Examples are Tilt Brush [Til20], Mozilla A-Painter [Ser20], Gravity Sketch [Ben18], and ANIMVR [NVR21b]. Brushwork [Bar21] uses a different approach and employs a discretised colour space.

The Tilt Brush colour picker contains a colour circle depicting hue and saturation and a vertical scroll bar on the right to adjust the brightness. The A-painter colour picker is similar. It also contains a colour circle for hue and saturation selection, and surrounding it is a brightness slider and fields that show the current selected colour and colour history.

The Gravity Sketch colour picker is three dimensional. The circular section displaying hues and saturation can be pushed inwards and outwards in order to change the intensity. The colour circle is surrounded by twelve 3D blocks representing pure hues, and there are other

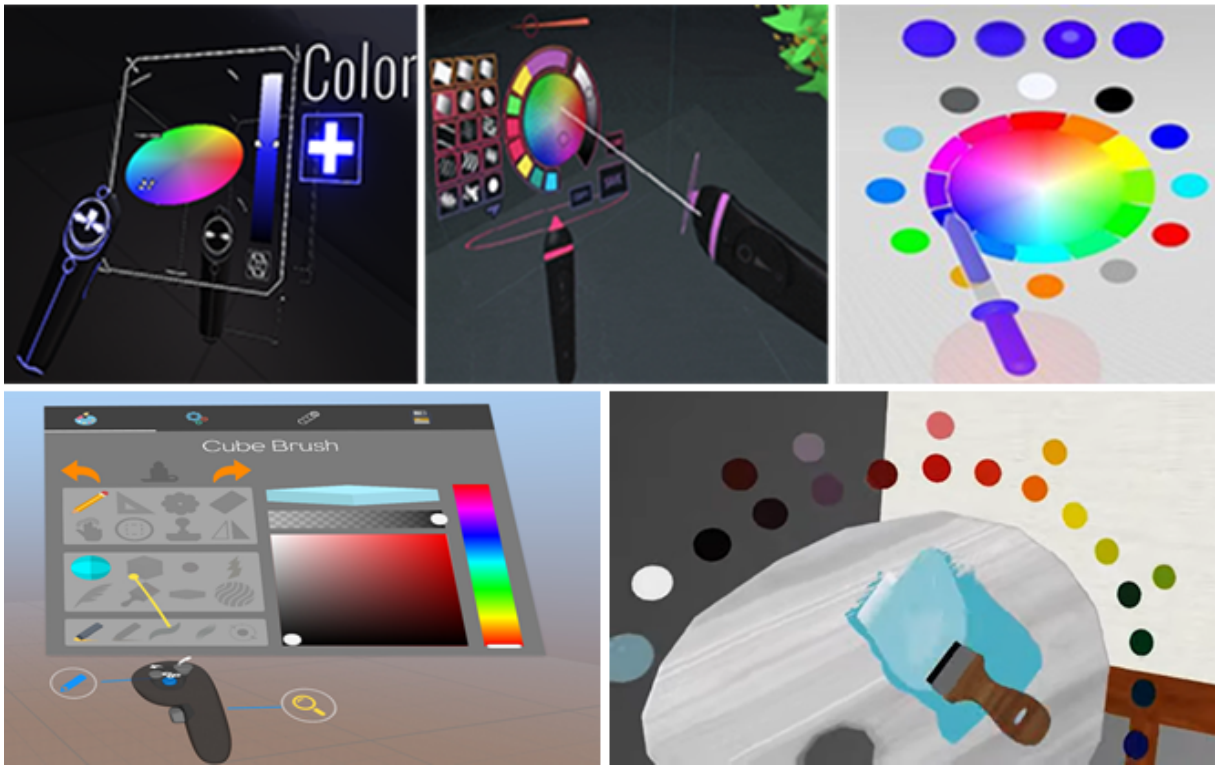


Figure 1: From left to right and top to bottom: Colour picker from Tilt Brush (Credit to: Juegos) [Jue20], Colour picker in Mozilla's A-Painter (Credit to: Fernando Serrano) [Ser20], Colour picker in Gravity Sketch (Credit to: xR.design) [xR.wn], Colour picker in ANIMVR (Credit to: NVRMIND) [NVR21a], Colour picker on Brushwork (Credit to Harry Barker) [Bar21]

smaller circles surrounding the hues displaying the recently selected colours. There are four circles on top of the colour picker that enable users to choose different shading methods for rendering the colour.

