Color-in-fist: a metaphor for color selection with mid-air interaction

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REGULAR PAPER

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Abstract Color picker is a necessary interactive component in visualization system. Current color pickers are based on the WIMP paradigm and are mainly designed for mouse, touch and ray interactions. In the context of immersive and remote interaction, mid-air interaction is an important method. However, common solution of color selection using hands is simulating cursors or rays with fingers, which does not take full advantage of mid-air interaction—intuition, naturalness and remote interaction. This results in fatigue and long selection time. In this paper, we proposed a mid-air interaction metaphor for color selection which enabled users to select hue, saturation and lightness simultaneously using mutually independent and intuitive hand motions. We conducted a user study to evaluate the performance of the interaction technique. Results showed that the metaphor improved the efficiency of color selection with mid-air interaction. Questionnaire results showed that the metaphor enhanced users' perception of color space; the semantics of hand motions were consistent with users' intention of color selection; the metaphor was easy to learn and memorize.

Keywords Color picker · Color selection · Mid-air interaction · metaphor · visualization

Mathematics Subject Classification MSC code1 · MSC code2 · more

1 Introduction

In visualisation and visual analysis systems, selecting colors is a common task. Color picker is a common interaction component used to select colors and create color schemes (Feisner and Reed 2014). Color is determined by three dimensions: hue, saturation and lightness, which form color space. Most color pickers in graphical user interface (GUI) project three-dimensional (3D) color space into a two-dimensional (2D)

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plane. There are two common forms of color pickers: one consists of three sliders corresponding to R, G, B, respectively, and the other consists of a color wheel and a slider. Current color picker interaction techniques are too engineering to help users form effective cognitive model. Besides, they require users to adjust back and forth between multiple components.

In immersive environments, large display walls, and other scenarios where mid-air interaction is needed, current color pickers directly applied the interaction technique in WIMP interface (In human–computer interaction, WIMP stands for "windows, icons, menus, pointer", denoting a style of interaction using these elements of the user interface (Hinckley 1997)), using mainly ray-casting (Liang and Green 1994) and cursor metaphor for color selection interaction. The ray-casting method uses a ray emitted from a hand or a handheld device to select colors. The cursor metaphor method uses hand position to control the movement of a cursor in WIMP interface to select colors. Due to lack of physical constraints, these methods could cause hand tremor and jump release (Cui and Sourin 2018), and prolonged operation could lead to fatigue. In addition, the methods do not take full advantage of the intuition and naturalness of mid-air interaction. Therefore, it is not appropriate to apply the traditional color picker simply to mid-air interaction scenarios. So, it is an important challenge to utilize the advantages of mid-air interaction to accomplish color selection tasks efficiently and naturally.

We proposed a mid-air interaction metaphor named Color-in-Fist for color selection which supported users to simultaneously select hue, saturation and lightness using mutually independent and intuitive hand motions (see Fig. 1). It improved the efficiency of color selection and enhanced users' perception of color space. We also conducted a user study to evaluate the performance of this interaction technique.

2 Related work

2.1 Color picker

2.1.1 Color picker interface and interaction

This section reviews the interface and interaction of digital color pickers, including traditional color pickers, touch-based color pickers and immersive color pickers. Applications used to create digital media often include a color picker which has three functions: (1) specifying a visual representation of color model; (2) organising colors into a three-dimensional color space; and (3) changing parameter values within color space (Douglas and Kirkpatrick 1999). Users can select a specific color directly from the color space, or specify values for the three dimensions. For many years, research in color pickers has focused on the perception and representation of color space, with little change in the form of color pickers (Jalal et al. 2015).

Besides, Meier (1988) showed that novices still have difficulties in selecting a particular color. Douglas and Kirkpatrick (1999) argued that visual feedback and interface design are more important factors than color model in improving the usability of a color picker interface, and selecting a specific color using existing color pickers is difficult (Pula and Yuen 2017). One reason is that cursor needs to move back and forth between two even three components, and the other is that these color pickers lack visual feedback when all three dimensions change at the same time.

The advent of touch devices has provided more possibilities for color picker interaction. ColorFingers (Ebbinason and Kanna 2014) allowed users to select hue and saturation in the color wheel with one finger and adjust value by moving the hand up and down on the display, reducing selection time and increasing accuracy. BiCEP (Gonzalez and Latulipe 2011) allowed users to use a laptop touchpad to interact with two components simultaneously using two hands, respectively, making it easier for users to explore a wide range of colors. However, the touch-based color picker interaction based on the WIMP paradigm can not help users understand color space very well.

