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Personality and other individual differences play a role in art-viewing experiences but have proven difficult to study in field environments. Thus, I aimed to explore how personality can be reflected in encounters with art in the context of museums, using a virtual art gallery tool that allows participants to visit researcher-designed art galleries. A sample of n = 264 adults recruited from the Prolific.co survey platform was asked to respond to individual difference and personality questionnaires before freely wandering around a virtual gallery. The gallery spanned three rooms and contained 24 artworks (half abstract and half representational) of various sizes and genres. Using structural equation modeling and multilevel models, I examined how the Big Five personality traits, aesthetic fluency, and aesthetic responsiveness predicted visit behavior—including visit time, distance traveled, artwork viewing ratio, artwork viewing time, and artwork viewing distance—in a virtual gallery space. Openness to experience was shown to have robust, positive effects on all five behavioral outcomes: visit time, distance traveled, artwork viewing ratio, artwork viewing time and viewing distance. Extraversion also accounted for many viewing behaviors, including negative associations with visit time, distance traveled, viewing time, and viewing distance. Within-person, artwork area predicted increased viewing time and distance. Representationalness was also associated with longer viewing times. Further, openness showed interactions with representationalness and artwork area that strengthened their effects on viewing time and distance; extraversion, meanwhile, tempered the relationships between representationalness and both viewing time and distance outcomes. Taken together, this project has demonstrated how the individual patterns in thought, behavior, and experience that we come

to the museum with affect our visit experience in ways that are difficult to capture with traditional field methods.

HOW DO PERSONALITY AND ART-RELATED INDIVIDUAL DIFFERENCES SHAPE ART VIEWING BEHAVIOR IN THE MUSEUM? EXPLORATIONS FROM A VIRTUAL GALLERY

by

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Approved by

Dr. Paul J. Silvia
Committee Chair

DEDICATION

I dedicate this work to my loving husband, Martin. When art galleries across the world were forced to shut their doors, he decided to build me my own. When, instead of hanging my own art, I decided to hijack his gift for use in my research, he gave me the keys. And when, after our inaugural project together, I named his creation after a man-eating giant, he didn't blink. I could not ask for a better collaborator or life partner.

APPROVAL PAGE

This thesis written by Rebekah M. Rodriguez has been approved by the following committee of the Faculty of The Graduate School at The University of North Carolina at Greensboro.

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CHAPTER I: INTRODUCTION

There is an enduring idea among art scholars that *art depicts the world*. Plato famously viewed art as *mimesis*, or an imitation of nature. Modernists at the turn of the 20th century fought in the trenches of the art world to dismantle this idea. But in doing so, they only strengthened it. A century later, the topic of art is gaining steam in the field of psychology because encounters with art are windows into human cognition (Zaidel, 2013), personality (Swami & Furnham, 2014), and emotion (Silvia, 2005).

Museums provide an optimal environment for art viewing but are often incompatible with the needs of those trying to study it. Field studies in museums often require specialized equipment, lots of time, and a large and eager team of research assistants to be successful. Further, museum-goers must be willing to give up their valuable time—which may be a lot to ask given that their motivations for visiting vary (Cotter et al., 2020)—and museum staff must be willing and able to assist with the complex needs of study designs. These challenges make data collection in real-life museums difficult when not entirely impossible to conduct.

Thus, in the present research, I aimed to explore how personality can be reflected in encounters with art in the context of museums, using a virtual art gallery simulation tool that allows participants to visit researcher-designed art galleries. I examined how a broad range of personality traits and other individual differences predict visit behavior—including visit time, distance traveled, global viewing ratio, artwork viewing time, and artwork viewing distance—in a virtual gallery space. Taken together, this project will show how the individual patterns in thought, behavior, and experience that we come to the museum with affect our visit experience in ways that are difficult to capture with traditional field methods.

Psychology of Museum Visit Behaviors

To many empirical aesthetics researchers, vision scientists, museum personnel, philosophers of art, and psychologists, *people viewing art* depicts the world. And these days, much of the world's most important artwork is housed in art museums and galleries. Thus, art viewing in museum or gallery contexts, and the visit behavior that surrounds it, are becoming increasingly studied as part of a greater view into how we encounter art (Pelowski et al., 2017).

But what does an art museum visit look like? Jeffrey Smith, education researcher and former head of the Office of Research and Evaluation at the Metropolitan Museum of Art, estimates that people typically spend one and a half to three hours in a museum, depending on the preferences of the visitor and the size of the institution (Smith, 2014). Visitors tend to "visit together—look alone," often splitting up to look at exhibits by themselves before rejoining each other when they are done (Smith, 2014). Once inside the institution, visitors are much more likely to visit exhibits or galleries near the entrance, often with a bias to taking right turns as they navigate around the edge of the space and neglecting areas in the center (Serrell, 1997).

Viewing Time

Viewing time has proven to be a major variable in museum-based psychological studies of art. For example, viewing time has been examined in terms of how it affects our visit outcomes like visit satisfaction and museum fatigue (Specht, 2010), and how it is affected by things like our social interactions with other visitors (Tröndle et al., 2012) or the length of labels that accompany the artworks we view (Smith et al., 2006; Smith et al., 2017; Specht, 2010).

In terms of time spent viewing artworks in museums, people tend to cluster into three levels of viewing time: people who "sample" a work, looking at it for only a few seconds; people who "consume" an artwork, examining it for a little longer; and people who "savor" an artwork, consuming it for upwards of a minute or so (Smith, 2001). But by far, museum visitors spend a short time viewing individual paintings. In a study of viewing time within the Metropolitan Museum of Art, Smith and Smith (2001) found that people spend a mean time of 27.2 s viewing a work of art, with a median time of just 17.0 s. Fifteen years later, Smith et al. (2017) successfully replicated this effect again at the Art Institute of Chicago with a larger sample and a more diverse set of artworks. This effort yielded remarkably similar results: there was a mean viewing time of 28.63 s and a median time of 21.00 s. Even shorter viewing times were observed in two discrete data collection periods within the Belvedere Museum in Vienna, with artworks including both painting and sculpture (M_1 = 15.44 s, M_2 = 14.93 s; Mdn_1 = 8.58 s, Mdn_2 = 8.07 s; Reitstätter et al., 2020). Notably, similar viewing times to Smith and Smith (2001) and Smith et al. (2017) were reported by Carbon (2017), who used human judges to time participants. Similar viewing times between Reitstätter et al. (2020) and Estrada-Gonzalez et al. (2020) were also recorded—both using mobile eye tracking equipment. Finally, people tend to view artworks for the shortest time in virtual galleries (M = 5.92 s; Rodriguez-Boerwinkle et al., 2022), but this finding needs to be explored more. For more details on viewing times from the studies discussed, see Table A1.

Viewing Distance

While viewing time, or how long someone views an artwork, is a popular variable in the psychology of the arts, viewing distance—how far someone looks from—has received little attention from arts researchers. An early examination of viewing distance was completed by Clarke et al. (1984), who varied the projection size of a set of art images and asked participants to view the images from whatever distance "looks best" or felt the most "comfortable." In both conditions, participants chose to stand further from larger artworks than smaller ones. Over three decades after the findings from Clarke et al. (1984), Carbon (2017) found that the effect held with a high positive correlation between artwork area and viewing distance using real artworks in a gallery environment.

More recently, Estrada-Gonzalez and colleagues (2020) examined viewing behaviors, including viewing distance, in an art museum using mobile eye tracking equipment and expanded the literature on viewing distance with the most in-depth examination to date. In addition to showing that image area had an effect on viewing distance, they found that viewing distance was predicted by formal image properties. Basic viewing distance findings regarding artwork area and viewing distance have been also extended by Rodriguez-Boerwinkle and colleagues (2022) to include 3D virtual gallery spaces. Together, these studies showed that preferred viewing distance increases as artwork size increases, regardless of whether the viewing space was physical or virtual, but that other variables such as the formal qualities of an image may moderate this relationship.

Personality and Visit Behavior

Our visit behaviors are like some others and like no other person's. Their idiosyncrasy—marked by broad trends but wide variability—may be explained by our personalities. Yet while personality factors, particularly openness to experience, have strong ties to aesthetic experiences (Silvia et al., 2015), a preference for abstract art (Gridley, 2013), and even diversity of emotions experienced during an art museum visit (Rodriguez et al., 2021), their connection to visit behaviors is not well-documented. Currently, only a handful of studies investigate the relationship between personality and visit behavior (Mastandrea et al., 2009; Rodriguez et al., 2021).

Research into personality largely relies on the Big Five, or the five-factor model

(Digman, 1990; Goldberg 1993), or the HEXACO model (Lee & Ashton, 2004). Both models are commonly measured with large self-report scales like the NEO PI-3 (240 items; McCrae & Costa, 2007) and the HEXACO PI-R (100 items; Lee & Ashton, 2006) to reflect the facets of the model. But due to the length and complexity of these comprehensive personality inventories (and even their accompanying 60 item short forms), they have not often been used for field research in museums.

