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Evaluating the Effect of Outfit on Personality Perception in Virtual Characters

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Abstract: Designing virtual characters that are capable of reflecting a sense of personality is a key goal in research and applications in virtual reality and computer graphics. More and more research efforts are dedicated to investigating approaches to construct a diverse, equitable, and inclusive metaverse by infusing expressive personalities and styles into virtual avatars. While most previous work focused on exploring variations in virtual characters' dynamic behaviors, characters' visual appearance plays a crucial role in affecting their perceived personalities. This paper presents a series of experiments evaluating the effect of virtual characters' outfits on their perceived personality. Based on the related psychology research conducted in the real world, we determined a set of outfit factors likely to reflect personality in virtual characters: **color**, **design**, and **type**. As a framework for our study, we used the "Big Five" personality model for evaluating personality traits. To test our hypothesis, we conducted three perceptual experiments to evaluate the outfit parameters' contributions to the characters' personality. In our first experiment, we studied the **color** factor by varying color *hue*, *saturation*, and *value*; in the second experiment, we evaluated the impact of different *neckline*, *waistline*, and *sleeve* **designs**; and in our third experiment, we examined the personality perception of five outfit **types**: *professional*, *casual*, *fashionable*, *outdoor*, and *indoor*. Significant results offer guidance to avatar designers on how to create virtual characters with specific personality profiles. We further conducted a verification test to extend the application of our findings to animated virtual characters in augmented reality (AR) and virtual reality (VR) settings. Results confirmed that our findings can be broadly applied to both static and animated virtual characters in VR and AR environments that are commonly used in games, entertainment, and social networking scenarios.

Keywords: virtual agents; virtual reality; augmented reality; perception; personality evaluation; nonverbal expression

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1. Introduction

One important focus in VR and AR research is to develop effective virtual characters for applications like computer gaming, social interaction, virtual story systems, online education, etc. To represent real humans that exist in the physical world, avatars in digital environments must be able to convey personality, mood, and emotions [1–7]. Even though research remains active in the area of constructing computational frameworks for designing expressive virtual characters, most efforts have been dedicated to modalities like language, gestures, body motion, eye movement, and facial expression. Little is known about how virtual characters' visual appearance, such as outfits, impacts their perceived personality. To bridge the gap in research, this work investigates the influence of outfits on virtual characters' perceived personality, enabling avatars to be created effectively to represent authentic humans with desired personalities, which promotes a more diverse, expressive, and inclusive virtual demographic in digital realms like the metaverse.

An outfit demonstrates a wearer's taste, mood [8], style [9], and social identity [10], and it plays a significant role in providing nonverbal cues [11] in communication. Both

Naumann et al. [12] and Fiore and DeLong [13] show that personality can be reliably inferred from peoples' clothing, which is a key channel of information. This paper examines how outfits impact personality perception of avatars in the virtual realm. We draw our insights and stimuli design from previous psychological literature to carefully select three main factors in outfits and systematically evaluate the associations people make between outfit variations and personality traits for virtual characters through a series of perceptual experiments.

According to previous psychological work, aspects of an outfit, such as color tone, darkness [13], saturation [9], collar, neckline, waistline [13], skin-revealing design [11], practicality [11], and professionalism [8,10], all impact the personality traits perceived in real humans. Hence, we categorized three main outfit factors—**color**, **design**, and **type**—that likely influence a virtual character's perceived personality. For each main factor, we further organized a set of outfit parameters as listed in Table 1 and performed a perceptual experiment to test our hypothesis. The hue, saturation, and value (HSV) model is used for the **color** factor, where red, green, and blue *hues*, high and low *saturation*, and light and dark *values* are examined in the first experiment. The **design** of *neckline*, *waistline*, and *sleeves* is evaluated in the second experiment. Five **types** of outfits, including *professional*, *casual*, *fashionable*, *outdoor*, and *indoor*, are studied in the third experiment. In order to create a sufficient variety of outfits on 3D virtual characters, social media applications Snapchat [14] and Bitmoji [15], which support expression at the demographic level, are utilized for experiment implementation. The factors and parameters in experiments have a good correspondence to common outfit options offered to virtual character designers and end users. We use the Big Five model [16–18], which has become a standard in psychology research, to evaluate the perception of virtual characters' personalities. The model consists of five traits: extraversion, emotional stability (EMS), agreeableness, conscientiousness, and openness to experience, and adjectives associated with these traits are listed in Table 2.

The great majority of our experiments yielded significant results, and the detailed findings are reported in Section 4. These results suggest that people do reliably associate what virtual characters are wearing with their personality traits. Factor analysis on the three experiments' ratings (in Section 4.4) indicates that outfit manipulation offers finer-grained influence on the five traits than motion adjustment in modalities such as gestures [1]. We propose outfit guidelines for creating avatars with specific personalities in Section 5.1. To generalize the applicability of our outfit findings and guidelines, we further conducted a verification test in an AR setting in the scenario of social communication and confirmed that significant outfit influence on perceived personality persists in the presence of animations.

To the best of our knowledge, this is the first work that systematically examines the impact of outfit parameters on virtual characters' personalities. Previous work either conducted a study in the physical world, investigating the effect of one specific outfit feature on real humans' one personality trait, or focused on studying the impact of virtual characters' animations and behaviors, with characters' appearance largely ignored. In comparison, our work involved comprehensive experiments on multiple outfit factors and parameters in the virtual realm and reported their impact on all five personality traits. We further integrated our outfit guidelines in a separate verification test and confirmed the broad applicability of our findings to both static and animated characters in AR and VR worlds. We summarize the fundamental contributions of our work as follows:

- We systematically designed and implemented a collection of experiments to better understand how outfits' **color**, **design**, and **type** impact virtual characters' perceived personality.
- We analyzed experimental results and summarized guidelines useful for designing avatars with specified personalities in the virtual realm.
- We discovered through factor analysis that outfit manipulation offers finer-grained impact on virtual characters' perceived personality than motion adjustment.
- We verified the broad applicability of our findings for animated virtual characters in AR settings.

Table 1. Main outfit factors and parameters.

Factors	*Parameters*	Values
Color	*hue*	red, green, blue
	saturation	high, low
	value	regular, dark
Design	*neckline*	round neck, shirt collar, turtleneck, U-neck
	waistline	high, regular
	sleeves	long, short, sleeveless
Type	*professional*	suit, tuxedo, trench coat
	casual	bomber, denim jacket, hoodie
	fashionable	leather jacket, animal print coat, plush top
	outdoor	down puffer, windbreaker, utility vest
	indoor	cardigan, pajamas, shirt dress

Table 2. Descriptions associated with the Big Five traits. Bold adjectives are used in the Ten Item Personality Inventory (TIPI) Questionnaire.