In immersive environments such as VR, color pickers have more forms than desktop applications. A-Painter[1] and Tilt Brush[2] both consist of two components (a color wheel and a slider), being interacted by ray-casting. Gravity Sketch[3] has a 3-D interface which effectively represents an HSV color cylinder, and

[1] A-Painter: paint in VR in your browser

[2] Tilt Brush: painting from a new perspective

[3] Gravity Sketch: the first pro-level VR app for artists

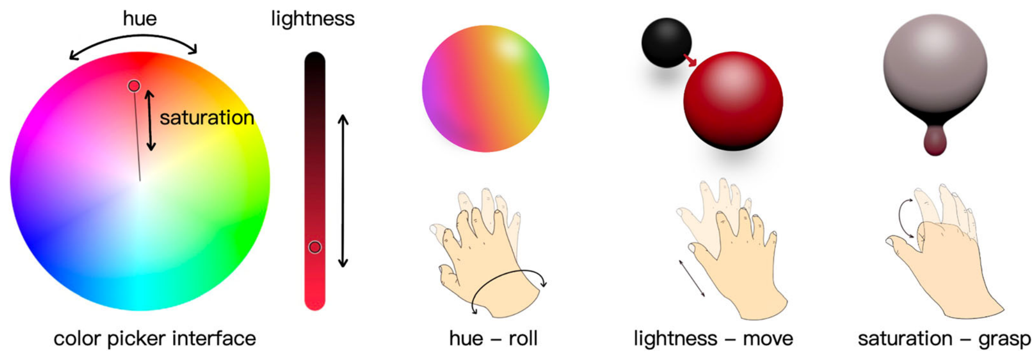

Fig. 1 Color-in-Fist: a metaphor for color selection with mid-air interaction in HSV color space

users change the lightness by pushing and pulling the color wheel. However, these color pickers applied the interface of color picker under WIMP paradigm directly and most of them do not allow simultaneous selection of all three dimensions. Moreover, they are not suitable for natural interaction techniques such as mid-air interaction, nor do they enhance users' perception of color space.

2.1.2 Color model

There are several commonly used color models such as RGB, HSV and CIELab (Jalal et al. 2015). Most color pickers in interactive applications used HSV color model, which has a more regular and simple layout and is more suitable for GUI, such as the color picker in PhotoShop[4] and macOS. Our work is based on HSV color model, since the cone presentation of HSV fits better with the hand motion space.

In terms of color perception, the CIELab is a color model based on physiological characteristics, which is established on the international standard for color metrics developed by the International Commission on Illumination (CIE) in 1931.[5] It has perceptual consistency in space, so is suitable for measuring color difference. Li et al. (2019) studied the effect of color feedback on interaction performance using CIELab color space. In this paper, we used CIELab to calculate color difference between target color and selected color in the experiment.

2.2 Mid-air interaction

Mid-air interaction is an interaction technique using camera to track bare hands without wearing any markers or holding handheld devices, which has intuition and naturalness.

2.2.1 Mid-air selection techniques

In 3D environments, ray-casting is a common selection method that uses rays or cones to point and select (Liang and Green 1994). An alternative to ray-casting is hand extension metaphor, where the position of hand is used to control a cursor. It is found that ray-casting has better performance than hand extension metaphor for target selection (Grossman and Balakrishnan 2006; Vanacken et al. 2007). In addition, controlling a cursor by moving hand is not accurate enough and easy to cause fatigue due to lack of support and constraint of physical surfaces (Liu et al. 2012). We used mutually independent hand motions to select all three dimensions of color space simultaneously, thereby reducing selection time and fatigue.

2.2.2 Gesture delimiters

A common issue with mid-air interaction is gesture delimiter (Benko 2009). However, when users move their hands freely in the air, it is difficult to determine the beginning and end of a gesture or distinguish a meaningful gesture from other random movements. A direct replication of WIMP interface that uses hand

[4] Adobe color

[5] CIELAB color space

opening or closing to simulate button click may not be suitable for mid-air interaction (Ren and O'Neill 2013).