In perhaps what is the most relevant work to studying the effect of personality on visit behaviors in an art museum, Mastandrea et al. (2009) compared people who chose to visit museums of modern art versus museums of ancient art using the *Openness to Experience* factor of the NEO and the *Experience Seeking* subscale of the Sensation Seeking Scale (Zuckerman et al., 1978). They found that although the two groups had no difference in openness to experience, modern-art visitors scored higher in experience seeking than ancient-art visitors.

Challenges to Studying Personality and Visit Behavior in Real Settings

Personality and visit behavior are important aspects of visitor studies but are challenging to systematically observe and assess in real museum environments. Although personality is a popular focus of lab and survey research, it is difficult to measure in museum visitors because most comprehensive personality scales are too long to practically use in the field where research assistants with clipboards must collect data from visitors who often have strict time constraints and conflicting goals. Researchers have tried to address this challenge in a number of ways. For example, Rodriguez and colleagues (2021) recruited two participant branches—community museum visitors and university students—so that longer self-report scales could be administered to the student group in the lab before they visited the museum. Some researchers have alternatively focused on demographic variables such as gender, age, or training in the arts that are quick to collect (Brieber et al., 2014; Mokatren et al., 2019); still others have narrowed their scope to include only what they think are the most salient personality factors (e.g., openness to experience and sensation seeking; Mastandrea et al., 2009).

Likewise, while timing and tracking visit behavior are at the core of understanding visitor experience and central to exhibition evaluation (Yalowitz & Bronnenkant, 2009), much of it is still reliant on outdated methods or hindered by tools that are still too immature to be reliable. For example, studies that employ pencil (or spreadsheet) and stopwatch approaches to timing participant behaviors like viewing specific artworks, stops at exhibitions, or overall visit duration run into two problems: human error and time intensiveness. Smith and Smith (2001) noted problems with determining when an artwork viewing began and, although they were able to collect an adequate sample size, they limited their data collection to just six artworks out of the Met's collection. Later, Smith et al. (2017) and Carbon (2017) both used human timers (and judges of viewing distance in the latter case), and similarly only had the human resources to collect data on less than 10 artworks.

These problems aren't restricted to traditional observational methods, however. Videotaping has become a popular means of recording visitor behavior due to the ability to rewatch and code recordings, but its use is constrained to small areas that can be covered with a camera and it is often not feasible to record detailed viewing behavior (Yalowitz & Bronnenkant, 2009).

Mobile eyetracking has started to gain popularity for studying visitor behavior, and its ability to provide precise, first-person viewing data gives it promise to become a powerful tool (Milekic, 2010), but the technology's use in field research is still hitting snags. Reitstätter et al. (2020) lamented the "countless hours in data preparation" (p. 17) spent manually annotating gaze data that had been collected by a mobile eye tracking system and noted that “reported MET [Mobile Eye Tracking] data still lacks accuracy” (p. 3). Worse still, during a museum test of calibration-free mobile eyetracking equipment, Dare and colleagues (2020) reported that data quality from the device was not sufficient to carry out their intended analyses, despite collecting results from over 800 participants.

Virtual Galleries as a Tool for Research

One emerging solution to these challenges comes with the use of virtual gallery applications as alternatives to traditional in-person museum spaces. Virtual gallery tools have developed along two lines: immersive virtual reality (VR) environments often viewed using head mounted displays, and non-immersive 3D environments viewed on single screens, such as desktop PCs. The first, immersive VR, has been shown to be an adequate comparison to real museums in terms of navigation and degree of presence once adaptation time to get used to the experience is considered (Marín-Morales et al., 2019). However, participant recruitment for immersive VR studies is often difficult and the resources needed for such studies are not widely available in the behavioral sciences or museum studies. The second, non-immersive 3D environments, holds greater promise in terms of accessibility. Users need only have access to standard PCs, and researchers can collect visitor data on lab computers or the personal equipment of the participant. These systems can be easily implemented by research labs or museum staff and are far less restrictive in terms of participant recruitment—a consideration that far better approximates real museum visitors.

For this reason, the current study will use the Open Gallery for Arts Research (OGAR; Rodriguez-Boerwinkle et al., in press), an online virtual gallery tool for studying the psychology of the virtual art museum visit. The opensource gallery software allows researchers to design a non-immersive 3D environment and embed it in a webpage or online survey software where it can then be accessed by participants recruited through online survey pools, like Amazon’s Mechanical Turk or the Prolific.co survey panel, or by lab-based participants with lab hardware. OGAR is designed to have minimal user constraints, so it is suitable for use on a diverse range of personal participant or lab equipment. The gallery spaces that one creates with OGAR are highly customizable, so researchers can design the environment to fit their needs—even going so far as making basic recreations of real spaces.

Although OGAR shares many features with other available virtual gallery tools, it was selected for use in this study because it was developed specifically with research use in mind. Where other systems limit customizations, hide back-end processes, or don’t record user data, OGAR collects and allows the designer to access a robust set of time-stamped variables about the user’s movements, gaze, and application usage. Further, the system has been evaluated as an acceptable alternative to in-person research in terms of navigation and artwork viewing behavior. Using a sample of 44 adults recruited from English-speaking countries, Rodriguez-Boerwinkle et al. (2022) demonstrated basic indicators of OGAR’s validity: as the gallery size increased, visitors spent longer in the gallery and traveled further within it. Results also reflected more sophisticated visit behaviors: participants actively approached and viewed the available artworks, and they were able to successfully navigate the space without major usability concerns. In addition, their viewing times reflected previous artwork viewing studies in real spaces, and in line with prior field studies that examined viewing distance, OGAR visitors viewed larger artworks from further away.

The Current Study

The aim of the current study is two-fold: first, it serves as an advanced proof-of-concept of OGAR’s usability and validity, and second, it expands the field’s limited knowledge of the roles of personality and other individual differences in museum visit behavior.

As the first study of its kind, Rodriguez-Boerwinkle et al. (2022) served as a valuable early exploration into the use of non-immersive 3D virtual galleries for psychology of arts research, but there is still much to learn about this new tool. For example, OGAR’s inaugural study was conducted using only a small sample and was likely too underpowered to detect some effects. The one- and two-room layouts used by Rodriguez-Boerwinkle et al. (2022) also restricted participants to relatively predictable, linear paths. To address these limitations, I will examine unconstrained movement and view behavior in a three-room, interconnected gallery space with more artworks and a larger participant sample than what was used in Rodriguez-Boerwinkle et al. (2022). The larger participant pool chosen for the current study will further validate OGAR’s reliability while the larger, interconnected room layout will allow for greater variability in participant path and corresponding visit behavior.

In addition to further validating OGAR, this work will broaden knowledge of how the psychological characteristics of art museum visitors predict visit behavior by conducting a more comprehensive assessment of visitor personality and other individual differences than has been done in traditional in-person research in art museums to date. As noted earlier, personality has seldom been studied in real-life museums due to the time constraints of field environments and measuring visit behaviors with a high degree of fidelity has also proven difficult using current timing and tracking methods. Using an online virtual gallery with precise movement, gaze, and time reporting in conjunction with traditional self-reported personality measures will allow me to address these challenges. Thus, in the current study, personality and individual difference measurements for gallery visitors will be examined in terms of their effects on visit behaviors like overall visit time, artwork viewing time, global viewing ratio, artwork viewing distance, and total distance traveled within the gallery.

CHAPTER II: METHODS

Participants

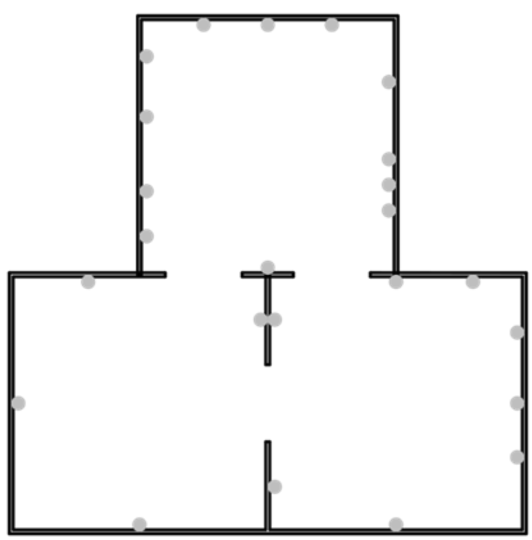
A total of 320 adult online participants were recruited from the Prolific.co survey panel and paid USD $3 for their participation. The recruited sample size was based on a power analysis conducted in Mplus 8.1 using Monte Carlo power simulations to determine what sample size would be needed to detect key effects of at least $r = .20$, given conventional levels of power (i.e., 80%) and significance (i.e., $p < .05$). To be eligible for participation, participants were required to be native English speakers between the ages of 18 to 70, to reside in predominantly English-speaking countries (Australia, Canada, Ireland, New Zealand, UK, USA), and to have completed at least 10 studies on Prolific.co with a minimum study approval of 95%. In addition, devices were restricted to computers only, so people must have used a desktop or laptop computer to participate. After the target recruited sample size was collected, participants were screened for careless responding, drop-out, and technology issues (described later) to yield our final sample size of 264 people.