Trait	High	Low
Extraversion	assertive, active, **extraverted**, **enthusiastic**	passive, solitary, **reserved**, **quiet**
EMS	peaceful, confident, **calm**, **emotionally stable**	neurotic, vulnerable, **anxious**, **easily upset**
Agreeableness	friendly, helpful, **sympathetic**, **warm**	malicious, selfish, **critical**, **quarrelsome**
Conscientiousness	controlled, careful, **dependable**, **self-disciplined**	inefficient, unreliable, **disorganized**, **careless**
Openness	creative, cultured, **open to new experiences**, **complex**	shallow, ignorant, **conventional**, **uncreative**

2. Related Work

Clothing is a form of nonverbal expression [19] and a systematic means of transmission of information about the wearer [20]. Many works in psychology have confirmed that information such as personality, emotion, and social identities can be reliably inferred from a person's outfit. Ref. [12] examined the accuracy of zero-acquaintance personality impressions that observers made based on physical appearance and reported that accurate judgments can be made for a variety of personality traits from an outfit in the form of full-body photographs without personal interaction. According to [21], observers can make accurate personality inferences from personal possessions, including full outfit, that agreed with self-ratings made by the owners of the possessions. Ref. [22] studied the causal relationships between clothing styles and personality traits. Significant predictive relationships were found between outfit preference and agreeableness and neuroticism traits in the Big Five personality model in the authors' follow-up work [8]. Ref. [23] confirmed that observers were able to perceive the social identity information presented in outfits selected by others to be representative of their personalities. Ref. [10] identified the links between clothing and self-concept and determined both public and private self-consciousness correlate to clothing attitudes and strategic use of clothing.

Based on findings from previous work, specific clothing features can be manipulated to elicit responses from observers. By using open-ended questions, Ref. [19] identified the collection of visual cues observers chose to use, e.g., fit, color, appropriateness, and overall assembly of an outfit, that leads to the impressions they make on others, including personality, behavioral traits, and social roles. Four clothing factors, i.e., exhibitionism, practicality, designer, and consciousness, are distilled in [11], and skin-revealing and fashionable designs, practical preferences, and occupational interests are investigated based

on personality traits. Ref. [13] evaluated clothing cues in personality perception using 25 sweaters of varying colors, body coverage, waist lengths, sleeve lengths, necklines, textures, and bulkiness features. Instead of using photos, actual garments were used, presenting physical features absent in pictorial stimuli. Eight outfits ranging from formal wear to evening wear to casual wear are presented by [8,22] to examine clothing preference based on the Big Five personality model. By extracting information such as outfit color, pattern, and silhouette from online celebrity images, ref. [9] trained a support vector machine (SVM) to accurately predict a person's personality. Previous work [24] manipulated the outfits of a virtual health counselor to be perceived as more professional, trustworthy, reassuring, and more persuasive regarding medical decisions. However, due to the scarcity of virtual assets and thus the difficulty of covering a variety of virtual outfits, very little research has been done to systematically investigate the impact of clothing features on personality perception of avatars in the virtual realm.

In addition to visual appearance, a considerable body of work has focused on investigating the impact of verbal and nonverbal behaviors on perceived personality in the psychology and virtual agent communities. Linguistic variations [3,25–27] and nonverbal behaviors, including body shape [19,28], body posture [29–34], interaction distance [32,35,36], gaze [37], facial expression [19], gesture [1,2,38], hand motion [39], and rendering style [40], have been confirmed to have significant influence on personality perception. Further, the effects of detailed verbal and nonverbal features like linguistic verbosity, content polarity [3], gesture rate [2], motion fluency [31,41,42], velocity [31,34,42,43], tension [44], rhythm [41], posture expansiveness, facial hair and attractiveness [19], and body height, weight, and surface [19,28] have been systematically investigated. In comparison to clothing features, Ref. [12] found that both dynamic cues (e.g., facial expression, etc.) and static cues (e.g., clothing, etc.), offer valuable information into personality judgment. Additionally, outfit cues were rated by observers as more typical and carrying more personality information than the behavioral cues in [21], though not verified to be transferable to virtual characters. These findings motivate our evaluation work of the impact of outfit variations on the perception of a virtual character's personality.

3. Stimuli Design and Implementation

While there has been little systematic research on outfits for virtual characters, variations in clothing have been shown to correlate to personality in the psychology literature (refer to Section 2 for more details). In this investigation, we selected three major factors in human perception, i.e., **color**, **design**, and **type**, from previous research. Our main hypothesis is that a virtual character's perceived personality varies based on the variations of these three factors, e.g., the type of outfit a virtual character is wearing, the color of the outfit, and the design of the outfit's neckline, waistline, and sleeves. To verify the hypothesis, we designed a collection of three experiments, each examining variations of one of the factors. Outfits were made for both male and female characters.

3.1. Stimuli Design

3.1.1. Outfit Color

Inspired by color features in [9,13], the HSV color model is used to examine the **color** factor instead of running random sampling on the RGB color palette. Thus, three fine-grained parameters, *hue*, *saturation*, and *value*, are explored. The color *hues* under investigation in our experiment are red, green, and blue. For each hue, we prepared one standard saturated color, its low-saturation light version, and another low-value, darker version. In order to better understand color, we further added three neutral colors—gray, white, and black—and examined their effects. To avoid any complications with the outfit design, simple T-shirts paired with gray pants are used in Experiment 1, with 12 varying top colors for male and female characters (illustrated in Figure 1).

Figure 1. Outfits in Experiment 1 with varying hues, saturation, and values for two genders. Superscript *f* and *m* indicate female and male versions, respectively.

3.1.2. Outfit Design

Skin-revealing features have been reported to correlate with perceived personality in psychology [11,13], and thus for the **design** factor, we focus on evaluating three design parameters: *neckline*, *waistline*, and *sleeves*. Selections for each parameter are listed in Table 1. By sampling the combinations of four necklines (round neck, turtleneck, U-neck, and shirt collar), two waistlines (high waist vs. regular waist), and three sleeve (long, short, and sleeveless) designs, we made 24 designs for two genders, totaling 48 characters, as illustrated in Figure 2. To avoid mixture with the color experiment, all tops in experiment 2 are white in color.

Figure 2. Combination of outfits in Experiment 2 with varying neckline, waistline, and sleeve designs for two genders.

3.1.3. Outfit Type

According to clothing features used in [8,11,22], such as exhibitionism, professionalism, practicality, and designer, we included five representative types of outfits—*professional*, *casual*, *fashionable*, *outdoor*, and *indoor*—in Experiment 3 to examine their impact on a virtual

character's perceived personality. For each outfit type, we selected three sets of full-body outfits for two genders to help mitigate any possible significant impact from a specific outfit selection and to better generalize the outfit type. We made 30 outfits (5 types × 3 variations × 2 genders). Detailed outfit configurations are listed in Table 3 and illustrated in Figure 3. During outfit selection, we tried to include similar color variation across types while still respecting the classic color association with a specific outfit, e.g., denim jackets are mostly seen in blue, trench coats are commonly in beige, and fashionable outfits often have more colorful patterns than other types. We regard such color association as intrinsic to the outfit type and did not make a deliberate effort to isolate them in Experiment 3.

Figure 3. Outfit variations of five types—*Professional*, *Casual*, *Fashionable*, *Outdoor*, and *Indoor* for two genders in Experiment 3.

Table 3. Full-body outfit configurations in Experiment 3 for five types, corresponding to the illustration in Figure 3.