Several different gesture delimiters have been designed for gesture interaction, such as finger movements (Vogel and Balakrishnan 2005; Grossman et al. 2005), pinch pose (Grossman et al. 2005; Benko and Wilson 2010) and hand pose (Liu et al. 2012). These delimiters have a large range of motion and can cause hand tremor and jump release problems. We used two micro-gestures that will not interfere with the main interaction motions as delimiters to trigger interaction and switch modes.

3 Metaphor and interaction design

We proposed Color-in-Fist, a novel interaction technique for color selection with bare hands. We have two design goals: (1) To improve selection efficiency by adjusting all three dimensions of color simultaneously. (2) To assist users to understand selection task in color space.

3.1 Color model

Color-in-Fist uses HSV color cone (Smith 1978) to represent color space (see Fig. 2a), which is a commonly used model for color picker interface (see Fig. 2b). In the HSV color cone, hue is arranged on a 360° cone bottom surface in a sequence of red, orange, yellow, green, blue, indigo and violet. Saturation varies with the radius of the bottom surface. The closer to the center, the lower the saturation; the farther from the center, the higher the saturation. The minimum value of 0 represents no color, and the maximum value of 1 represents fully saturated color. Lightness varies with the central axis of the cone. The closer to the top of the cone, the lower the lightness; the farther from the top of the cone, the higher the lightness. The minimum value of 0 represents black, and the maximum value of 1 represents white or saturated color.

3.2 Squeeze-and-drag metaphor

To help users understand color selection better, we designed a metaphor for selecting saturation and lightness. We imagined selecting a color as manipulating a small elastic sponge ball containing pigment and illuminated by a white point light source. The concentration of pigment is determined by the strength of squeezing, and the intensity of light is determined by the distance from the ball to the light source.

Squeeze the color: the metaphor is used to select saturation, where the concentration of pigment represents metaphorically the saturation. When the ball is squeezed, the pigment is squeezed out and saturation is decreased; when the ball is released, the pigment is absorbed back and saturation is increased (see Fig. 3).

Drag in lightness: the metaphor is used to select lightness. As the distance from the ball to the light source changes, the intensity of light changes, resulting in the lightness change as well. When the ball is dragged to the closest point, light intensity and lightness are both highest, and the color is the original color of the ball; when the ball is pushed to the farthest point, light intensity and lightness are both lowest, and the color of the ball is black (see Fig. 4).

For selecting hue, we used the general position metaphor.

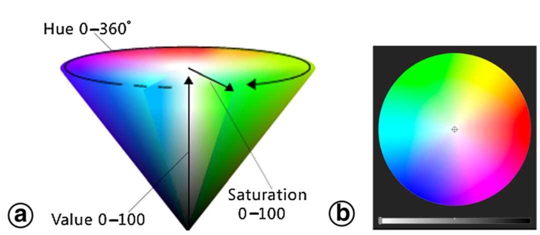

Fig. 2 **a** HSV color cone. **b** Color picker in macOS

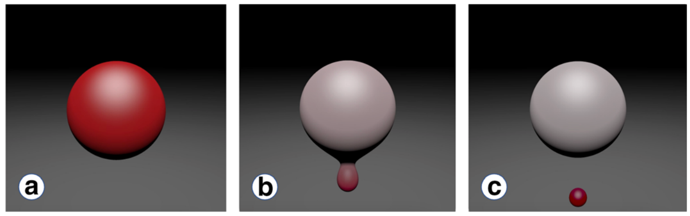

Fig. 3 Squeeze the color. **a** Full of color. **b** Half of color. **c** None of color

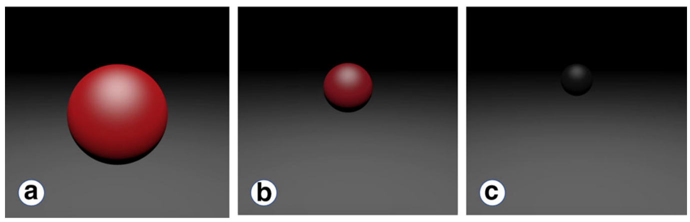

Fig. 4 Drag in lightness. **a** Near and bright. **b** Mid and dim. **c** Far and dark

3.3 Hand interaction motion design

3.3.1 Design principle

We summarised three principles of hand interaction design that are consistent with design goals:

- **Independent of each other:** mid-air interaction has high degree of freedom(DOF), so we need to minimize mutual interference when adjusting hue, saturation and lightness simultaneously.
- **Metaphorical:** this can help users better understand color selection task in color space.
- **Avoid large movements:** since mid-air interaction can easily cause fatigue, it is necessary to avoid using hand motions with large movement range as much as possible.