Procedure and Apparatus

The present study was conducted in a Qualtrics online survey with an embedded instance of OGAR. After responding to some basic demographic questions—age, country of residence, and gender—and assessments of personality and arts knowledge, participants were directed to a survey page containing OGAR.

Along with instructions for navigating within the gallery, participants were shown a preview window of the gallery that expanded into full screen once clicked, allowing them to start their gallery visit. When full screen mode is entered, controls are enabled and participants can move cardinally to their view direction using their keyboard arrow keys or the W, A, S, and D keys. View direction, presented in a first-person viewing perspective, can be changed by moving their mouse, trackpad, or similar device. Participants were allowed to visit the space for as long as they wished; when they finished, they were able to press the *Escape* key to exit full screen mode and continue their Qualtrics survey, which concluded with post-visit questions about their experience.

Figure 1. Gallery Floorplan



Note. Floorplan measured in meters. Gray dots indicate artwork locations.

Gallery Definition

The gallery definition outlines the parameters of the gallery space and includes information about walls, environment textures, and artworks. For this study, I designed a three-room gallery layout where visitors were free to pass into any room from any other room. Rooms were identically set at 10 m × 10 m with a total gallery floor area of 300 m^2. Artwork choices, sizes, and placements were also defined in the gallery definition (see Figure 1). All artworks are shown in their “true size” in the gallery.

Artworks

Twenty-four artworks were selected from the Vienna Art Pictures System (VAPS; Fekete et al., 2022) for use in the current study. VAPS is a comprehensive dataset of 999 art images developed for research in empirical aesthetics. The chosen artworks span historical period, genre, style, content, and size. The artworks were selected with the constraint that the set was evenly split between representational and abstract works. Splitting works between abstract and representational is important because past work has shown that people respond differently to these categories based on their openness (Feist & Brady, 2004), expertise, and training in the arts (Belke et al., 2006; Van Paasschen et al., 2015). Further, artworks were chosen such that there was no significant difference between the mean artwork area in square meters, $t(22) = -1.14$, $p = .268$, $d = -.48$ [-1.29, .33], for the representational ($M = 1.22$, $SD = 1.40$) and abstract groups ($M = 2.18$, $SD = 2.57$) and checked to ensure that they were high enough resolution to meet the viewing demands of the virtual gallery. A complete artworks list for this study can be found in the Appendix.

Pre-visit Assessments

Before people were allowed to visit the virtual gallery, I collected measures of personality, art knowledge, and aesthetic responsiveness. Descriptive statistics for each pre-visit assessment can be found in Table A2

Personality

I measured personality using the NEO-3 Five Factor Inventory (McCrae & Costa, 2007). The 60-item inventory uses a five-point scale (from *strongly disagree* to *strongly agree*) to measure five broad factors of personality: neuroticism, extraversion, openness to experience (hereafter referred to simply as openness), agreeableness, and conscientiousness. While all five factors are relevant to art and aesthetic experience, openness has particularly strong relationships with art knowledge, art interest, and nuanced emotional responsiveness to the arts (Feist & Brady, 2004; McCrae, 2007; Silvia, 2007; Silvia et al., 2015). In the present study, reliability for the NEO was high: each facet had a Cronbach's alpha of $\alpha = .92$ (N), $\alpha = .85$ (E), $\alpha = .79$ (O), $\alpha = .75$ (A), and $\alpha = .89$ (C), respectively.

For a more in-depth look at openness, I also used the openness inventory by Woo et al. (2014; hereafter referred to as the Woo scale). This scale was chosen because it has broad coverage of the overall construct of openness when compared with other openness scales (Christensen et al., 2019). In total, the scale examines six facets of openness—intellectual efficiency, ingenuity, curiosity, aesthetics, tolerance, and depth—through a 54 item self-report scale. Each facet is equally divided into nine items. Items such as "I like coming up with imaginative plans" and "I am constantly amazed by the complexity of human nature" are evaluated using a five-point Likert scale (from *strongly disagree* to *strongly agree*) and can be grouped into higher-order culture (aesthetics, tolerance, depth) and intellect (intellectual efficiency, ingenuity, curiosity) aspects of openness. The Woo scale achieved good reliability for each facet (aesthetics: $\alpha = .89$, curiosity: $\alpha = .74$, tolerance: $\alpha = .74$, depth: $\alpha = .78$, intellectual efficiency: $\alpha = .85$, ingenuity: $\alpha = .83$).

Art Knowledge

Art knowledge was assessed with a revised version of the aesthetic fluency scale. The original scale, introduced by Smith and Smith (2006), uses domain-specific knowledge about the arts to gauge *fluency*, or art expertise (Atari et al., 2020; Cotter et al., 2021; Silvia, 2007), by asking participants how familiar they are with 10 topics and individuals from art history (e.g., Impressionism, John Singer Sargent, Isamu Noguchi). The original scale uses a five-point scale ranging from zero (*I have never heard of this artist or term*) to (*I can talk intelligently about this artist or idea in art*) and results in an overall score.

The revised Aesthetic Fluency scale, currently in development (Cotter, Rodriguez-Boerwinkle et al., 2021), retains many of the characteristics of the original but has a wider scope. It includes 36 items with a simplified three-point response scale ranging from zero (*I don't really know anything about this artist or term*) to two (*I know a lot about this artist or item*). This scale also showed good reliability with the current sample: α = .95.

Aesthetic Responsiveness

As a final pre-visit assessment, I measured aesthetic responsiveness with the English language version of the Aesthetic Responsiveness and Engagement Assessment (AREA; Schlotz et al., 2020). Using 14 items with statements like "I am deeply moved when I see art," the AREA asks participants to indicate their levels of aesthetic appreciation, intense aesthetic experience, and creative behavior on a five-point point scale ranging from zero (*Never*) to four (*Very Often)*. Specific items are averaged to form the subscale sores, with aesthetic appreciation being represented by items like "I notice beauty when I look at art," intense aesthetic experience by items like "When I look at art, my heart beats faster," and creative behavior by items like "I write poetry or fiction." Alternatively, researchers may choose to represent aesthetic responsiveness using the overall score based on the 14 items; I take the latter approach in this study. Both the overall scale (α = .91) and each sub score (aesthetic appreciation: α = .89, intense aesthetic experience: α = .84, creative behavior: α = .70) fared well in terms of reliability in this study.

Post-visit Assessments

After completing their virtual gallery visits, participants were asked, "Did you feel motion sick, dizzy, or nauseous from the virtual gallery?" on a scale from one (*No, not at all*) to seven (*Yes, very strongly*). Placing this question directly after exiting allowed participants to answer when their visit experience was still salient. In Rodriguez-Boerwinkle et al. (2022), nausea ratings were related to lower user experience in OGAR and may further indicate poor gallery performance or low data quality.

Since OGAR was designed for mouse usage in mind, but online participants cannot practically be restricted to using mouses, the final question I asked participants was "What kind of device did you use in the gallery?" Optional responses to this question included *mouse, touchpad, touchscreen, trackpoint,* and *some other device*. People who don't use a mouse are also more likely to find the gallery less usable (Rodriguez-Boerwinkle et al., 2022). In addition, this question served to help me reason about gallery performance issues should they have arisen.[1]

Visit Behavior

As participants visit the virtual gallery, OGAR collects movement data in the form of X and Y coordinates within the gallery floorspace and gaze data in the form of pitch and yaw (defined in terms of radians) every 200 ms. From these, several visit behavior variables can be constructed.

Visit Time

Visit time—the total time in seconds that someone spends in the virtual gallery—was quantified as the total time between when participants entered and exited OGAR's fullscreen mode within Qualtrics (accounting for if they did so multiple times).

[1] Another measure—a single item measure of visit satisfaction called the Overall Experience Rating—was intended to be assessed post gallery visit but was sadly forgotten (Pekarik et al., 2018).

Distance Traveled

Since the gallery definition is scaled in meters, each one-coordinate shift in X or Y represents a change of 1 meter of distance within the gallery. Thus, distance traveled was calculated with the following equation, where *i* represents the second position in the coordinate chain and *n* is the total number of points in the path that the user took through the gallery:

$\sum_{i=2}^{n} \sqrt{(y_i - y_{i-1})^2 + (x_i - x_{i-1})^2}$.