In ANIMVR, the square box in the middle adjusts the colour's brightness and a vertical scroll bar on the right adjusts the colour's hue and saturation. The opacity of the colour can be adjusted by dragging the opacity bar's cursor, which is right above the colour box. Above the opacity bar is the background colour bar.

Brushwork has brushes with two modes. The first brush mode allows users to paint a different colour on the existing layer of paint while the second mode allows the user to mix colours together. When in the first mode, users can pick up and hold the colour palette and brushes at any angle to paint. The Brushwork's colour picker offers a relatively small selection of colours, however the second mode allows users to change shade of colours through mixing.

As shown by this review of popular tools, the HSV picker is a common paradigm for digital painting colour picker, however it may not be appropriate for all types of users. Selecting a specific colour in HSV colour spaces can be challenging for novices due to not understanding the underlying colour model and having difficulties in finding a colour within the colour space [AWL21, LM04]. Furthermore, colour may appear differently in the application than in the colour picker because of simultaneous contrast [EF12]. Typical colour pickers represent individual colours on a very small space which may be as small as the size of a single pixel. This small target makes it difficult to identify specific colour in 2D or 3D colour spaces [PY17]. Discretised colour pickers can help to solve some of the usability challenges with HSV pickers [ALL+20]. However, it is not known how initial perceptions of colour pickers differ, which can influence adoption of an application when first seeing it.

## 2.2 Therapeutic Uses of VR Art

Art therapy is a popular complementary therapy to treat a wide variety of health problems [JRWB22]. VR art-making has been investigated as an approach to make art therapy more accessible and better address patients' needs. The presence, immersion, point of view, and perspective within the virtual environment, along with virtual materials and unreal characteristics give VR much potential for the practice of art therapy [HRS18]. VR art-making has been found to be enjoyable, engaging and therapeutic for older adults with dementia and depression [PDHR17] and for older adults with neurocognitive disorders [WCWS+13].

Tilt Brush was evaluated in the context of art making programs in an art therapy studio [AWL21] with older adults with physical and/or cognitive impairments. The field study showed that artists tend to draw inspiration from natural scenes and materials in their art-making. In standard digital colour selection tools, the types of natural colours that artists chose for traditional painting were not immediately visible. Additionally, the field study also found that participants were unable to find their desired colours (i.e., brown, black, white, and bright blue). This motivates research on the usability of discrete pickers, which was investigated by Alex et al. who found that participants used different colours when painting with the discrete versus HSV pickers, however they found no differences in usability between them [ALL+20].

# 3 METHODS

In this study, we were interested in investigating participant's perceptions and first impressions of the colour pickers. These aspects of VR art applications could be customised based on different populations, and thus we want to better understand whether first impressions of older adults differ from adults in order to better customise these applications in the future. We hypothesised that older adults might have different impressions of the discrete picker and HSV picker compared to adults.

## 3.1 Design of the Stimuli

The VR art-making application was built using Unity3D software. Because popular tools such as Tilt Brush [Til20], Mozilla A-Painter [Ser20], Gravity Sketch [Ben18], and ANIMVR [NVR21b] all contain a space to select hue and saturation with a function to adjust the brightness, we selected an HSV picker that offers similar basic functions. It has a round circle for selecting hue and saturation and a triangle in the middle to adjust the brightness. The cube below the circle shows the colour selected by user. The HSV picker was downloaded from the Unity Asset Store (Figure 2 (right)). We also utilised the discrete picker from Alex et al. [ALL+20]. Discrete picker allows its users to select a colour with a single step without the need to adjust hue and saturation/intensity. It contains seven groups of small colour wheels. These wheels consist of the three primary colours (i.e., yellow, red, blue), three secondary colours (i.e., orange/brown, purple, green), and greyish colours (black to white). The circle in the middle shows the colour selected by the user (Figure 2 (left)).

We created four videos [VRA21] displaying identical scenes of VR art-making (Figure 3). Two of these videos used the discrete picker and two the HSV colour picker, with similar times spend on the colour selection process. For each colour picker we added to one of the videos an additional 13-second footage of an artificial companion (AC). The evaluation of the artificial companion will be reported in another paper. This resulted in four near-identical videos showing:

1. the discrete picker without the AC
2. the discrete picker with the AC
3. the HSV picker without the AC
4. the HSV picker with the AC.