Type	Top	Bottom	Footwear
P_1	blue suit	brown skirt	dark Mary Jane
P_2	black tuxedo	gray pants	black oxford
P_3	beige trench coat	gray pants	brown Chelsea
C_1	brown bomber	light jeans, rolled cuff	taupe loafer
C_2	denim jacket	dark jeans	blue flip flop
C_3	yellow pullover hoodie	tan cargo pants	olive loafer
F_1	black leather jacket	zebra-print skirt/ floral-print shorts	black high boots
F_2	cheetah-print fur coat	black leggings	combat boots
F_3	green knitwear/plush top	art print wide-leg	green high heel
O_1	yellow down puffer	beige cargo pants	gray sneaker
O_2	blue windbreaker	gray sweatpants	high-top sneaker
O_3	army utility vest	brown work pants	green Crocs
I_1	gray cardigan	lavender sweatpants	puffer slip-on
I_2	blue pajamas	N/A	plush slippers
I_3	white shirt dress	N/A	slide slippers

3.2. Implementation

3.2.1. Stimuli Implementation

To create virtual characters with all the aforementioned outfit variations, we used social media applications Bitmoji [15] and Snapchat [14], which support customizing 3D virtual characters with a large demographic diversity. The experimental outfits are configured in the Bitmoji app and rendered in the Snapchat app. First, we created male characters with medium weight and female characters with medium weight and medium breast body configuration in the Bitmoji app, on top of which, we customized different outfit selections. Although minor differences in outfit options for genders exist in the app, we tried to make similar outfits for gender counterparts. The created virtual characters are then posed in a natural standing posture with hands in pockets and rendered in a 3D scene with a solid gray background using the Snapchat app. The original rendered images are 894 $\times$ 1605 pixels in size, enclosing the character's full body. To remove the software logo, the images were further cropped to 716 $\times$ 1200 pixels, in which the virtual character takes up the central 330 $\times$ 1080 region. We then masked the head part in gray blocks to avoid complications with the influence of facial features.

3.2.2. Experiment Organization

To recruit participants for the experiments, we posted online ads on Twitter and personal homepage websites. We had a brief screening to make sure that the participants are above 18 years old and had reasonable English understanding skills and color vision. The study was organized into three online experiments, which were made and delivered to participants through Google Forms. The first experiment presented 24 rendered images of characters in outfits with different **color** *hues*, *saturation*, and *values* (as shown in Figure 1), and was estimated to be able to be completed in about 30 min. The second experiment presented 48 rendered images of characters in outfits with **design** variations (Figure 2) and was estimated to be able to be completed in about 60 min. The third experiment presented 30 rendered images of characters in different **types** of outfits (Figure 3), and the estimated completion time was 40 min. Due to the large amount of stimuli, we acknowledged the potential fatigue among participants during the experiments and tried an experiment organization that could help reduce the fatigue effect. As the experiments were organized in three Google Forms, participants could choose to work on the experiments separately, which allows for rest time in between if needed. Participants completed the experiments through the web browsers on their own devices at their own pace, with the resolution of the rendered image fixed at 716 $\times$ 1200 pixels. For each experiment, participants viewed one virtual character at a time for all the outfits in random order and rated characters' perceived Big Five personality traits using the Ten Item Personality Inventory (TIPI) questionnaire [45] on a 7-point Likert scale. Participants submitted their answers online and were compensated with Starbucks gift cards. We initially received responses from 39 participants, among which four incomplete answer forms were removed. Thus, the reported results were computed based on the ratings from the 35 participants (22 M, 13 F, ages ranged from 20$\sim$60 years old), with no further filtering applied. To be comparable and consistent with previous research in virtual characters' personality perception [1,39], we considered results to be significant at the 95% level ($p < 0.05$). With balanced data, we conducted post hoc analyses using Tukey tests as in previous work [39].

4. Experiment Results

4.1. Experiment 1—Color

This study explored how variations in color *hue*, *saturation*, and *value* (listed in Table 1) influence a virtual character's perceived personality traits. We used 24 outfits with 12 selected T-shirt colors for two genders in Experiment 1, as discussed in Section 3 and illustrated in Figure 1. Based on the previous outfit research in psychology [9], we hypothesized that:

- **H1**: Variations in *hue*, *saturation*, and *value* will significantly affect all personality traits perceived in virtual characters.
- **H2**: Warm hues will lead to high extraversion and agreeableness.
- **H3**: Reduced saturation will improve the perceived EMS, agreeableness, and conscientiousness.
- **H4**: Darker colors will be perceived as less extraverted and less open, but emotionally more stable and more conscientious.

Results

To evaluate the impact of different *hues*, we grouped the personality ratings of saturated red, denoted as R_s, low-saturation light red R_l, and low-value dark red R_d in the red group; similarly, we included $\{G_s, G_l, G_d\}$ in the green group and $\{B_s, B_l, B_d\}$ in the blue group for the two genders (gender superscript omitted here). Across the hue and gender groups, we ran a two-way ANOVA test to analyze their effects and interactions. From the ratings, no significant differences were found between genders. Warm hues in the red group significantly increased a virtual character's perceived extraversion and agreeableness but led to low emotional stability. In comparison, the blue group had the opposite effect as the warm hues. The findings confirm **H2**. However, the impact of hues is not significant on a character's perceived conscientiousness and openness.

To examine the effect of *saturation*, we grouped saturated colors R_s, G_s, and B_s in the high-saturation group and R_l, G_l, and B_l in the low-saturation group for the two genders and ran the two-way ANOVA test across the saturation and gender groups. Results show that low-saturated colors are perceived as significantly less extraverted, less open, more emotionally stable, agreeable, and more conscientious, part of which confirms **H3**. No significant differences were found between genders.

To understand the impact of *value*, which corresponds to the darkness of the colors, we grouped low-value dark red R_d, dark green G_d, dark blue B_d, and black N_b in the dark color group and compared their personality ratings with the regular group of R_s, G_s, B_s, and gray N_g. No significant gender differences were found in the personality ratings. The results confirmed **H4**. Darker outfits improved the virtual character's perceived emotional stability and conscientiousness and made characters look more introverted and less open. However, darker colors did not lead to significantly different agreeableness. The resulting analysis in Experiment 1 shows that *hue*, *saturation*, and *value* impact different personality traits, but not all five, which disconfirms **H1**. Significant results are listed in Table 4, and detailed ratings are shown in Figure 4b.

When analyzing the 12 experimental colors individually, each color achieved high or low personality ratings based on their corresponding *hue*, *saturation*, and *value*, which was generally consistent with the findings above. Neutral colors in the experiment included white N_w, gray N_g, and black N_b. Colors in the neutral group all achieved significantly high and low ratings in specific personality traits: N_b elicited the lowest extraversion, the lowest agreeableness, and the highest conscientiousness ratings; N_w led to the highest EMS rating; and gray N_g was perceived as the least extraverted and open. Detailed ratings for individual colors are shown in Figure 4a.

Table 4. Significant results for the outfit **color**, **design**, and **type** experiments.