Artwork Viewing Time

Artwork viewing time is another obtainable variable in OGAR. The predetermined eye height of the participant's avatar and avatar's location within the gallery form a viewpoint, and artwork locations (any space within the artwork's area) define possible viewing targets. Then, the shortest distance intersection was calculated between the viewpoint and the viewing target. If the intersection was within the parameters of an artwork, the view behavior was coded as a binary *yes* (1) and the corresponding artwork was assigned to the view at that timestamp. Timestamps that consecutively view an artwork with no more than one 200 ms gap in view assignment were summed to arrive at a single chunk of viewing time in seconds. Participants may choose to view an artwork more than one time during their visit, so to arrive at the operationalization of viewing time used in the current study, every instance of an artwork view by a single participant was added up.

Artwork Viewing Ratio

Artwork viewing time was also examined globally by calculating the percentage of total time spent in the gallery that is spent looking at artworks as opposed to other features (e.g., walls, floors, and ceiling). This allows for a measure of artwork viewing time that is not conflated with the total time that someone spends in the gallery.

Artwork Viewing Distance

Finally, at each timestamp where a person is viewing an artwork, the distance between the coordinate for the viewed artwork and coordinate location of the avatar was calculated to obtain a measure of artwork viewing distance in meters.

CHAPTER III: RESULTS

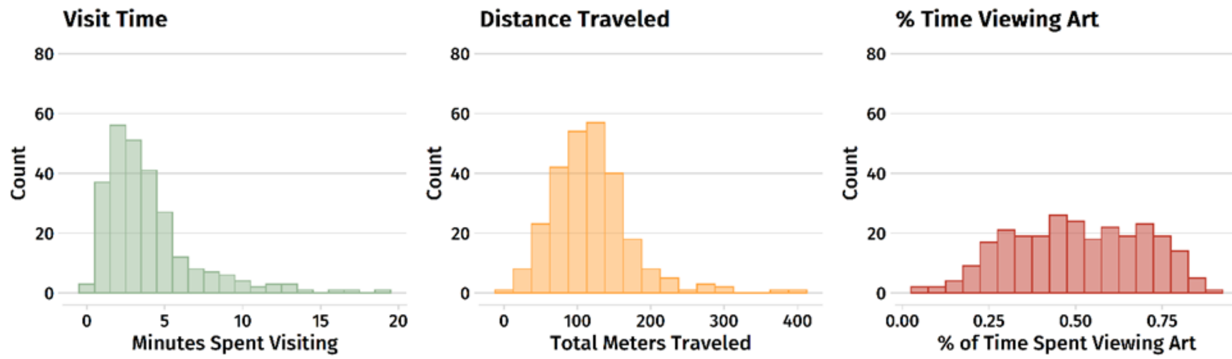
Screening and Data Reduction

The data were screened and cleaned in R 4.1 (R Core Team, 2022). Among the 320 Prolific participants recruited for this study, those who did not finish the study or who failed to meet the requirements of the study (i.e., not using a laptop or desktop computer, or not completing the survey in Microsoft Edge, Google Chrome, or Mozilla Firefox browsers) had their responses rejected, and their spots were reopened to the Prolific participant pool. After data collection was complete, responses from 320 recruited participants were examined for inattentive and careless responding based on failing directed response items and having extreme values on measures of long-string responding and Mahalanobis distance, calculated using the *careless* package (Yentes & Wilhelm, 2018). No participants were excluded for careless responding.

Participant data was also screened for technological considerations relevant to gallery performance quality. Participants were dropped if they never controlled their avatar with their keyboard or never moved their mouse (39 cases). These indicate that the avatar position or view direction never changed within the gallery. People were also omitted if their maximum avatar movement speed was too slow (0 cases distinct from no mouse movement), indicating poor gallery performance caused by excessive system load, or if they did not visit at least two of three gallery rooms (18 cases). Finally, participants were considered unusable if gain and loss of mouse control by the gallery and full-screen entrances and exits were not reported in rational patterns (0 cases). When someone enters the gallery, their mouse is captured to use for moving the view direction (as opposed to normal pointing and clicking) and their screen enters fullscreen mode. Should they exit the gallery to continue their Qualtrics survey, it is expected that these functions will cease. If this fails to happen, it is likely related to specific browser settings, the use of certain browser extensions, or browser failures. Some participant cases matched multiple omission criteria; after all criteria were assessed, a final sample size of 264 participants remained. Of note, this study achieved an exclusion rate of 17.5%, compared to a 27.9% exclusion rate obtained in Rodriguez-Boerwinkle et al. (2022). This increase in usable data speaks to improvements made in the OGAR tool and data collection process since its initial development.

Participant demographics, including age, gender, and country of residence, were recorded during the survey. Responses to gender were coded as binary (female = 1, male = 0, other responses = missing). Records of participant input device were also recoded as binary (mouse = 1, other = 0). Additionally, browser information was collected for the purposes of debugging the OGAR system, if necessary, and was not included in analyses. Time spent visiting the gallery was measured in minutes and distance traveled was measured in meters. A global view percentage for time spent looking at artwork relative to other gallery features was also calculated as the ratio of cumulative time in seconds spent viewing any artwork to the cumulative time in seconds spent viewing any non-artwork feature of the gallery (walls, floor, or ceiling). Figure 2 provides the distributions of total visit time, total distance traveled, and the percentage of time spent viewing artworks.

Figure 2. Distributions of Visit Time, Distance Traveled, and Artwork Viewing Time Percentage



Note. Scores are shown in their raw metric. For the analyses, transformed versions of visit time, distance traveled, and the percentage of time spent viewing art were used.

For the purposes of the current analyses, visit time, distance traveled, and the percentage of time spent viewing art were transformed via the *bestNormalize* package in R (Peterson & Cavanaugh, 2020) using ordered quantile normalization to make their distributions more normal. An overview of descriptive statistics for these raw values, participant information, and results for each scale can be found in Table A2. Correlational data for our measures can also be seen in Table A3. Correlations for continuous variables are reported in the Pearson's *r* metric, which can be interpreted as small (.10), medium (.30), or large (.50) effects (Cumming, 2012). For categorical variables, the Cohen's *d* metric is used with benchmarks of .20 for small, .50 for medium, and .80 for large effects. The materials and R code are available at Open Science Framework (https://osf.io/f823r/).

Model Specification

Between-person predictors of gallery behavior were examined using structural equation models estimated in Mplus 8.1 with maximum likelihood estimation and robust standard errors (for a full list of between-person predictors and outcomes, see Table A4). Structural regression models were specified for the NEO, including each of five personality traits measured coded as latent factors (Figure 3), and the Woo Scale, including all six of its subscales as latent factors; a final model, examining arts-specific predictors, was created using the aesthetic fluency and AREA scales (see Figure 4). All structural regression models predicted visit time, distance traveled, and percentage of time spent viewing artworks as simultaneous, correlated outcomes. Indicators of each latent variable, except for aesthetic responsiveness[2], were created by randomly assigning each associated scale item to a parcel. This resulted in each latent factor from the NEO scale model having four indicators of three items each, and each latent factor from the Woo scale model having three factors with four items each. The latent variables of aesthetic fluency and aesthetic responsiveness were assigned four parcels of nine items and three parcels of a varying number of items, respectively, within the art-specific predictor model. Reported structural regression results are fully standardized with respect to X and Y variables.

[2] Indicators of aesthetic responsiveness were assigned based on the *a priori* subscales present in the AREA survey. Interestingly, two of the indicators (aesthetic appreciation and intense aesthetic experiences) load very highly on the aesthetic responsiveness latent factor, because they share an item (Woo et al., 2014).