The two videos without the AC were 4m 03s long and the two videos with the AC were 4m 17s long.

In this paper we will report our findings for participants' perception of the colour pickers. The effects of artificial companions are discussed in previous research [ALW20, AWL22].

## 3.2 Survey

To answer our research question, we conducted an online survey using Qualtrics. We selected a survey methodology in order to gather first impressions from a larger and more diverse audience than could be reached in another manner. The online survey comprised a pre-video demographic questionnaire, one of two recorded online videos, and a post-video questionnaire. The online survey took approximately 15 - 25 minutes to complete. The post-video questionnaire consisted of three major sections: the first was on VR art-making in general, the second on the colour picker and the third on the AC.

The first section on general art-making consisted of 15 closed-ended questions on general perception of the VR art-making and one open-ended question to obtain qualitative feedback. The section on first impressions of the colour pickers contained 14 closed-ended questions and one open ended question. The first question (closed-ended) assessed the participant's satisfaction with the range of colours in the colour picker. The remainder of the closed-ended questions were semantic differential scales grouped into three subgroups: Pragmatic Quality (PQ), Hedonic Quality (HQ), and APPEAL [HST08] (Table 1). PQ refers to the participants' thoughts on the effectiveness of the colour picker in fulfilling its main task (i.e., painting). HQ refers to participants' sense of how stimulated they were by the colour picker. APPEAL refers to participants' general evaluation of the colour picker. The single open-ended question in the second section gathered qualitative feedback on participants' perceptions of the colour picker. Beyond these subgroups, there was an additional semantic differential item Social/Isolating. The single open-ended question in the second section gathered qualitative feedback

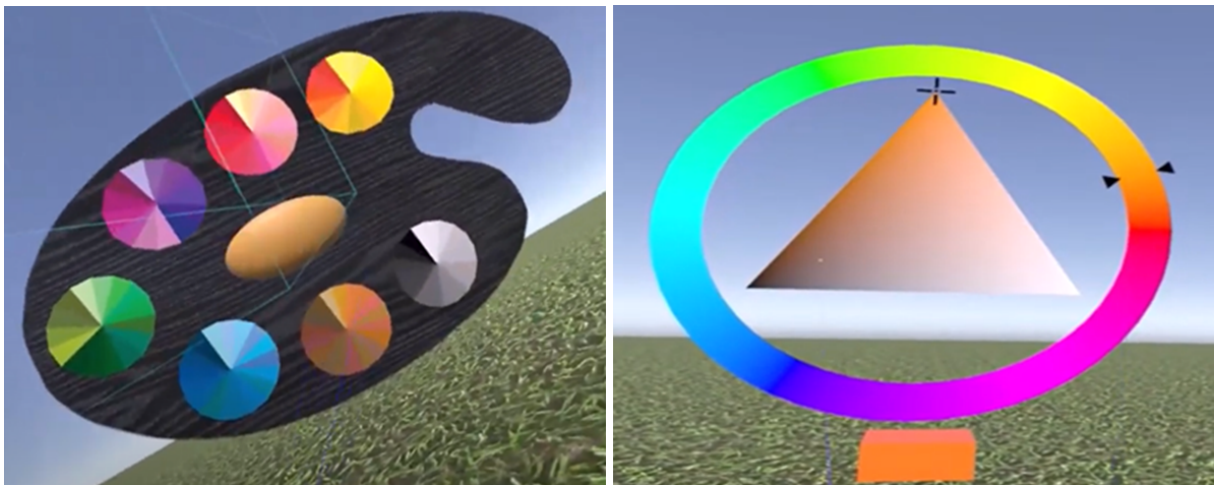

Figure 2: Two colour pickers: Discrete picker (left), HSV picker (right)