Experiment	Traits	Effect	F-Test	Post hoc
Color	Extraversion	Color	$F_{11,816} = 45.743, p < 0.001$	Most Extraverted: $\{R_s, G_s\}$. Least Extraverted: $\{G_d, N_g, N_b\}$
		Hue	$F_{2,624} = 33.249, p < 0.001$	Red > {Green, Blue}
		Saturation	$F_{1,416} = 68.909, p < 0.001$	High Saturation > Low Saturation
		Value	$F_{1,556} = 49.282, p < 0.001$	Regular > Dark
	EMS	Color	$F_{11,816} = 23.497, p < 0.001$	Most Stable: $\{N_w, B_d, N_b\}$. Least Stable: $\{R_s, G_s\}$
		Hue	$F_{2,624} = 18.59, p < 0.001$	Blue > Green > Red
		Saturation	$F_{1,416} = 63.138, p < 0.001$	Low Saturation > High Saturation
		Value	$F_{1,556} = 76.735, p < 0.001$	Dark > Regular
	Agreeableness	Color	$F_{11,816} = 7.864, p < 0.001$	Most Agreeable: $\{R_l, R_d\}$. Least Agreeable: $\{N_b, N_g, B_s, B_d, G_s\}$
		Hue	$F_{2,624} = 23.305, p < 0.001$	Red > {Green, Blue}
		Saturation	$F_{1,416} = 14.739, p < 0.001$	Low Saturation > High Saturation
	Conscientiousness	Color	$F_{11,816} = 18.017, p < 0.001$	Most Conscientious: $\{G_d, B_d, N_b\}$. Least Conscientious: $\{G_s, B_s, N_g, R_s\}$
		Saturation	$F_{1,416} = 52.708, p < 0.001$	Low Saturation > High Saturation
		Value	$F_{1,556} = 140.516, p < 0.001$	Dark > Regular
	Openness	Color	$F_{11,816} = 25.61, p < 0.001$	Most Open: $\{G_s, R_s, B_l\}$. Least Open: $\{G_d, N_g\}$
		Saturation	$F_{1,416} = 20.712, p < 0.001$	High Saturation > Low Saturation
		Value	$F_{1,556} = 38.79, p < 0.001$	Regular > Dark
Design	Extraversion	Design	$F_{23,1632} = 19.46, p < 0.001$	Most Extraverted: $\{UHN, RHN\}$. Least Extraverted: $\{RRL, SRL, RRS, TRL, TRS\}$
		Neckline	$F_{3,1632} = 28.732, p < 0.001$	U-neck > {Shirt, Round} > Turtle
		Waistline	$F_{1,1632} = 457.137, p < 0.001$	High Waist > Regular
		Sleeves	$F_{2,1632} = 121.556, p < 0.001$	Sleeveless > Short > Long
	EMS	Design	$F_{23,1632} = 12.928, p < 0.001$	Most Stable: $\{TRL, RRS, SRL, RRL, TRS\}$. Least Stable: $\{UHS, URN, UHL, UHN\}$
		Neckline	$F_{3,1632} = 53.261, p < 0.001$	{Round, Turtle} > Shirt > U-neck
		Waistline	$F_{1,1632} = 24.705, p < 0.001$	Regular > High Waist
		Sleeves	$F_{2,1631} = 33.806, p < 0.001$	Long > Short > Sleeveless
	Agreeableness	Design	$F_{23,1632} = 15.934, p < 0.001$	Most Agreeable: $\{TRL, RRS, RRL, TRS\}$. Least Agreeable: $\{RHN, RHL, THL, SHN, SRN, RHS, UHN\}$
		Neckline	$F_{3,1632} = 4.77, p = 0.003$	{Turtle, Round} > {Shirt, U-neck}
		Waistline	$F_{1,1632} = 166.242, p < 0.001$	Regular > High Waist
		Sleeves	$F_{2,1632} = 32.416, p < 0.001$	Short > Long > Sleeveless
	Conscientiousness	Design	$F_{23,1632} = 17.367, p < 0.001$	Most Conscientious: $\{SRL, TRL, RRS, RRL, TRS, SRS\}$. Least Conscientious: $\{UHN, URN, UHL, THN, UHS, RHN\}$
		Neckline	$F_{3,1632} = 36.32, p < 0.001$	{Round, Turtle, Shirt} > U-neck
		Waistline	$F_{1,1632} = 109.165, p < 0.001$	Regular > High Waist
		Sleeves	$F_{2,1632} = 66.607, p < 0.001$	{Long, Short} > Sleeveless
	Openness	Design	$F_{23,1632} = 26.356, p < 0.001$	Most Open: $\{UHN, SHN, UHS\}$. Least Open: $\{SRL, RRL, TRL\}$
		Neckline	$F_{3,1632} = 14.28, p < 0.001$	U-neck > {Round, Shirt, Turtle}
		Waistline	$F_{1,1632} = 318.318, p < 0.001$	High Waist > Regular
		Sleeves	$F_{2,1632} = 81.468, p < 0.001$	Sleeveless > Short > Long
Type	Extraversion	Outfit	$F_{14,1020} = 42.504, p < 0.001$	Most Extraverted: $\{F_1, F_2, F_3\}$. Least Extraverted: $\{P_1, I_2, C_3\}$
		Type	$F_{4,1040} = 92.13, p < 0.01$	Fashionable > Outdoor > Casual > {Indoor, Professional}
	EMS	Outfit	$F_{14,1020} = 48.879, p < 0.001$	Most Stable: $\{P_2, P_3, C_3, O_1, C_2\}$. Least Stable: $\{F_1, F_2, F_3\}$
		Type	$F_{4,1040} = 122.386, p < 0.001$	{Professional, Casual, Outdoor} > Indoor > Fashionable
	Agreeableness	Outfit	$F_{14,1020} = 32.982, p < 0.001$	Most Agreeable: $\{C_3, I_1\}$. Least Agreeable: $\{F_1, P_2, F_2, P_1, F_3\}$
		Type	$F_{4,1040} = 74.872, p < 0.001$	{Casual, Outdoor, Indoor} > {Professional, Fashionable}
	Conscientiousness	Outfit	$F_{14,1020} = 54.41, p < 0.001$	Most Conscientious: $\{P_0, P_1, P_2\}$. Least Conscientious: I_3
		Type	$F_{4,1040} = 153.897, p < 0.001$	Professional > Outdoor > Casual > Fashionable > Indoor
	Openness	Outfit	$F_{14,1020} = 26.522, p < 0.001$	Most Open: $\{F_3, F_1\}$. Least Open: $\{P_1, P_2, I_2, I_1, C_3\}$
		Type	$F_{4,1040} = 60.636, p < 0.001$	Fashionable > Outdoor > Casual > {Indoor, Professional}