3.3.2 Hand interaction design

We combined metaphor and hand movement characteristics to design three hand motions corresponding to the three metaphor mentioned above.

Hue selection one important movement feature of mid-air interaction is wrist tilting, including rolling, yawing and pitching (Rahman et al. 2009). The motion space of rolling coincides with the display space of hue ring, so we used wrist rolling to map hue. The angle of rolling determines hue, which starts with the palm up and ends with the palm down (see Fig. 5a).

Saturation selection grasping is another movement feature of mid-air interaction, which has a smaller movement range compared to rolling and moving. Based on the *squeeze the color* metaphor, we used strength of grasping to map saturation. The grasping strength determines saturation. When the fingers are straight, saturation is 1; when the fingers are fully bent, saturation is 0 (see Fig. 5b).

Lightness selection the recognition based on hand movement is quite robust (Ren and O'Neill 2013). Based on the *drag in lightness* metaphor, we used hand moving in depth to map lightness. The coordinate of

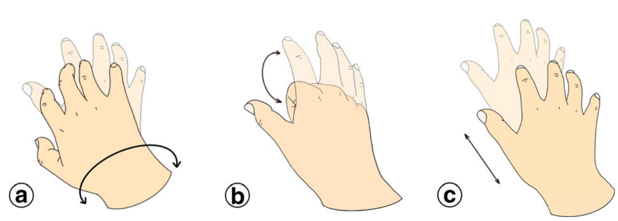

Fig. 5 **a** Rolling wrist. **b** Grasping. **c** Moving in depth

hand position in depth determines lightness value. When the hand is just above the device, the lightness is 50%; when the hand is closest or furthest from the user, the lightness is 100% or 0% (see Fig. 5c).

3.4 Color picker for mid-air interaction

The interface of Color-in-Fist consists of two components: a color wheel and a slider. On the color wheel, the angle of the pointer represents current hue and the length of the pointer represents current saturation. On the slider, the position of the small circle represents current lightness.

Color selection task consists of two steps: select and confirm. We used two micro-gestures to perform air-click: Thumb Trigger and Middle Airtap (Ebbinason and Kanna 2014) (see Fig. 6). Thumb Trigger is used to confirm, and Middle Airtap is used to switch the direction of the pointer on the color wheel.

3.4.1 Selection phase

Selecting hue in order to select hue, users need to roll wrist along the color wheel. The range of rolling is limited, but the color wheel is usually a full circle, so we designed a pointer which direction can be switched by Middle Airtap gesture, since this gesture will not affect the angle of rolling. When the target color is in the upper half of the color wheel, the pointer is oriented upwards; when the target color is in the lower half of the color wheel, the pointer is oriented downwards. With the pointer, users can easily select hue in the range from 0° to 360° by rolling wrist (see Fig. 7a).

Selecting saturation in order to select saturation, users need to grasp the four fingers at the same time except thumb, since thumb needs to perform Thumb Trigger gesture. When the four fingers are extended completely, the maximum value of saturation is 1. When the four fingers are bent completely, the minimum value of saturation is 0 (see Fig. 7b).

Selecting lightness in order to select lightness, users need to push or pull the hand in depth. When pushing the hand backward, lightness decreases to a minimum value of 0. When pulling the hand forward, lightness increases to a maximum value of 1 (see Fig. 7c).

3.4.2 Confirmation phase

Once the selected color is close enough to the target color, users need to perform Thumb Trigger gesture to confirm. Thumb Trigger gesture has a small range of motion and is relatively stable, so it will not affect rotation angle or grasping strength when performed, avoiding hand tremor and jump release problems.

4 Experiment

We conducted a controlled experiment to compare the performance differences between Color-in-Fist and traditional color picker for color selection task. Measurement indicators include task completion time, accuracy, number of errors and subjective satisfaction. The experimental program automatically recorded