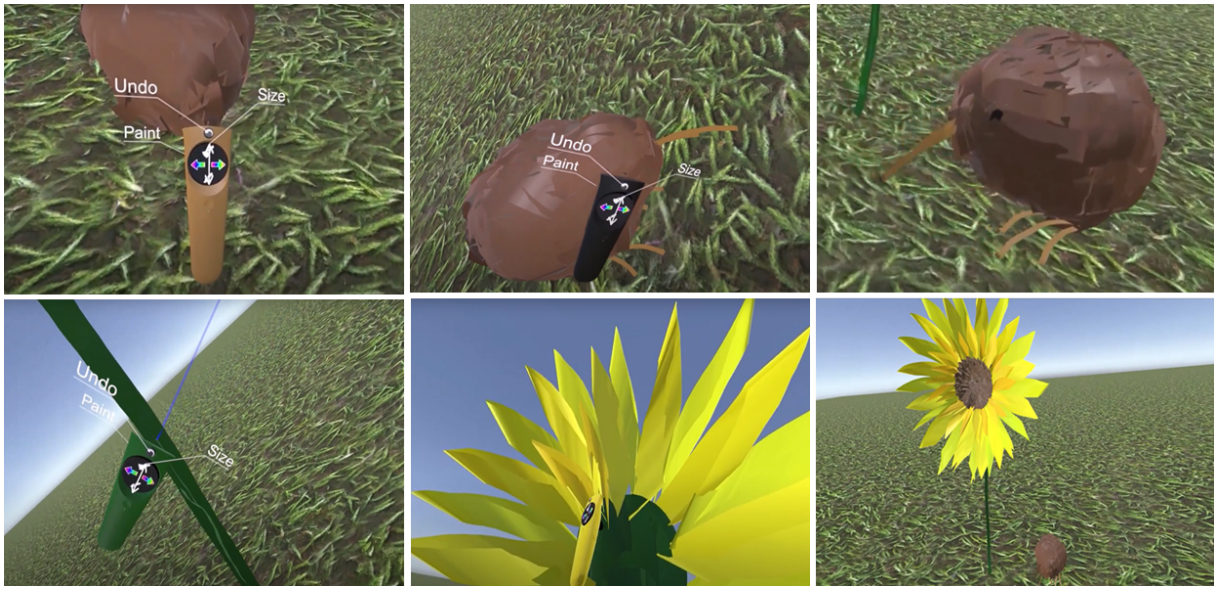


Figure 3: All participants watched the same drawing scenes: successive brushstrokes creating a kiwi bird and a sunflower.

on participants' perceptions of the colour picker. The third section contained seven closed-ended questions and five open-ended questions. This section was only made available to participants who were randomly allocated to watch videos with the AC present. In this paper, we only report the results of the VR art-making colour pickers.

## 3.3 Analysis

The statistical analysis was conducted using the SPSS statistics software. We did a factor analysis, reliability analysis, analysis of variance (ANOVA), and multivariate analysis of variance (MANOVA) to analyse the data. The factor analysis grouped the semantic differential items into three groups: PQ, HQ, and APPEAL. We scored each group by averaging its items.

We read all the quotes from the survey and created affinity diagrams. We used affinity analysis [Ash20, HB97] to group the quotes from the survey based on 'similarity'.

## 3.4 Participants

To recruit a wide variety of participants including adults and older adults, we distributed invitations to participate via email and social media to multiple organisations all over the world including stroke organisations, universities, and other organisations (e.g., SeniorNet, retirement homes etc.). In the invitation, we let participants know they could complete the survey with the assistance of a caregiver.

A total of 87 participants participated (Table 2). Participants comprised 24 older adults aged 60 and above with

| Scale item | Anchors | |
|---|---|---|
| PQ 1 | Comprehensible | Incomprehensible |
| PQ 2 | Supporting | Obstructing |
| PQ 3 | Simple | Complex |
| PQ 4 | Clear | Confusing |
| PQ 5 | Controllable | Uncontrollable |
| HQ 1 | Interesting | Boring |
| HQ 2 | Exciting | Dull |
| HQ 3 | Impressive | Nondescript |
| HQ 4 | Original | Ordinary |
| APPEAL 1 | Pleasant | Unpleasant |
| APPEAL 2 | Attractive | Unattractive |
| APPEAL 3 | Motivating | Discouraging |
| APPEAL 4 | Desirable | Undesirable |

Table 1: Semantic differential items for Pragmatic Quality (PQ), Hedonic Quality (HQ), and general evaluation (APPEAL) [HST08]

| | DISCRETE | HSV |
|---|---|---|
| Adult | 27 | 36 |
| Older Adults | 16 | 8 |

Table 2: Number of participants who watched discrete or HSV picker video

a mean age of 69.9 years, 62 adult people aged 16 - 59 years with a mean age of 33.2 years and one participant did not provide his age.