Figure 3. Confirmatory Factor Analysis for the Five NEO Factors

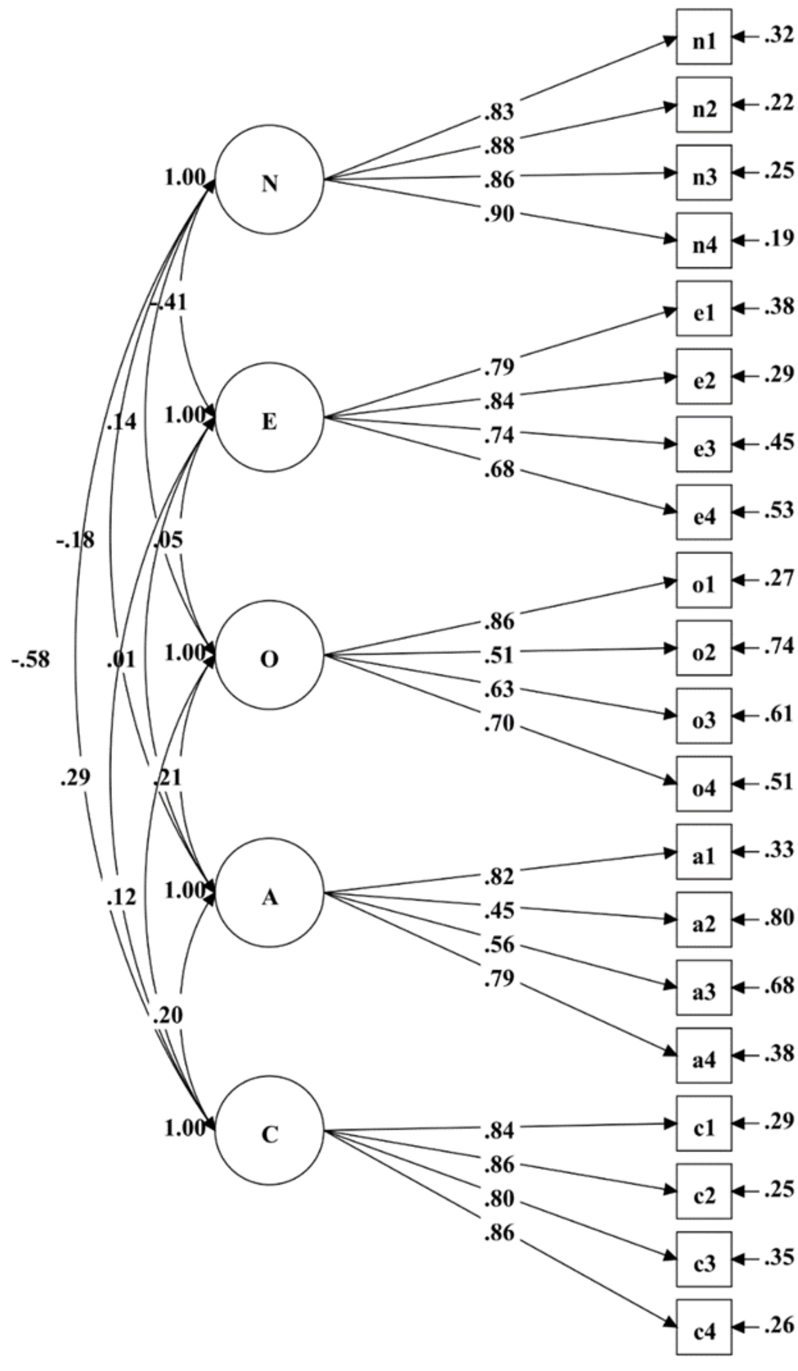
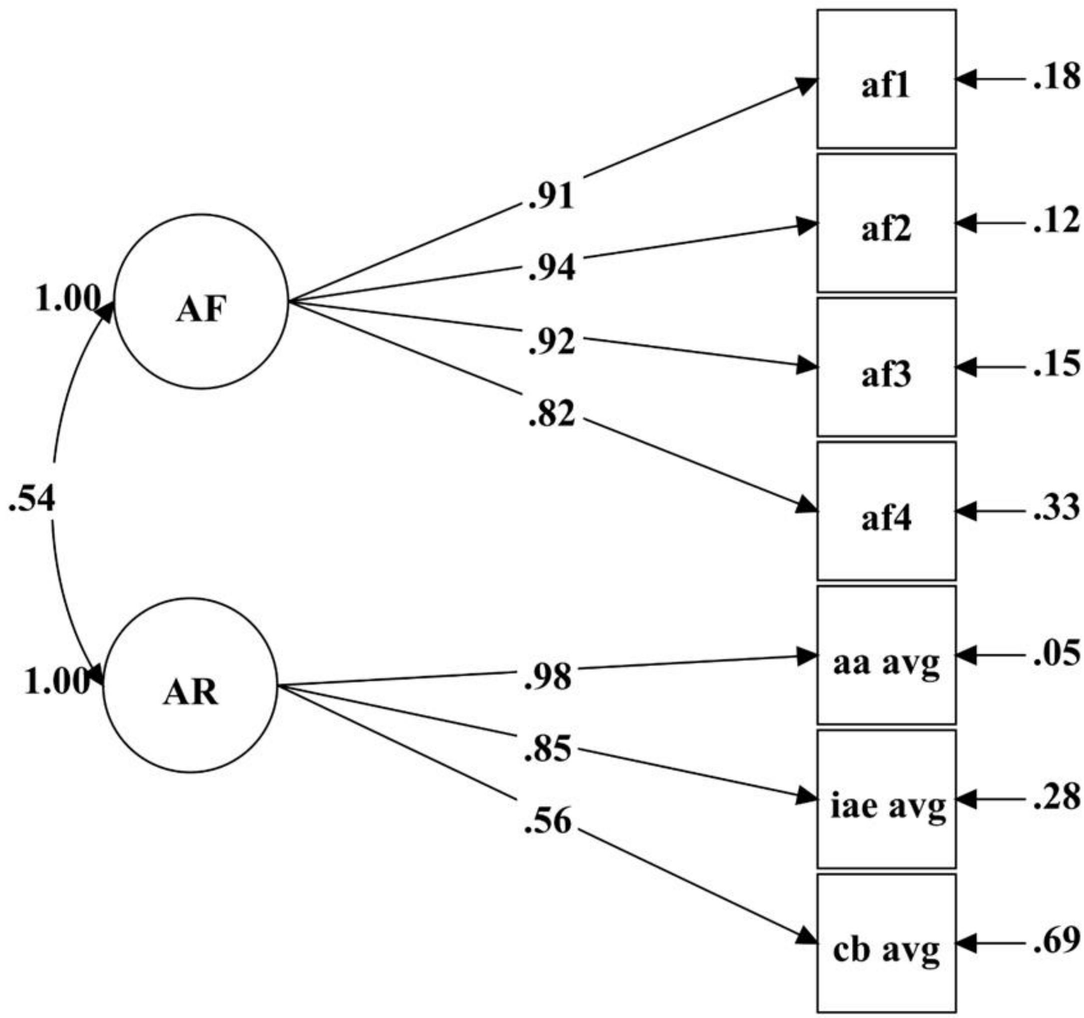


Figure 4. Confirmatory Factor Analysis for Art-specific Variables



Confirmatory factor analysis (CFA) of the measurement models was conducted to evaluate model fit. A model representing the NEO scale had the following fit indices: χ^2 (160, N = 264) = 354.19, $p < .001$, Root Mean Squared Error of Approximation (RMSEA) = 0.068 [90% CI: 0.058, 0.077], Comparative Fit Index (CFI) = 0.924, Tucker-Lewis Index (TLI) = 0.909, Standardized Root Mean Squared Residual (SRMR) = 0.071, suggesting adequate model fit.

Model fit for the art-specific predictors was also reasonable (χ^2 (13), N = 264) = 52.61, p < .001, RMSEA = 0.107 [90% CI: 0.078, 0.139], CFI = 0.970, TLI = 0.952, SRMR = 0.058).

Unfortunately, the model for the Woo openness scale was not as promising. First, the CFA model was created with each of the six factors outlined by the Woo et al. (2014). While this model also had adequate fit, χ^2 (120, N = 264) = 340.10, p < .001, RMSEA = 0.083 [90% CI: 0.073, 0.094], CFI = 0.892, TLI = 0.863, SRMR = 0.064, it was fraught with high latent variable correlations. In particular, curiosity exhibited high correlations with the other five Woo facets (depth: r = .83 [.73, .94], p < .001; tolerance: r = .73 [.57, .89], p < .001; intellectual efficiency: r = .54 [.38, .70], p < .001; ingenuity: r = .70 [.55, .85], p < .001; aesthetics: r = .58 [.45, .72], p < .001). According to collinearity statistics, curiosity had a variance inflation factor of 6.37 and a tolerance of only .16. This indicates that a very high proportion of the variance in curiosity is caused by collinear relationships with the remaining factors in the model, and that only about 16% of the variance in the curiosity factor is unique to it. The rest of the variance, or influence each independent variable has on the outcome, cannot be isolated to any specific predictor.

In response to these findings, a CFA model was specified using the Woo scale's two super-factors (culture and intellect). However, this model also did not converge without extensive modifications, and it showed evidence of great collinearity between the two facets (r = .87 [.80, .94], p < .001).

Based on the results of these CFA analyses, the factor structure obtained for the Woo scale with the current sample is not in line with the structure reported by Woo et al. (2014). Since Woo and colleagues (2014) built a scale with a reported factor structure of six facets that could be combined into two super-factors, this is how I chose to specify the regression model in the current study. However, a regression model with six factors that are highly correlated leaves little room for explaining the unique variance contributed by any individual factor. With the present sample, openness (as measured by the Woo items) does not take the form of distinct facets or super-factors. As a result, the scale cannot be used for its intended purpose and will not be examined further.

After structural regression models for each between-person outcome were examined, a series of multilevel models were specified to examine the relationships between individual differences, artwork qualities, and within-person viewing behaviors for individual artworks. These models were also created using Mplus 8.1 with maximum likelihood estimation with robust standard errors. For this study, four two-level models with random slopes were specified containing two within-person predictors, one between-person predictor, and their cross-level interactions (for a full list of predictors and outcomes, see Table A5).