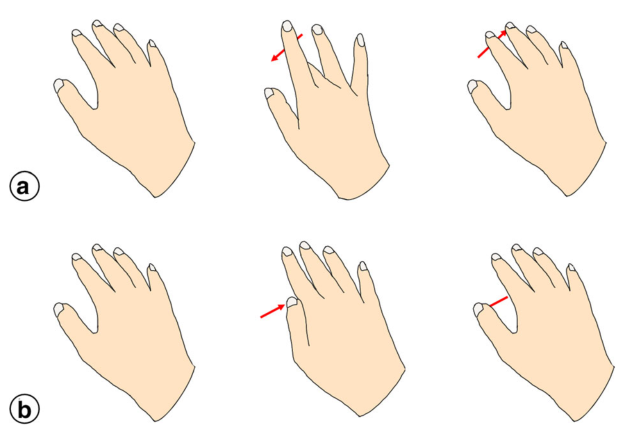

Fig. 6 Micro-gestures: **a** Middle Airtap. **b** Thumb Trigger

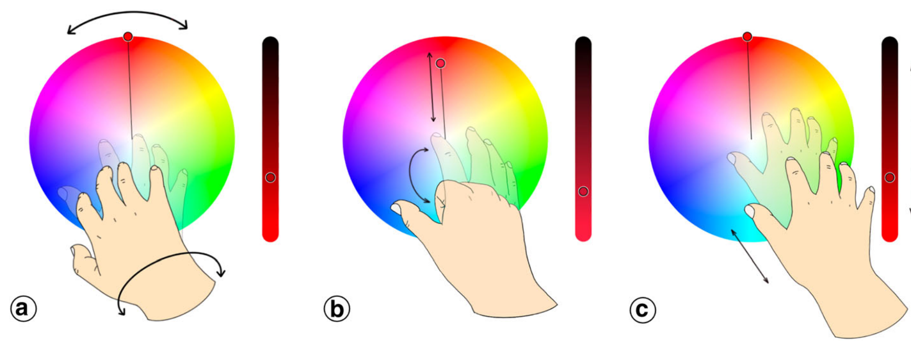

Fig. 7 **a** Select hue by rolling wrist. **b** Select saturation by grasping. **c** Select hue by moving in depth

task completion time, accuracy and number of errors. After experiment, users were asked to fill out a Richter scale and accept an interview.

4.1 Hypothesis

When using traditional color picker, the cursor can only interact with one component at a time, so users' focus has to switch between the two components. According to Fitts's law, the time taken to reach target is related to the size of target and the distance travelled. The slider component is too small to aim at with a virtual cursor controlling by a hand, resulting in longer completion time and more errors. Based on these considerations, we made following hypotheses:

In the color selection task,

H1: Color-in-Fist is faster than traditional color picker.

H2: There is no significant difference in accuracy between Color-in-Fist and traditional color picker.

H3: Color-in-Fist will cause fewer errors than traditional color picker.

H4: Color-in-Fist is easier to learn than traditional color picker.

H5: Color-in-Fist will cause less fatigue than traditional color picker.

H6: Color-in-Fist is easier to use than traditional color picker, and users are more willing to use Color-in-Fist.

4.2 Task

We asked users to select a group of given colors and then calculated the color difference (ΔE) between target color and selected color using the color difference formula CIEDE2000 proposed by CIE[6]. In general, two colors are perceived as different when $\Delta E = 2.5$.[7]

However, due to insufficient accuracy of mid-air interaction, it is difficult for users to select a color that exactly same as target color. We conducted a pilot test to determine the threshold for color difference. 6 users with normal color perception were asked to select a group of 12 colors as accurately as possible, and the system recorded the color difference for each trial. We used the upper quartile of the group as the threshold for this user.

To ensure that every participant can complete experiment, we toke the maximum value of 5.0 among the 6 users as the threshold for the formal experiment. If the color difference between selected color and target color is less than 5.0, the trial was recorded successful; otherwise, it was recorded as a failure and the user needed to reselect the color.

In the control group, we used the same color picker interface to select the same set of colors (randomly generated). Different from the experimental group, the control group used hand position to control the virtual cursor in order to simulate mouse interaction. To control variables, the control group used the same micro-gestures as experimental group to trigger interaction. We used within-subject design and adopted ABBA balance method to balance the effects of condition order. Participants were randomly assigned to two condition orders.

[6] Delta E (CIE 2000)

[7] Color management: current practice and the adoption of a new standard

4.3 Apparatus

The hand tracking device used in experiment is leap motion controller. The experimental program was developed in JavaScript with leap-0.6.4.js as a dependency library. The experimental program was run on a 13” Macbook Pro with an Intel Core i5 2.4 GHz quad-core processor, 8 GB of 2133 MHz LPDDR3 memory, macOS Big Sur 11.2.3 operating system and Chrome (see Fig. 8).