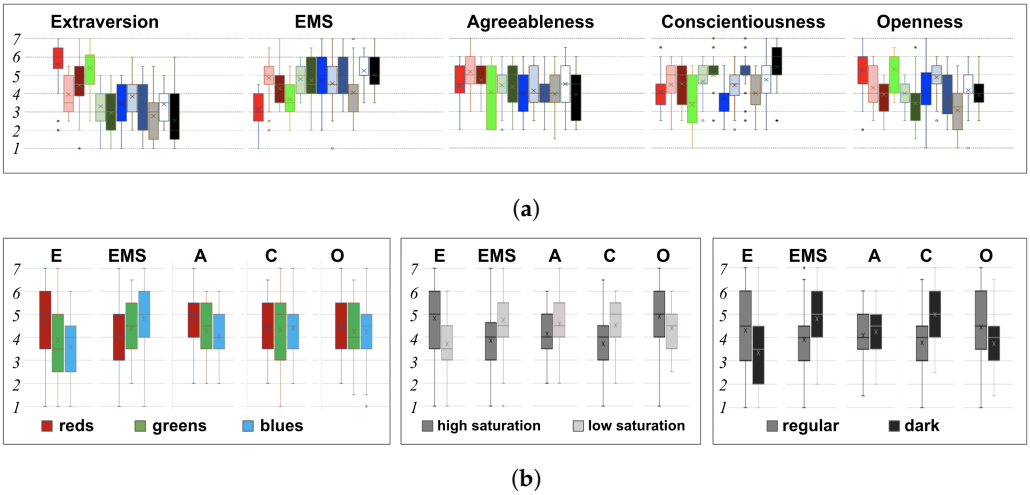


Figure 4. Personality ratings for Experiment 1. (**a**) Personality ratings for the 12 experimental colors. Bar color indicates the outfit color. (**b**) Personality ratings for different hues, saturations, and values. **E**, **EMS**, **A**, **C**, and **O** are short for extraversion, emotional stability, agreeableness, conscientiousness, and openness, respectively.

4.2. Experiment 2—Design

Experiment 2 was designed to examine how outfits' *neckline*, *waistline*, and *sleeve* variations (listed in Table 1) impact a virtual character's personality perception. We configured 48 outfits, covering different collars, waistlines, and sleeve lengths, as discussed in Section 3 and illustrated in Figure 2. For identification purposes, we use three letters to denote each design, where the first letter indicates neckline (R, T, S, U for round, turtleneck, shirt collar, and U-neck, respectively), the second letter indicates the waistline (H for high waist and R for regular waist), and the last letter indicates sleeve length (L for long, S for short, and N for no sleeves), with the superscript remaining for gender. According to previous psychological literature, skin-revealing designs are perceived as more confident, aggressive [11], spontaneous, and energetic [13]. Hence, for virtual characters, we hypothesized that:

- **H5**: Variations in the *neckline*, *waistline*, and *sleeves* will impact all personality traits in a significant way.
- **H6**: Low U-necks, high waistlines, and sleeveless designs will be perceived as more extraverted and open.
- **H7**: Shirt collars will lead to the highest perceived conscientiousness and emotionally stability.

Results

To analyze the experiment results, we conducted a four-way ANOVA with *neckline*, *waistline*, *sleeve*, and gender as the factors. Significant results are listed in Table 4, and personality ratings and main effects are shown in Figure 5. For the *neckline* design, results show that a high turtleneck design achieved the highest EMS and agreeableness, but the lowest extraversion ratings; U-neck was perceived as the most extraverted, the most open, the least emotionally stable, and the least conscientious design. Having a shirt collar led to lower agreeableness ratings than a turtleneck and a round neck, possibly due to its formality. Although a shirt collar design is rated as more conscientious than a U-neck design, it is in the same conscientiousness level as a turtleneck and a round neck, which disconfirms **H7**. For the *waistline* design, results show that high-waist outfits were perceived as significantly more extraverted and open, but less stable, less agreeable, and less conscientious, compared to a regular waistline. For the design of *sleeves*, the results indicated that a sleeveless design significantly increased a virtual character's perceived extraversion and openness, yet lowered a character's perceived EMS, agreeableness, and conscientiousness. Further, an increase in sleeve length positively correlated to perceived

EMS, but inversely correlated to extraversion and openness. However, long sleeves are not the most conscientious design, but rather were perceived as equally conscientious as short sleeves. Short sleeves are rated as significantly more agreeable than both long sleeve and sleeveless designs. Overall, the three design factors in the experiment—*neckline*, *waistline*, and *sleeve*—all led to significantly different personality ratings, which confirms **H5**. Skin-revealing designs (i.e., low U-neck, high waist, and no sleeves) all significantly improved a virtual character's perceived extraversion and openness, which confirms **H6**. Although no significant gender differences were found as a main effect, gender interacts with *neckline* and *waistline* designs on EMS, agreeableness, conscientiousness, and openness, as illustrated in Figure 6. Male characters wearing round, shirt, and turtleneck tops are perceived as more stable than female characters in the same neckline designs, but when in U-neck designs, they have a lower EMS level than female characters. Male characters are perceived as more agreeable than female characters while wearing shirt collar designs, but less agreeable in other neckline designs. For conscientiousness, male characters are more conscientious than female characters in round neck and shirt collar designs, but less conscientious wearing turtle and U-neck designs. Compared to female characters, male characters are more open, less stable, and less conscientious in high-waist designs but more stable, more conscientious, and less open in regular waistline designs.

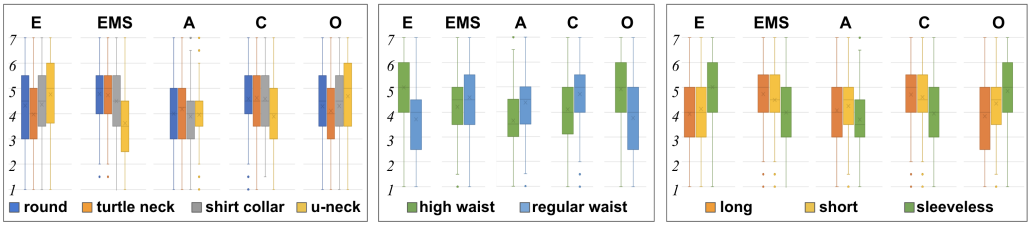


Figure 5. Personality ratings for different necklines, waistlines, and sleeves in Experiment 2.

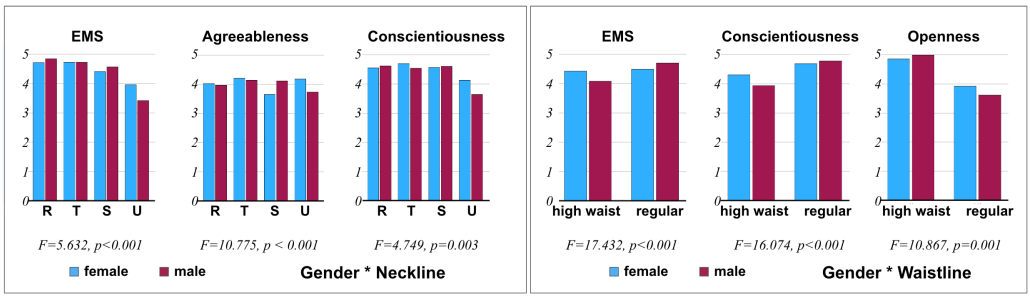


Figure 6. Gender * *neckline* and gender * *waistline* interaction effects in Experiment 2.