For example, I examine how individual differences such as personality (containing five factors, via the NEO scale) interact with individual artwork qualities (e.g., artwork size and whether the work is representational or abstract) to predict viewing behaviors (e.g., viewing time or distance). One additional participant was excluded from this portion of the analyses (bringing the sample size to n = 263), because they did not view both representational and abstract images and therefore had no variance in this predictor. Each model using personality or arts-specific predictors contained latent variables for each factor as they were outlined in the CFA models. Each parcel-defined factor was then standardized by subtracting the mean from each value and dividing by the standard deviation before analysis. Within-person predictor variables describing artwork characteristics (artwork area and representationalness) were within-person centered.

Observed Gallery Behavior

I first examined overall gallery behavior in the study sample, using visit time, distance traveled, and percent of time spent viewing artworks as behavioral indicators of visit experience. As shown in Table A2, people tended to spend about 3.91 (*SD* = 3.00) minutes visiting the gallery and traveled about 118.83 (*SD* = 55.50) meters. The two measures were highly correlated: $r = .70$ [.63, .76], $p < .001$, but individual experiences varied greatly. Participants tended to view artworks about 51% (*SD* = .19) of the time, but this measure achieved an almost uniform distribution (see Figure 2). Ratio of time spent viewing art was also positively correlated with visit time ($r = .17$ [.05, .28], $p = .006$) and distance traveled ($r = .22$ [.11, .34], $p < .001$), respectively.

Some of the variance in gallery behavior could be explained by age differences. Older participants, for instance, tended to spend longer ($r = .31$ [.20, .42], $p < .001$) and travel further ($r = .19$ [.07, .30], $p = .002$) in OGAR. Increased age had moderate negative associations with the ratio of time spent viewing artwork ($r = -.40$ [-.50, -.29], $p < .001$).

Gallery behaviors also varied by gender. Although there was no difference in distance traveled between women and men ($d = -.01$ [-.26, .24]), women tended to visit the gallery for longer than men ($d = .26$ [.01, .51]). Men were more likely to use a mouse when interacting with the gallery ($d = -.34$ [-.59, -.09]) and had higher ratios of art viewing, relative to viewing other gallery features, than women ($d = -.40$ [-.65, -.15]).

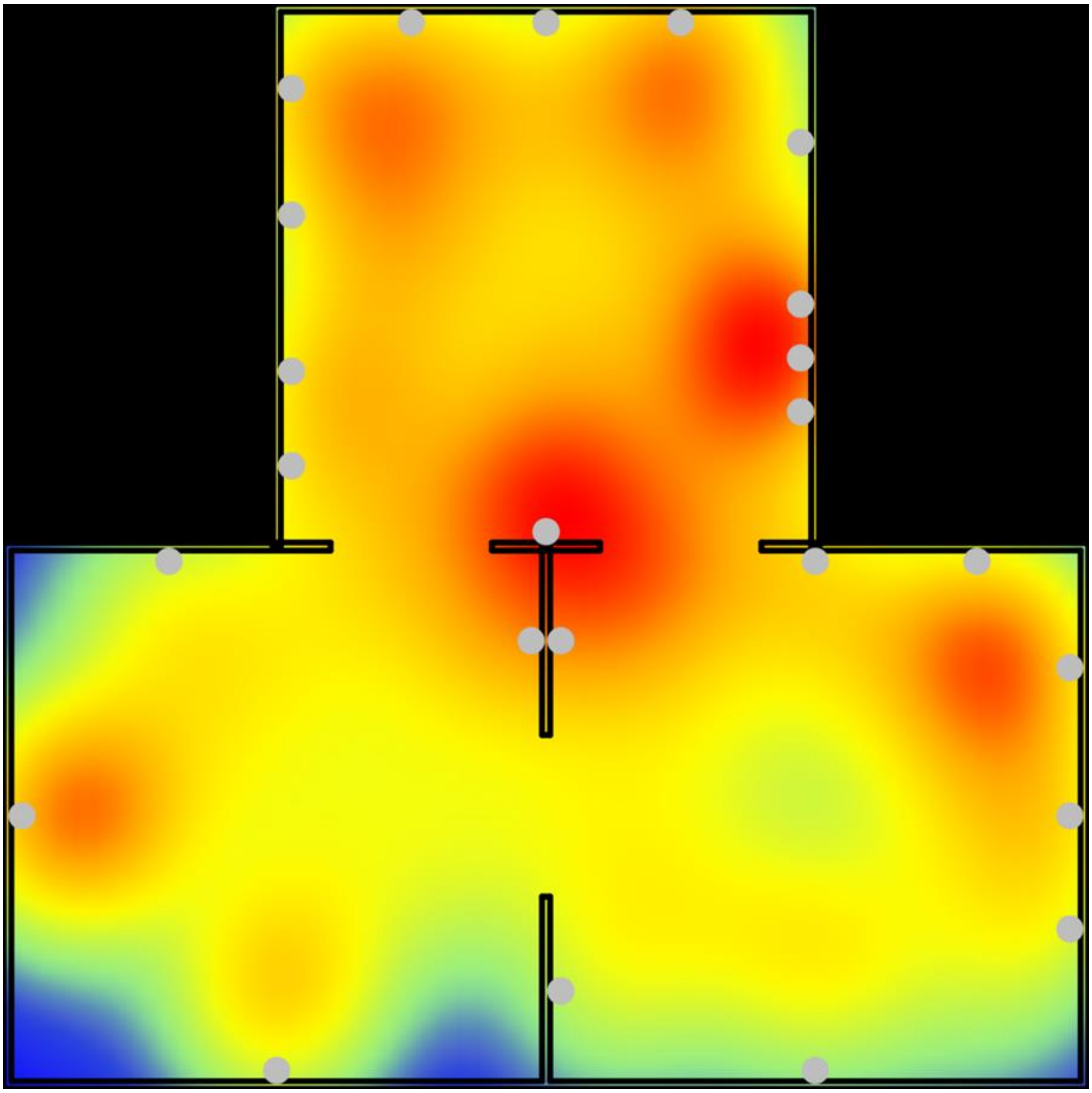
In addition to more art- and navigation-focused between-person behaviors, nausea was measured immediately after the visit. On average, participants had very low nausea levels (M = 1.49, *SD* = 1.10). Although uncommon, participant experiences weren't completely free of the effects of nausea. While nausea showed no effects on time spent or distance traveled in the gallery, it did have a modest, negative correlation with percent of time spent viewing art ($r = -.22$ [-.34, -.11], $p < .001$), suggesting that those who experienced greater levels of nausea spent less of their visit time actively viewing artworks. Those who used a mouse during their visit also typically spent less time in the gallery (*d* = -.25 [-.50, -.01]) and traveled a marginally shorter distance (*d* = -.19 [-.43, .05]).

Overall gallery behaviors can further be illustrated using heatmaps of the virtual space. Since participant movement is confined within the walls of the space and is represented in meters, using a floorplan of the gallery is particularly apt. For an example, Figure 5 depicts the movement patterns of the current study's total sample. This figure is in line with previous findings from Rodriguez-Boerwinkle et al. (2022) by showing that participants indeed cluster in front of artworks in a viewing behavior similar to that seen in a real-life space.

In terms of viewing specific artworks, the average OGAR visitor viewed about 18 out of 24 artworks (78%). Participants tended to view any given artwork for an average of 4.78 seconds (*SD* = 9.81), but this too varied widely between artworks. How far in meters a person chose to view an artwork from, or the viewing distance, was also highly variable (*M* = 2.43, SD = 2.08). For a full list of descriptive statistics related to individual artworks, see Table A6.

Taken together, the sample showed virtual gallery behaviors that were largely in line with previous literature, yet nuanced and fickle in a way that has largely been under-studied in museums. The next natural step then, is a deeper examination of potential predictors of gallery behavior.

Figure 5. Heatmap of Total Participant Movement



Note. This image is a to-scale, bird's-eye representation of the gallery space used in this study. Red areas denote more highly trafficked locations. Artworks are represented with gray dots, slightly offset from the walls for better visibility.

Predictors of Gallery Behavior

Structural regression results using continuous predictors are reported as standardized effects (β), which can be interpreted like effect sizes in the *r* metric using the following guidelines: .10 for small effects, .30 for medium effects, and .50 for large (Cumming, 2012). *P*-values and 95% confidence intervals are reported alongside all effects. A full list of predictors and outcomes for the structural regression models are available in Table A4.