4.4 Procedure

We recruited 12 postgraduate students on campus as participants, including 3 males and 9 females, all of whom had normal color perception (no color blindness). 10 of them are familiar with color picker interaction and 8 have experience with mid-air interaction. The participants sat on a chair at a distance of approximately 30 cm from the table and their operating hand was approximately 15 cm above the recognition device. They were first introduced to the interaction and task and then performed 3–4 groups of exercises under each condition. Participants were advised to take a 5–10 min break after each condition. It took per participant approximately 1 hour to complete the experiment.

Each participant was required to select a group of 12 colors under two conditions and performed a total of 2 techniques * 12 trials = 24 trials. Finally, we collected 12 participants * 24 trials = 288 trials.

The user started a group of trials by performing Thumb Trigger gesture. At the start of each trial, the interface showed the number of current trial. The target color was displayed in the top left corner of the screen, and the currently selected color was displayed in the bottom left corner of the screen (see Fig. 8). The participant had to successfully complete each trial. If an trial failed, the system refreshed the current trial until the user successfully completed it. Once a trial was completed, a next trial displayed automatically until 12 trials had been completed.

We asked participants to perform the task as quickly and accurately as possible. Task completion time was measured from start time to end time of a trial. Accuracy was measured as the color difference between target color and selected color. Number of errors was measured as the number of failures in a group (12 trials). After user completed a group, the program automatically downloaded data. After experiment, users were asked to fill out an Likert scale to reflect their subjective satisfaction. Each question had five options: strongly disagree(-2), disagree(-1), neutral(0), agree(1), strongly agree(2). The questions covered three aspects: learnability, fatigue and usability, as follows.

Q1: I think this interaction is easy to understand.
Q2: I think I need help of an expert to use this interaction.
Q3: I need to study for a long time before I can use this interaction.
Q4: I think this interaction is easy to remember.
Q5: I think this interaction is easy to cause fatigue.
Q6: I think this interaction is easy to use.
Q7: I would like to use this interaction.

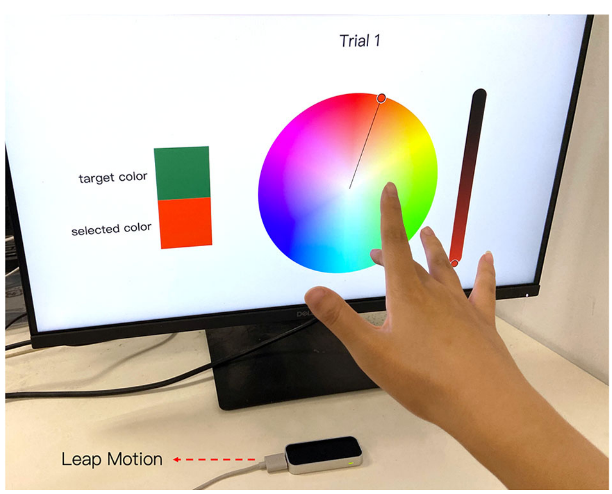

Fig. 8 Hardware setup and experimental program interface

Q8: I feel very confident when using this interaction.

4.5 Result

We used the Wilcoxon signed rank-sum test to analyse the data.

(1) Color-in-Fist is faster than traditional color picker

Results showed a significant difference in task completion time between Color-in-Fist and the traditional color picker (see Fig. 9). The task completion time for Color-in-Fist (Mdn = 8.99s, SD = 5.00s) was significantly lower than the traditional color picker (Mdn = 12.40s, SD = 7.49s), $z = 3.059$, $p = 0.002 < 0.01$. H1 was accepted.

(2) No significant difference in accuracy between Color-in-Fist and traditional color picker

Accuracy (color difference) was not significantly different between Color-in-Fist (Mdn = 3.00, SD = 0.40) and the traditional color picker (Mdn = 2.59, SD = 0.38). H2 was accepted.

(3) No significant difference in number of errors between Color-in-Fist and traditional color picker

There was no significant difference in number of errors between Color-in-Fist and the traditional color picker. The median of errors for Color-in-Fist was 7, while the median of errors for the traditional color picker was 9.5.