42 participants identified as male, 43 participants identified as female, one participant identified as non-binary, and one participant did not provide an answer. We are missing two pieces of demographic data from the survey as one participant did not provide his age and another participant did not provide a gender.

# 4 FINDINGS

A reliability analysis found high values for PQ ($\alpha$ = .926), HQ ($\alpha$ = .943), and APPEAL ($\alpha$ = .964), indicating a high internal consistency among the semantic items within the group. The MANOVA analysis showed that the colour picker had a significant effect on HQ ($F(1, 86) = 5.35$, $p = .023$), with the discrete picker garnering higher scores, but not PQ ($F(1, 86) = .077$, $p = .781$) and APPEAL ($F(1, 86) = 2.47$, $p = .120$). Figure 4 illustrates the results. Overall, there were no differences between adults and older adults. Therefore, our hypothesis that older adults might have different impressions of the discrete picker and the HSV picker compared to adults is rejected. We conducted an ANOVA to examine the satisfaction with the range of colours in the colour pickers and found no statistical differences between the discrete picker and the HSV picker. We grouped participants' open-ended comments into three subthemes which we explain next.

## 4.1 Colour Pickers' Colour Ranges

There was a mix of satisfaction with the discrete picker's colour range. Most participants were satisfied with the range of colours in the discrete picker, with comments such as: "[It] has all the colour types available [P9]", "There is a wonderful choice of colours [P18]", "Sufficient range of colours [P37]", "There seem to be enough colours to use [P80]", "All the colours are there [...] plenty of choice [P85]". One participant mentioned that there is a reasonable choice of colours, but stated: "Undoubtedly, I would eventually want a colour not on there, but it looks like a reasonable selection of colours nevertheless [P3]". Some participants were dissatisfied with the range of colours in the discrete picker. One participant commented: "It should be variables and options to choose more color [P38]". It seems like the discrete picker may have enough selection for many but not all users. Two other participants felt unable to answer the question. P14 stated: "I don't know much about colours".

There were many participants who were satisfied with the range of colours in the HSV picker. Those who commented about that said, "All the colours of the rainbow seem to be there [P47]", "RGB colour wheel is pretty much every colour [P61]", "Looks beautiful with complete rainbow colours [P63]", "Has almost all colours that's needed to create stuffs [P65]", "[...] most of the colours are available [P69]", "Enough colours to work with [P70]".

There were some participants who were dissatisfied with the range of colours in the HSV picker. One of them stated, "[...] When there are too many colors, one faces a paralysis of choice [P79]". Another participant had the opposite reaction, that the HSV picker was, "[...] very limited [P40]". P40 may have misunderstood the HSV, as happened in Alex et al.'s study [AWL21], where participants thought the colour picker only contained the colours that were immediately visible and did not imagine all the variations of saturation were available. The fully saturated colours around the HSV picker wheel might attract users with strong colour preferences. Two participants commented on the colour preferences for HSV picker such as, "I like the strong colours [P55]", "Like the color [P73]". These comments indicate that they were attracted to vibrant colours which may be more eye-catching relative to the desaturated colours in the discrete picker.

## 4.2 Design Satisfaction

Participants commented on the design of the colour pickers. Participants commented on the colour arrangement within the discrete picker: "They are well mixed perfectly arranged colours [P10]", "The colours are well organised and beautifully done [P22]", "The mixing of colours are in order I must say it's complete