4.3. Experiment 3—Type

Thirty outfits of five types i.e., *professional*, *casual*, *fashionable*, *outdoor*, and *indoor*, were configured for both genders and examined in Experiment 3, with detailed specifications listed in Table 3 and illustrated in Figure 3. Based on the previous psychology literature [8,11,19], for the five outfit types, we hypothesized that:

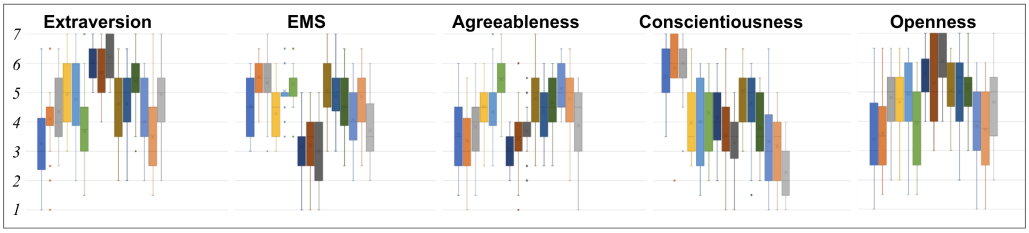
- **H8**: *Professional* outfits will be perceived as the most conscientious type.
- **H9**: *Casual* outfits will lead to the highest agreeableness.
- **H10**: *Fashionable* outfits will be perceived as the most extraverted.
- **H11**: *Outdoor* clothing will receive the highest ratings for openness.
- **H12**: *Indoor* outfits will be perceived as the least open type.

Results

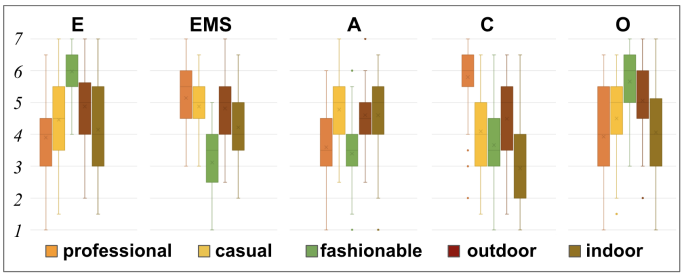
We ran a two-way ANOVA test to examine the effects of outfit type and gender. No significant gender influences were found from the personality ratings. The results verified the significant impact of outfit types on all personality traits. Among the five outfit types,

the *professional* outfits achieved the highest conscientiousness and the lowest extraversion, agreeableness, and openness levels, which confirms **H8**. *Fashionable* outfits were perceived as the least emotionally stable, the least agreeable, and the most extraverted, which confirms **H10**. *Fashionable* also received the highest ratings for openness, which were significantly higher than *outdoor*, thus disconfirming **H11**. *Casual* outfits were perceived as significantly more agreeable than *professional* and *fashionable* types but were in the same agreeableness level as *indoor* and *outdoor* outfits, which disconfirms **H9**. *Indoor* outfits achieved the least extraversion, the least conscientiousness, and the least openness levels, which confirms **H12**. Significant impacts and detailed rankings of the five outfit types on the Big Five personality traits are listed in Table 4.

Among the 15 outfit variations, the most extraverted outfits are all the fashionable outfits, F_1, F_2, F_3, and the least extraverted ones are the professional suit P_1, indoor pajamas I_2, and casual hoodie C_3. The most emotionally stable outfits are the professional tuxedo P_2 and trench coat P_3, the casual denim jacket C_2 and hoodie C_3, and the outdoor puffer O_1, and the least emotionally stable ones are all three fashionable outfits. The most agreeable outfits are the casual hoodie C_3 and indoor cardigan I_1, and the least agreeable ones are the professional P_1, P_2 and all the fashionable outfits. The most conscientious outfits are all the professional outfits, and the least conscientious one is the indoor shirt dress I_3. The most open outfits are fashionable F_1, F_3, and the least open ones are professional P_1, P_2, indoor I_1, I_2, and casual hoodie C_3. Personality ratings for each individual outfit are presented in Figure 7a, and ratings of the five types are illustrated in Figure 7b.



(**a**)



(**b**)

Figure 7. Personality ratings for Experiment 3. (**a**) Ratings for 15 individual outfits. From left to right are $P_1 \sim P_3, C_1 \sim C_3, F_1 \sim F_3, O_1 \sim C_3$ and $I_1 \sim I_3$, in order. (**b**) Ratings for five outfit types.

4.4. Discussion

The Big Five traits are generally regarded as orthogonal, although previous psychology literature [46] and gesture research [1] reported higher-order factors and substructure of the five personality traits and explained their cause as genetics and neurobiological substrates [47,48]. In particularly, with the same goal of generating virtual characters with desired personality profiles, Ref. [1] found that motion adjustments in gestures could only impact personalities in a 2D subspace rather than five: "plasticity", which includes extraversion and openness, and "stability", which includes EMS, agreeableness, and conscientiousness. Through principal component analysis (PCA), they reported that the two principal components (PCs) were sufficient to explain about 75% variance of the personality ratings. Although the personality impact from motion adjustment is mostly restricted in the 2D subspace, the authors suggested other modalities that convey preference and

identity claims, such as clothing choice, may help influence personalities in a finer and more independent way.

To better understand the manifold personality impacts from outfit manipulation, we conducted PCA on the Big Five ratings of the three outfit experiments. The Kaiser–Guttman criterion [49] indicates three components for the outfit type experiment and two components for the outfit color and design experiments, with eigenvalue 1 as the threshold. By inspecting the scree plot and to match the ∼75% explained variance used in [1], three PCs are retained for all three experiments, which better explain the substructure of personality ratings. The PCs were subjected to varimax rotation, and the loadings presented in Table 5 are very similar across the three experiments. Thus, different from the 2D personality subspace identified in [1], our experiments indicate that, separate from EMS and conscientiousness traits, agreeableness could be influenced more independently by outfit manipulation than by motion adjustment. Stated differently, outfit manipulation offers finer-grained personality influence compared to motion adjustment.

Table 5. Similar principal components in all three experiments, with explained variance presented in parentheses.

Trait	Experiment 1—Color (75.813%)			Experiment 2—Design (73.11%)			Experiment 3—Type (83.265%)		
	PC1	PC2	PC3	PC1	PC2	PC3	PC1	PC2	PC3
Extraversion	0.756			0.758			0.841		
Openness	0.845			0.846			0.914		
EMS		0.767			0.887			0.678	
Conscientiousness		0.878			0.636			0.925	
Agreeableness			0.98			0.977			0.953

5. Guidelines and Verification

5.1. Guidelines

Based on the experiment results, we propose guidelines for creating virtual characters with particular personalities.

Extraversion: To generate characters with high extraversion, designers can prioritize selecting fashionable outfits and design their outfits in warm, highly-saturated, bright colors, with low necklines and high waists, and without sleeves. On the contrary, for virtual characters to look more introverted, they can wear black or dark, low-saturated colored professional or indoor outfits with regular waist lengths, turtlenecks, and long sleeves.