(4) No significant differences in learnability between Color-in-Fist and traditional color picker

For the question Q3 "I need to study for a long time before I can use this interaction", there was no significant difference between Color-in-Fist and the traditional color picker (see Fig. 10). H4 was rejected. But for the question Q2 "I think I need the help of an expert to use this interaction" separately, Color-in-Fist scored higher significantly (Mdn = 1.5, SD = 1.07) than the traditional color picker (Mdn = 1.0, SD = 1.12), $z = 2.309$, $p = 0.021 < 0.05$.

(5) Color-in-Fist will cause less fatigue than traditional color picker

For the question Q5 "I think this interaction is easy to cause fatigue", Color-in-Fist (Mdn = 1.0, SD = 0.83) scored significantly lower than the traditional color picker (Mdn = 2.0, SD = 0.64), $z = 2.308$, $p = 0.021 < 0.05$ (see Fig. 10). H5 was accepted.

(6) There was no significant difference in usability between Color-in-Fist and traditional color picker, but users preferred to use Color-in-Fist

Scores of the question Q6 "I think the interaction is easy to use" didn't differ significantly (see Fig. 10). However, the results for the question Q7 "I would like to use the interaction" showed that users preferred to use Color-in-Fist (Mdn = 1.5, SD = 0.5) rather than the traditional color picker (Mdn = 0.0, SD = 1.04), $z = 2.968$, $p = 0.003 < 0.01$. H6 was partially accepted.

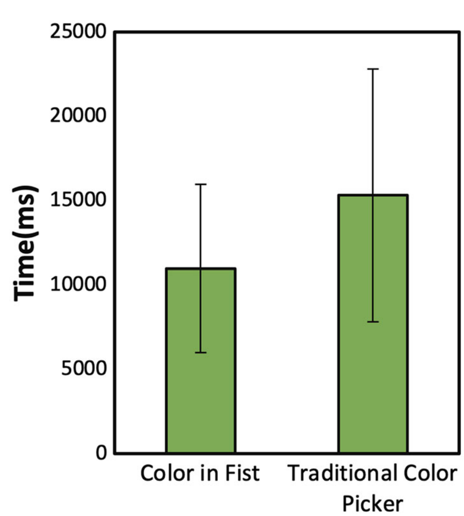

Fig. 9 Task completion time

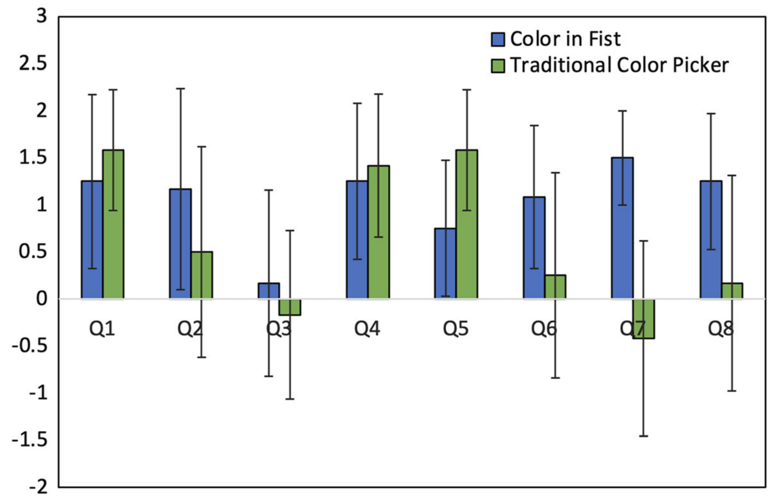

Fig. 10 Likert scale

4.6 Supplementary experiment

To further investigate whether there is interference effect of the three interaction metaphor channels, we conducted a supplementary experiment. We defined a interaction metaphor channel as a combination of an interaction motion and its associated visual feedback, since the performance of an interaction motion is inseparable from the visual feedback.

After the main experiment, the 12 users took part in the supplementary experiment. We chose two of the three interaction metaphor channels to combine into an experimental condition, so there were 3 conditions in total: hue and lightness (C1), hue and saturation (C2), saturation and lightness (C3). The program automatically recorded task completion time, accuracy and number of errors. This experiment used Latin square design to balance the effects of the condition order. This experiment lasted half an hour. Finally, we collected 12 participants * 12 trials * 3 blocks = 432 trials.