Visit Time

First, I explored how visit time was predicted by broad personality traits, measured via the NEO. Extraversion (β = -.29 [-.43, -.16], $p < .001$) and openness (β = .27 [.13, .40], $p < .001$) were the strongest predictors of time spent visiting the gallery but presented in opposite directions. While people who were high in extraversion were more likely to spend a shorter amount of time in the gallery, those high in openness to experience often chose to visit for longer. Agreeableness (β = .18 [.04, .31], $p = .009$) and neuroticism (β = -.18 [-.34, -.02], $p = .028$) also predicted visit time with more agreeable individuals spending longer in the gallery, but those high in neuroticism leaving earlier. Conscientiousness had no appreciable impact on visit time (β = -.02 [-.16, .13], $p = .842$).

Art-specific predictors of visit time were assessed with the aesthetic fluency scale and the AREA scale. Aesthetic fluency was found to have a modest effect on time spent in the gallery (β = .18 [.02, .34], $p = .028$), indicating that those with higher art knowledge were more engaged with OGAR. For the AREA scale, however, aesthetic responsiveness did not have any appreciable effect on visit time (β = .07 [-.09, .23], $p = .395$). Aesthetic fluency and aesthetic responsiveness had a correlation of $r = .54$ [.44, .63], $p < .001$.

Distance Traveled

Distance traveled in OGAR—another important indicator of visit experience—was predicted by extraversion, openness, and agreeableness. Extraversion again had the largest influence on this outcome, such that extraverted visitors traveled shorter distances (β = -.21 [-.36, -.07], *p* = .004). Participants who were high in openness (β = .18 [.03, .33], *p* = .017) and agreeableness (β = .18 [.03, .33], *p* = .019) exhibited positive effects and were likely to travel further in the virtual gallery. Neuroticism and conscientiousness did not yield any significant relationships to distance traveled (neuroticism: β = -.06 [-.23, .12], *p* = .526; conscientiousness: β = .02 [-.14, .17], *p* = .830).

Neither aesthetic fluency (β = .11 [-.07, .28], *p* = .230) nor aesthetic responsiveness (β = .03 [-.13, .20], *p* = .695) had significant relationships with distance traveled. This indicates that there is some determinant of distance traveled that separates it from time spent in the gallery, despite their high correlation.

Percent of Time Spent Viewing Artworks

Another gallery behavior outcome, the ratio of time spent viewing artworks versus other features of the gallery, was found to have a positive association with openness (β = .23 [.09, .37], *p* = .001), suggesting that people high in openness to experience spend more of their time in the gallery actively viewing artworks than those with personalities lower in openness. None of the other personality traits defined by the NEO revealed significant effects on viewing time ratio (neuroticism: β = -.01 [-.20, .16], *p* = .908; extraversion: β = -.10 [-.23, .04], *p* = .170; agreeableness: β = -.08 [-.23, .07], *p* = .292; conscientiousness: β = -.03 [-.20, .13], *p* = .695).

The final between-person relationship I modeled was that between art viewing ratio and the art-specific predictors aesthetic fluency and aesthetic responsiveness. Overall, neither latent variable was associated with the percent of time a given participant spent looking at art versus other parts of the gallery (aesthetic fluency: β = -.10 [-.25, .05], *p* = .181; aesthetic responsiveness: β = .05 [-.08, .19], *p* = .456).

Predictors of Within-Person Art Viewing

Multilevel models were used to examine how between-person individual differences (personality or art-specific predictors) interacted with within-person predictors of artwork characteristics (artwork area, representationalness) to predict within-person viewing behavior outcomes (viewing time, viewing distance) for a given artwork. Within-person predictor variables describing artwork characteristics were within-person centered. Multilevel model results are reported as unstandardized effects (*b*) with 95% confidence intervals and associated *p*-values.

Interclass correlations (ICC) were examined to determine the proportion of variance explained at the between-person level for each predictor. For viewing time, the ICC was .26. This indicates that 26% of the variance in viewing time at the between-person level; the rest occurs at the within-person level via factors such as individual artwork characteristics. The ICC for viewing distance was slightly higher at .39, meaning that 39% of the variance observed in viewing distance occurred between-persons while the rest took place within-persons.

Artwork Viewing Time

For between-person main effects, personality had numerous direct effects on the amount of time that a person chose to view an artwork. In general, individuals high in extraversion chose to view an artwork for significantly less time than those low in this trait (b = -1.50 [-2.50, -.50], p = .003). In contrast, openness offered a strong, positive relationship with viewing time (b = 1.72 [.89, 2.54], p < .001), so being high in openness was associated with viewing an individual artwork for a longer period of time. Neuroticism showed marginal effects on viewing time, b = -.99 [-2.04, .06], p = .065. Main effects from the other five-factor traits—agreeableness (b = .32 [-.53, 1.17], p = .456), and conscientiousness (b = -.51 [-1.49, .47], p = .305)— did not reveal any effects. In addition, neither art-specific predictor yielded significant main effects on viewing time (aesthetic fluency: $b = .25$ [-.69, 1.19], $p = .602$; aesthetic responsiveness: $b = .60$ [-.18, 1.39], $p = .130$).

For within-person main effects, an association between each individual artwork feature and viewing time was supported (for artwork area: $b = .75$ [.65, .85], $p < .001$; for representational works: $b = 2.04$ [1.57, 2.51], $p < .001$). An individual's viewing time for a given artwork was greater for representational artworks and for larger artworks.

Finally, for cross level interactions with personality predictors, as openness goes up, the relationship between area and viewing time gets stronger ($b = .26$ [.13, .38], $p < .001$), such that those high in openness were more affected by artwork size when deciding how long to view an artwork for than their peers. The other facets of personality examined—neuroticism ($b = -.14$ [-.30, .03], $p = .113$), extraversion ($b = -.11$ [-.24, .02], $p = .101$), agreeableness ($\beta = .00$ [-.14, .14], $p = .974$), and conscientiousness ($b = -.04$ [-.20, .13], $p = .660$)—had no significant effects on the relationship between area and viewing time.

Openness also played a role in moderating the relationship between representationalness and viewing time ($b = .53$ [.06, 1.00], $p = .027$). Those high in openness showed especially long viewing times for representational works, relative to their less-open peers. Extraversion had the opposite effect towards representational work ($b = -.75$ [-1.37, -.14], $p = .017$); the positive relationship between representational artwork and viewing time was stronger for introverted individuals than for people high in extraversion. None of the other examined personality traits reported cross level interactions between representationalness and viewing time (neuroticism: $b = .02$ [-.88, .93], $p = .959$, agreeableness: $b = .27$ [-.29, .82], $p = .347$, conscientiousness: $b = .43$ [-.41, 1.27], $p = .317$).

The art-specific variables measured in this study did not reveal any cross-level interactions predicting viewing time. Neither aesthetic fluency nor aesthetic responsiveness had a significant effect on the relationship between artwork size and viewing time (aesthetic fluency: $b = .01$ [-.16, .18], $p = .916$; aesthetic responsiveness: $b = .10$ [-.03, .24], $p = .136$). Likewise, neither predictor interacted with the relationship between representational status and viewing time ($b = .55$ [-.23, 1.33], $p = .170$; $b = -.06$ [-.53, .40], $p = .788$) This indicates that individuals high in these traits exhibited viewing behaviors that were in line for those of their peers when engaging with diverse artworks.

Artwork Viewing Distance

Viewing distance was also examined in terms of between-person main effects, within-person main effects, and cross level interactions. For between-person main effects, openness had a significant negative effect with viewing distance ($b = -.36$ [-.56, -.17], $p < .001$). This suggests that people high in openness likely approached specific artworks for closer examination. Extraversion had a marginal effect on viewing distance, $b = .24$ [.00, .48], $p = .050$. Extraverted visitors tended to view artworks from further away. Effects for the other personality factors were weak and insignificant: neuroticism ($b = .01$ [-.25, .28], $p = .932$), agreeableness ($b = -.01$ [-.22, .19], $p = .907$), conscientiousness ($b = .06$ [-.15, .28], $p = .581$). Aesthetic fluency ($b = .04$ [-.16, .23], $p = .707$) and aesthetic responsiveness ($b = -.07$ [-.25, .11], $p = .449$) also had no discernable main effects on viewing distance.

Within persons, artwork area showed a main effect, contributing positively to viewing distance ($b = .41$ [.38, .44], $p < .001$); people stood further away from larger artworks. No such relationship was found for representationalness ($b = .10$ [-.05, .24], $p = .181$). People did not stand any further from or closer to representational works than they did for abstract works of the same size.

Finally, for cross-level interactions, highly open people didn't pay as much mind to artwork size as people low in openness did when choosing how far to stand (*b* = -.04 [-.08, .00], *p* = .070). No other individual difference variables—personality (neuroticism: *b* = -.02 [-.07, .04], *p* = .539; extraversion: *b* = .03 [-.01, .08], *p* = .128; agreeableness: *b* = .00 [-.04, .04], *p* = .887; conscientiousness: *b* = -.01 [-.05 .04], *p* = .779) or art-specific variables (aesthetic fluency: *b* = -.02 [-.05, .02], *p* = .408; aesthetic responsiveness: *b* = -.02 [-.05, .02], *p* = .270)—interacted with artwork size to predict viewing distance.