EMS: To increase a virtual character's perceived emotional stability, designers can select professional outfits in low-saturated, dark, cool colors, or in pure white or black, with round neck or high turtleneck and long-sleeve designs. To be perceived as more neurotic and less stable, virtual characters can wear a fashionable low neckline and sleeveless designs in highly-saturated, warm colors.

Agreeableness: To make characters look more agreeable, they can wear casual outfits in warm, low-saturated colors, preferably having a round or a high turtleneck, a regular waist length, and short sleeves. Contrarily, to create less agreeable characters, professional or fashionable outfits can be selected. The outfits can be designed in black or cool colors with a shirt collar, a high waist, and no sleeves.

Conscientiousness: To increase the perceived conscientiousness, virtual characters can wear professional outfits in black or low-saturated, dark colors, with a regular waist length and long sleeves, avoiding U-neck designs. To make characters less conscientious, their outfits can be designed as indoor clothing, in highly saturated bright colors, with low necklines, high waists, and no sleeves.

Openness: To make virtual characters look more open, they can be designed to wear fashionable outfits in saturated colors, with low necklines, high waists, and a sleeveless design. On the contrary, for characters to be perceived as less open, they can wear professional or indoor outfits, preferably in low-saturated, dark colors, with a round or turtleneck or a shirt collar, in regular waist length, and with long sleeves.

5.2. Verification

To verify the applicability of our findings of virtual outfits discussed in Section 5.1, we further designed and conducted a verification test. The general use cases of virtual characters in games, user interfaces, virtual education, and social interactions are with animations. While the great majority of the outfit factors experimented with in Section 4 lead to significant differences in perceived personality, virtual characters are evaluated based on the rendered images, with a domain gap from virtual characters in animation. To generalize our guidelines to a broader scope of applications, a verification test was conducted using animated virtual avatars in the scenario of social communication, to represent the end users in the metaverse at the demographic level. Design options regarding the outfit factors and parameters were offered to users through the user interface of social media apps [14,15]. The test results confirmed that the significant outfit factors listed in Table 4 consistently carry a strong impact on personality perception for virtual characters in the presence of animations.

5.2.1. Test

For the verification test, we selected outfits that correspond to high and low ratings of each personality trait based on Table 4. Factors in outfit **color**, **design**, and **type** were investigated separately. For **color**, T-shirts described in Section 4.1 were used. According to Table 4, saturated red R_s was selected as the high extraversion, high openness, low EMS, and low conscientiousness configuration. Black N_b was selected as the high EMS, high conscientiousness, low extraversion, low agreeable, and low openness configuration. Low-saturated pink R_l was selected as the high agreeableness outfit. For **design**, we selected two outfit designs described in Section 4.2: turtleneck with regular waist and long sleeves TRL was selected as the high EMS, high agreeableness, high conscientiousness, low extraversion, and low openness configuration, and sleeveless U-neck with high waist UHN was selected as the high extraversion, high openness, low EMS, low agreeableness, and low conscientiousness configuration. For **type**, outfits in Section 4.3 were used. Leather jacket F_1 was selected as the high extraversion, high openness, low EMS, and low agreeableness configuration. Black suit P_2 was selected as the high EMS, high conscientiousness, low extraversion, and low openness configuration. Indoor cardigan I_1 was selected as the high agreeableness and low conscientiousness configuration. Detailed outfit selections are listed in Table 6. Note that each selected outfit was worn by characters of both genders. We denote high configuration of outfit for each personality trait as O_1 and low configuration of the personality trait as O_0, and leave the superscript to indicate gender. Thus, for the verification test, we have 16 characters, 8 in each of two genders wearing outfits $\{R_s, N_b, R_l, UHN, TRL, F_1, P_2, I_1\}$.

Table 6. High and low configurations for the outfit factors **color**, **design**, and **type** in the verification.

Trait	**Extraversion**		**EMS**		**Agreeableness**		**Conscientiousness**		**Openness**	
	High O_1	**Low O_0**	**High O_1**	**Low O_0**	**High O_1**	**Low O_0**	**High O_1**	**Low O_0**	**High O_1**	**Low O_0**
Outfit Color	R_s	N_b	N_b	R_s	R_l	N_b	N_b	R_s	R_s	N_b
Outfit Design	UHN	TRL	TRL	UHN	TRL	UHN	TRL	UHN	UHN	TRL
Outfit Type	F_1	P_2	P_2	F_1	I_1	F_1	P_2	I_1	F_1	P_2

For each virtual character in the selected outfit, we compiled a sequence of animations. To simulate the generic and neutral animations in most use cases, we included six balanced Bitmoji Snaps in the animation sequence to reflect multiple aspects of the virtual character: "thumbs up" and "disapproval" expressing positive and negative attitudes; "two-step dance" and "so sleepy" showing energetic and tired sides of the characters; and "water cooler" and "filing nail" for performing two daily activities (illustrated in Figure 8). Each snap is around 7∼8 s, which makes the compiled animation sequence approximately 47 s long (please see the Supplementary Materials Video S1 for more details). Snaps were

captured with an iPad in an AR environment, with a gray floor and a white wall as the background. Minor background color variations may occur due to the natural lighting changes in the room. There were no color variations for the outfits or for all the other virtual content. For each animation sequence, the video resolution is 720×1280 pixels, where the virtual character stays animated in the $(160, 520) \times (200, 800)$ region of the screen. A total of 16 videos were made, one for each virtual character in the selected outfit. As facial features and facial animations are not the focus of our work, we blurred the face area for all the videos.

Figure 8. Six animations used in the verification test. From left to right, they are: "thumbs up", "disapproval", "two-step dance", "so sleepy", "water cooler", and "filing nail", shown with a female character in the fashionable outfit F_1. Please see the Supplementary Video for more details.

We recruited 27 subjects (21 M, 6 F) in the same way as described in Section 4 to participate in the verification test. They were shown each video and then asked to rate the virtual character's five personality traits using the TIPI questionnaire on a 7-point Likert scale. Subjects were allowed to replay the clips as many times as they wanted. We hypothesized that high configurations of outfits would yield significantly stronger perceptions of the personality trait, in the presence of generic animations.

5.2.2. Results

Based on the subjects' ratings, for each personality trait between the high O_1^f, O_1^m and low O_0^f, O_0^m configurations, we ran a two-way ANOVA test to verify the effects and interactions of gender and outfit configurations. Detailed results are reported in Table 7 and illustrated in Figure 9. In general, high configuration outfits O_1 do receive higher ratings for the evaluated personality trait compared to low configuration outfits O_0; however, not all of them led to significant differences. High configurations in outfit **color** significantly increase virtual characters' perceived extraversion and EMS levels. High configurations in outfit **design** lead to significantly higher EMS, conscientiousness, and openness ratings. High configurations in outfit **type** significantly impact perceived extraversion, conscientiousness, and openness. In particular, there is no significant impact found on virtual characters' perceived agreeableness among varying configurations of all three outfit **colors**, **designs**, and **type** factors in this verification. Compared to the major significant results in Table 4, the diminished significance in this verification could be due to the extra information subjects drew from the neutral animations when making personality judgments, as in the previous experiments, personality cues were solely from static renderings. Although outfits' impacts are diluted, the significant results in the verification test still confirm the influence of outfit **color**, **design**, and **type** on virtual characters' perceived personalities in the presence of animations and suggest the general applicability of our outfit guidelines in the use case of animated characters. From another perspective, the results also reflect the important role that animation plays in virtual characters' personality perception. No significant gender effects and interactions were found in the verification test, which is consistent with previous experiments.