We used ANOVA and post-hoc test for data analysis. Results from ANOVA showed that only accuracy differred from each other significantly, $F = 8.878$, $p = 0.001$ (see Fig. 11). C1 had the highest accuracy (smallest color difference, Mdn = 2.02, SD = 0.40), followed by C2 (Mdn = 2.15, SD = 0.35), and C3 had the lowest accuracy (biggest color difference, Mdn = 2.64, SD = 0.48). Results from post-hoc test showed there was no significant difference between C1 and C2, while there was a significant difference between C1 and C3 ($p = 0.001$), so as C2 and C3 ($p = 0.013 < 0.05$).

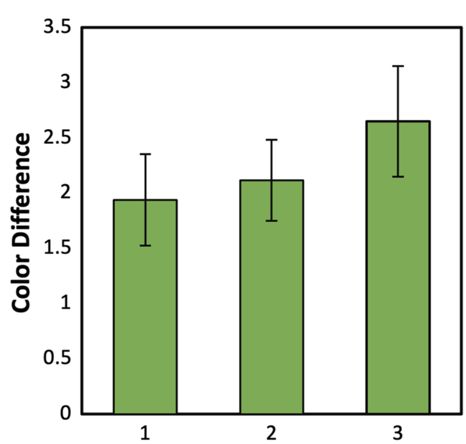

Fig. 11 Color difference in supplementary experiment

5 Discussion

(1) Efficiency

Color-in-Fist was significantly more efficient than traditional color picker because it allowed users to select and adjust all three dimensions (hue, saturation and lightness) at the same time and presented feedback of the selected color synchronously. We have also noticed that Color-in-Fist became more efficient as users became more proficient.

(2) Accuracy

Accuracy of Color-in-Fist is not significantly different from the traditional color picker, suggesting that Color-in-Fist could improve selection efficiency while maintaining accuracy.

The results of supplementary experiment showed that for the combination of saturation and lightness channels, accuracy was lower and the interference effect was more pronounced compared to the other two combinations. There were two possible reasons. On the one hand, the palm position was determined by the hand movement, but the grasping motion had an effect on the palm position, leading to a cumulative error of the two interaction motions. On the other hand, users were less sensitive to color changes caused by saturation and lightness at the same time.

(3) Error

There was no significant difference in number of errors between Color-in-Fist and traditional color picker. However, the reasons were different. When using Color-in-Fist, Thumb Trigger gesture was not easy recognise once the inside of palm is facing users, making it difficult to trigger confirmation. Besides, users needed to keep thumb separate from the other four fingers consciously. Once relaxing, confirmation would be triggered incorrectly. When using the traditional color picker, errors were mainly caused by the jump release when dragging the cursor.

(4) Learnability

In terms of learnability, there was no significant difference between Color-in-Fist and the traditional color picker, suggesting that the metaphor we designed was as easy to learn as the traditional color picker. The traditional color picker was easy to understand and remember, because users were able to refer to previous interaction experiences under WIMP paradigm without too much learning time. Although the set of hand motions we designed are novel relatively, users were able to understand them quickly with the help of the metaphor, reducing learning and memory burden.

(5) Fatigue

There were two reasons why Color-in-Fist caused less fatigue. For one thing, it didn't require users to adjust back and forth between two components, reducing task completion time and fatigue. For another, users didn't need to maintain Middle Airtap gesture for long time, and therefore, their muscles did't need to be under tension for long. However, when selecting purple and green, to compensate for the lack of device recognition, users had to roll their hands in a wide range leading to fatigue. In the future, we may adjust the mapping range to address this problem.

(6) Usability

The usability of Color-in-Fist was comparable to that of traditional color picker, but users' feedback was positive generally. A user said, "The metaphor helped me remember the gestures easier and understand color selection better". They preferred to use Color-in-Fist rather than the traditional color picker, because Color-in-Fist gave them confidence. It not only provided users with a sufficient sense of control, but also made interaction more smooth and natural. Although it takes some time to master, the advantages, especially in efficiency, are enormous. As another user said, "Learning to use Color-in-Fist is like learning to ride a bike, if you want to go far away, riding is obviously much faster than walking".

6 Conclusion

We presented a mid-air interaction metaphor for color selection that allowed users to select hue, saturation and lightness simultaneously using mutually independent, intuitive hand motions. We conducted a user study to evaluate the performance of this interaction technique. The results showed that it improved the efficiency of color selection while ensuring accuracy and helped users understand hand motions, making color selection interaction more smooth and natural.

In future work, on the one hand, we will propose solutions to the problems of insufficient accuracy and poor device recognition; on the other hand, we will apply this interaction metaphor to other scenarios where mid-air interaction is needed.

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