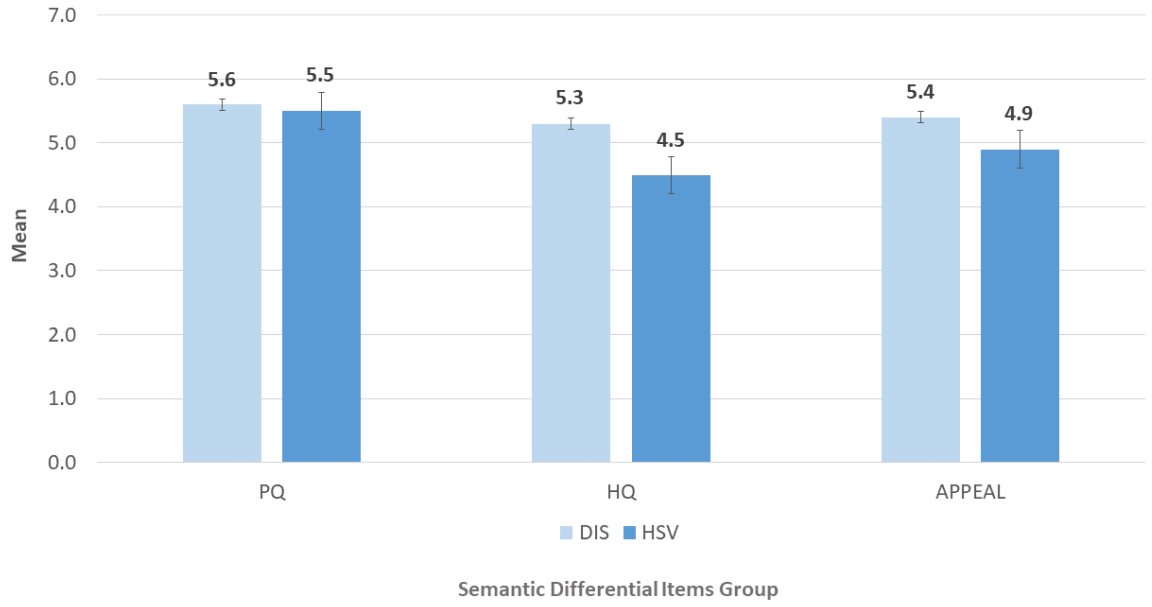


Figure 4: Discrete picker (DIS) versus HSV picker

[P26]", "Complete and well-arranged [P31]". One participant mentioned the discrete picker is "very comprehensive [P15]". P13 suggested that it will be better if it is bigger. We cautiously interpret P13 as referring to the size of the colour picker wheels and propose that it may be beneficial to be able to magnify particular wheels. Three participants provided comments on what they disliked about the discrete picker. P16 said that "it looks mediocre", P38 stated that "The quality of the colour picture is low density and look unattractive", and P86 mentioned that "Lots of colours muddled together. How would I choose a colour?". Another felt unable to comment on the design: P56 said that he has no experience and needed to use it in order to be able to comment.

Participants also gave mostly positive and some negative reviews on the design of the HSV picker. "RGB ring and shade/tint triangle is mostly understandable for anyone exposed to modern digital art tools [P41]", "The colour picker seems pretty straight forward to use [P49]", "It looks standard to me. I think it is adequate for what a screen can display [P46]". These comments seem to indicate that some participants have experience and are already quite familiar with the HSV picker. Two participants were dissatisfied with the HSV picker. P79 said, "There are other ways to pick color, not just a color wheel" and P59 commented: "The HSL colour picker, while a traditional mainstay in professional art applications, seems out of place in the three dimensional world of VR. It also requires understanding of how it operates, and that the outer ring and inner triangle are linked, before it can be used effectively [...] the colour picker is unsuitable for VR, and potentially daunting for inexperienced artists who have not seen or used it before. A novel colour picker, specifically designed for use in three dimensions so that all available colours can be seen at once, around the user, would be better suited for VR".

### 4.3 Customisation

Multiple participants desired customisation. After seeing the discrete picker, P21 stated that, "I'd want a customised palette chooser where you can roll your own". P80 and P85 asked if it is possible to mix colours.

Two participants who had seen the HSV picker suggested customisation features. P41 suggested having a way to store previously-picked colours that could be retrieved easily. The other participant suggested "[to have] an option to be able to choose from a colour palette [...]" and "[...] a way to save colours used in the art [...] [P61]".

## 5 DISCUSSION

We conducted a quantitative survey study to rigorously assess initial perceptions of virtual reality colour pickers within VR art. We were particularly interested in how older adults' perceptions might differ from adults' perceptions. We found that the discrete picker scored higher overall for its hedonic qualities of being more interesting, exciting, impressive and original compared to the HSV picker, and there were no differences across age groups.