Table 7. Results of verification test, with significant impacts highlighted in bold.

	Effects	Extraversion	EMS	Agreeableness	Conscientiousness	Openness
Color	color	$\mathbf{F = 6.817}$ $\mathbf{p = 0.01}$	$\mathbf{F = 4.371}$ $\mathbf{p = 0.039}$	$F = 1.18$ $p = 0.28$	$F = 0.968$ $p = 0.327$	$F = 0.733$ $p = 0.394$
	gender	$F = 0.58$ $p = 0.448$	$F = 0.754$ $p = 0.387$	$F = 0.053$ $p = 0.818$	$F = 0.029$ $p = 0.866$	$F = 1.472$ $p = 0.228$
	gender * color	$F = 0.003$ $p = 0.957$	$F = 0.125$ $p = 0.724$	$F = 0.183$ $p = 0.67$	$F = 0.029$ $p = 0.866$	$F = 0.005$ $p = 0.943$
Design	design	$F = 0.531$ $p = 0.468$	$\mathbf{F = 7.788}$ $\mathbf{p = 0.006}$	$F = 1.982$ $p = 0.162$	$\mathbf{F = 32.775}$ $\mathbf{p < 0.001}$	$\mathbf{F = 8.053}$ $\mathbf{p = 0.005}$
	gender	$F = 0.009$ $p = 0.924$	$F = 0.053$ $p = 0.819$	$F = 0.737$ $p = 0.393$	$F = 0.737$ $p = 0.392$	$F = 0.725$ $p = 0.397$
	gender * design	$F = 0.122$ $p = 0.728$	$F = 0.182$ $p = 0.67$	$F = 0.095$ $p = 0.758$	$F = 0.02$ $p = 0.886$	$F = 0.02$ $p = 0.887$
Type	type	$\mathbf{F = 5.387}$ $\mathbf{p = 0.022}$	$F = 2.231$ $p = 0.138$	$F = 0.398$ $p = 0.53$	$\mathbf{F = 4.962}$ $\mathbf{p = 0.028}$	$\mathbf{F = 6.674}$ $\mathbf{p = 0.011}$
	gender	$F = 0.433$ $p = 0.512$	$F = 0.893$ $p = 0.347$	$F = 0.099$ $p = 0.753$	$F = 0.006$ $p = 0.939$	$F = 0.078$ $p = 0.78$
	gender * type	$F = 0.203$ $p = 0.653$	$F = 0.023$ $p = 0.879$	$F = 0.064$ $p = 0.801$	$F = 0.053$ $p = 0.818$	$F = 0.047$ $p = 0.828$

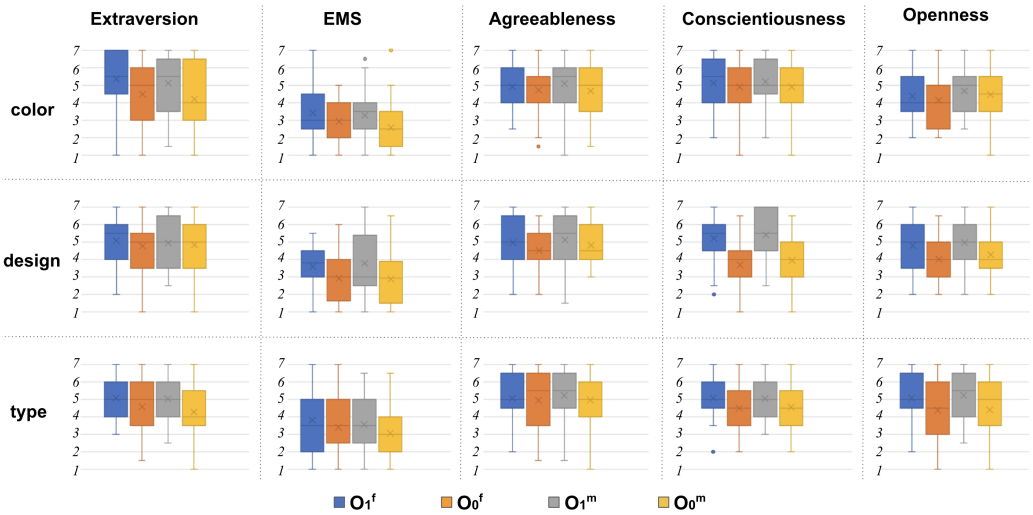


Figure 9. Personality ratings of high and low configurations in outfit **color**, **design**, and **type** factors among male and female characters in the presence of generic animations.

6. Conclusions

Understanding how outfit variations are associated with personality perception is a key component in creating diverse and believable virtual characters. This work focused on evaluating the effect of three main outfit factors, i.e., **color**, **design**, and **type**, on a character's perceived personality through a series of experiments. The significant results reported here provide fundamental insights into how color *hue*, *saturation*, and *value*; design of *neckline*, *waistline*, and *sleeves*; and outfit types of *professional*, *casual*, *fashionable*, *outdoor*, and *indoor* influence virtual characters' perceived personalities. We summarized general guidelines for character designers aiming to create avatars with specific personality profiles. Our verification test confirmed that the outfit guidelines are largely valid for virtual characters in the presence of animations. While the study was designed thoughtfully to reduce the fatigue effect, due to the large amount of stimuli, we acknowledge that participant fatigue could potentially impact the results. To overcome this limitation, we will further investigate better approaches to minimize the fatigue effect in future work. With the emergence of neural radiance fields (NeRF), it is possible to procedurally generate digital humans. In the

future, it would be interesting to further research how to integrate outfit guidelines into human asset generation pipelines.

Although we evaluated many outfit parameters in this work, outfit perception research is by no means complete. In the future, it will be worthwhile to investigate the effect of outfit patterns, prints, and logos on virtual characters' perceived personalities. Using physically based rendering (PBR), outfits' fabrics and hygiene conditions can be well visualized to reflect avatars' specific characteristics. It is also worth investigating how outfits' body fit, which is commonly implemented through mesh deformation algorithms in industry, conveys characters' personalities.

As the findings in this work indicate, visual appearance could carry larger and finer-grained impacts relative to body movement on characters' perceived personalities. In addition to outfits, virtual characters' visual appearance includes body shape, facial features and expressions, facial hair and hair styles, etc., and each could be an interesting research topic. Accessories such as hats, glasses, and jewelry may also provide significant personality information and need to be further explored.

We hope that our work can provide general guidelines for designing outfits for virtual characters, and we encourage more research in this direction.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/virtualworlds3010002/s1, Video S1: Evaluating the Effect of Outfit on Personality Perception in Virtual Characters.

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