In our study design, participants were randomly allocated to one of four near-identical videos. The strength

of this study design is that we can attribute causal effects to the manipulated variables. As each participant only sees a single stimulus, there are no order effects or transfer effects. The study design is intended to have some similarities to the experience of first perceptions of new applications, where people tend to see images, videos or advertisements before being able to try a tool themselves. These first impressions are an important step toward deciding whether to try a new application or not. We argue that assessing initial perceptions is worthwhile as negative initial perception may introduce barriers that may not be known if a user is funneled into initial use. A drawback of our study design is that participants do not experience all the options, and so cannot comment on the differences and their preferences. Further, initial perceptions may differ from perceptions after a period of usage. The discrete picker's higher hedonic qualities may be due to its novelty, colour wheels, or other aspects of its design. The semantic differential items could be administered after a period of art-making to see how first impressions and usage impressions are related, and whether habituation to the design impacts perceptions.

The discrete picker is 2-dimensional whereas the HSV enables traversal through 3-dimensional colour space with a second colour selection step. Some initial impressions of the HSV were based on the visible colours — it was intriguing that the vibrant, high saturation colours of the HSV picker's wheel attracted some people's attention. A weakness of the 2-dimensional design is that it does not utilise the full potential of virtual reality. This presents a dilemma on complexity. Even 2D colour pickers may be difficult to understand for novice users, as shown by some of the comments we received. To a novice, the colours displayed around the HSV colour wheel look may appear limited as the HSV picker seems to contain only fully saturated colours. Three dimensional colour pickers would take advantage of the immersive environment however they may be even more difficult to understand.

People who are novices in digital art may require simpler tools [AWL21] whereas those with understanding of colour spaces can be offered complex 3-dimensional tools. Simple tools will be unlikely to satisfy expert digital artists who are accustomed to more choice. For instance, some of our participants mentioned the limited range of colours in the discrete picker. Others mentioned a potential paralysis of choice using the HSV picker because there are too many colours. Thus, our findings are in line with [LM04, ALL+20]: the discrete picker may be more suitable during a novice period of digital art, whereas the HSV picker is more suitable for experienced users who like to explore more colours. We recommend that digital art applications have the ability to evolve the sophistication of the toolset as the artist becomes more familiar with the toolset, so that the complexity grows as the user is better able to utilise it.

## 6 LIMITATIONS

Our study has several limitations. Since our study was accessible to everyone self-selection bias is present. It is possible that users participating in the research are more curious, interested in VR, and open to new ideas, and hence findings might not be representative.

Since we assigned participants randomly to each video, the demographics of participants watching each video was not evenly distributed. For example, we had 16 older adults watching videos with the discrete colour picker, but only eight participants watching videos with the HSV colour picker. This also resulted in small sample sizes for some conditions.

Some participants in our online survey might suffer from impairments (cognitive and physical, e.g., stroke) and perceptions and expectations might be different from those of a healthy user.

## 7 CONCLUSION AND FUTURE WORK

This research investigated perceptions of VR colour pickers on the VR art-making experience from a wider range of potential users. Compared to the HSV picker, the discrete picker had higher hedonic qualities: it was seen to be more interesting, exciting, impressive, and original. Qualitative feedback suggested that the discrete picker may be more suitable for novice users who do not have knowledge in 3D colour space, while experienced users would appreciate the range of colours offered by the HSV picker.

In future work we would like to test the different colour pickers with participants using them for VR art applications and investigate how initial perceptions and actual experiences differ. For example, participants might be unaware that pointing towards a location with a VR controller is for many users harder than when using a mouse, e.g., due to slight hand tremours and not being able to rest the hand on a surface.

More work is needed investigating the tool's accessibility and usability such as adding customisation functions to the colour picker. For example, creating a function that allows users to blend or mix colours or switch colour pickers (e.g., discrete or HSV) and a magnifier tool for the discrete colour picker to make it easier to select a specific colour. We also would like to have an option to enable or disable colour selection with a single controller to support accessibility.

We observed in previous research that for many older adults art-making is a social experience [AWL21]. We

would like to expand the tool to support social interactions, e.g., users discussing colour choices and their affect on the art piece.

Music is a powerful motivator, can improve mood, and support creativity [EASG20]. We hope to integrate music into the art making process both as background music and by visualising the music and enabling users to interact with it [TWM19].

## 8 ACKNOWLEDGEMENTS

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