Only extraversion was found to moderate the relationship between representationalness and viewing distance (*b* = .18 [.00, .37], *p* = .050), such that highly introverted people were more likely to choose a closer viewing distance to representational works. Neuroticism (*b* = .16 [-.06, .38], *p* = .142), openness (*b* = -.06 [-.22, .09], *p* = .420), agreeableness (*b* = -.04 [-.16, .09], *p* = .559), and conscientiousness (*b* = .07 [-.10, .25], *p* = .421) had no such effect. Aesthetic fluency (*b* = -.09 [-.25, .07], *p* = .264) and aesthetic responsiveness (*b* = .01 [-.14, .17], *p* = .861) also showed no effect.

CHAPTER IV: DISCUSSION

Although museum visits are an increasingly popular context through which to study the psychology of art (Pelowski et al., 2017), some aspects of art encounters—such as personality and other individual difference predictors (Mastandrea et al. (2009), or fine-grained behavioral measurements (Yalowitz & Bronnenkant, 2009)—are difficult to study in real-life environments. Virtual gallery tools offer a way to fill these gaps that is affordable and accessible to a diverse study population (Rodriguez-Boerwinkle et al., in press). Therefore, the present research used a new virtual gallery tool to expand on previous museum studies of the psychology of art in two important ways: first, it further validated OGAR as a viable tool for research into interactions with art; second, it explored the roles of personality and other individual differences at a deeper level than what has been accomplished with traditional museum studies to-date.

This study administered a battery of personality and individual difference questionnaires to a diverse online sample of adult Prolific users, followed by unstructured virtual gallery visit. The gallery used featured three rooms—each accessible by the other two—with a total of 24 artworks hung in the space. Artworks were half representational and half abstract, spanning a range of genres, styles, art historical periods, and sizes. The project's main goals were to observe how the Big Five personality traits (neuroticism, extraversion, openness, agreeableness, and conscientiousness) and art-related individual differences (aesthetic fluency and aesthetic responsiveness) affected overall gallery behaviors such as visit time, total distance traveled, and global art viewing ratio. Then, it aimed to examine how individual artwork qualities like artwork size and representationalness affected the viewing behavior (viewing time and viewing distance) of artworks. Finally, it sought to explore how visitor characteristics and artwork qualities interacted to influence the greater gallery visit experience.

Overall Gallery Behavior

Based on the overall gallery behaviors obtained in the current sample, evidence for OGAR's usability by researchers was replicated from Rodriguez-Boerwinkle et al. (in press). Recorded in-gallery behaviors demonstrate that participants actively used the gallery to approach and view artworks, as evidenced by hot-spots in front of each artwork on the gallery heatmap in Figure 5. Consistent with Rodriguez-Boerwinkle and colleagues (in press), viewing behaviors indicated considerable variance between participants, and between artworks themselves when viewed by a single person (such variance has been a theme in studies of art viewing, e.g., Smith & Smith, 2001). In addition, within-person viewing behaviors were affected by individual artwork characteristics: participants viewed larger and representational works for longer and also viewed larger artworks from further away on average (in line with Estrada-Gonzalez et al., 2020). Overall, the behaviors recorded for the current sample pointed at a need to further examine the cause of their variability—a gap which personality and other individual differences at least partially fill.

Personality as a Predictor of Visit Behavior

How do personality traits and other individual differences influence our visit behaviors? Openness, which is known to contribute broadly to art- and aesthetics-related outcomes (Feist & Brady, 2004; Kaufman et al., 2016; Silvia et al., 2015), is associated with most of the outcomes examined in the current study. In terms of between-person gallery behaviors, people high in openness spent longer and traveled further in OGAR. Higher openness also predicted greater ratios of artwork viewing, relative to viewing other features of the gallery, so even controlling for increased visit time, highly open individuals spent more of their visit time looking at art.

These results lend support to the idea that people high in openness are more likely to experience immersion in mediated environments—environments where content or environmental stimuli are created (or curated, if you will) and then experienced, such as in museums, art galleries, or institutions or when people read books, watch movies, or play videogames (Weibel et al., 2010). Immersion in virtual gallery environments like OGAR, in turn, directly predicts a range of greater well-being measures following virtual art gallery visits (Cotter et al., 2022).

The intensity of these overall visit experiences may help explain more fine-grained behaviors as well. In terms of between-person main effects, visitors high in openness to experience tended to view individual artworks for a longer period and from a closer average distance for any given artwork than their less-open peers. While openness has been found to predict greater viewing times for isolated art images before in lab settings (Fayn et al., 2015), this is the first study to demonstrate this effect in the context of a virtual gallery space.

Further, openness was found to exhibit several cross-level interactions with artwork characteristics to produce viewing behaviors. For example, higher openness tended to increase the positive correlation between artwork size and viewing time as well as the positive relationship between representationalness and viewing time. Thus, while viewing time tended to be longer for representational artworks and for artworks of a larger size, this effect was particularly strong for individuals high in openness. A marginal cross-level interaction of openness was also found for the relationship between representationalness and viewing distance. Together with the openness's main effect on viewing distance, this suggests that open people tended to stand closer to artworks but were also slightly more likely to stand a little further than their peers in response to viewing representational artworks. Overall, this adds to the idea that openness—the most extensively studied personality correlate of activity in the arts and other aesthetic experiences (Swami & Furnham, 2014)—contributes highly to experiences with visual art in museum contexts. In this study, higher openness predicted longer, more intense, and more active engagement with the artwork presented in OGAR.

Structural regression and multilevel models also highlighted a variety of effects associated with extraversion. Looking at the results through a lens of low extraversion, or introversion, frames the engagement highlighted by this trait. In this sample, for example, introverted visitors spent longer in the gallery (extroverts, however, were quicker to leave). Introverts were also likely to travel further in the gallery, which, given the high association between visit time and distance traveled, makes sense. Introversion corresponded with longer viewing times for individual artworks and a stronger relationship between artwork area and viewing time, so introverted visitors were more sensitive to changes in artwork size when choosing how long to look. Introversion also had a negative relationship with viewing distance and cross-level interactions indicated that introversion was associated with a weaker relationship between representationalness and viewing distance. In other words, introverts tended to view from closer in general and were less sensitive to the difference between representational and abstract artworks when choosing how far to view artwork from.

Overall, introversion was widely related to greater engagement with the virtual gallery, but the reasons for this remain unclear. Introversion has not been widely studied in the psychology of arts and aesthetics literature. An early study into the psychology of aesthetics reported that introverts showed a stronger preference for modern and abstract art, relative to extraverts (Cardinet, 1958; as cited in Swami & Furnham, 2014). This may explain why introverts do not show as strong of a viewing time effect for representational artwork as other visitors do. More recently, Chamorro-Premuzic and Furnham (2005) found that introversion predicted art judgements. More broadly, museums are quiet, solitary places, and people tend to interact with works of art alone, even if they visit as a group (Smith, 2014). However, the literature is very mixed on this and other aesthetic effects of introversion (see for example, McManus & Furnham, 2010). Detached from aesthetics, another possibility is that introverted individuals are simply more comfortable in the virtual gallery. A variety of literature links internet use with introversion, including the ability to engage with one's interests and express one's true self through computer-based interactions with content and other individuals (Amichai-Hamburger et al., 2002; Ebling-Witte et al., 2007; Koch & Pratarelli, 2004). If introverted visitors are more comfortable in the online gallery due to their computer habits, then they may be more likely to engage with the experience.

A few effects also cropped up among other variables in the current study. Highly neurotic visitors, for example, did not spend as long in the gallery. Conversely, participants that were high in agreeableness both visited for longer and traveled a greater distance in OGAR. This effect may have been brought on by the study requests made of paid participants, as more agreeable people are more likely to be overrepresented in demanding studies (Zhou & Fishbach, 2016). Finally, aesthetic fluency predicted visit time as well, which indicates that people high in art knowledge were more engaged with OGAR.

What variables didn't influence visit behavior? Unlike the other personality measures, conscientiousness was not found to have any effects on any of the outcomes examined in this study. Past work has linked conscientiousness to having a preference for representational artwork (Furnham & Walker, 2001) and the trait has been reported to have negative associations with general art preferences by several studies (Chamorro-Premuzic, Reimers et al., 2009; McManus & Furnham, 2006), but overall evidence for any effects of conscientiousness on art-related outcomes is mixed, where it exists at all. Like this work, several studies have also found little to no effects for conscientiousness on aesthetic responses (Silvia et al., 2015; Swami & Furnham, 2012). In addition, aesthetic responsiveness was not found to have any effects on the outcomes measured in the current study. This may be explained by the factor structure of the AREA, revealed by confirmatory factor analysis. While two indicators for the latent variable (aesthetic appreciation and intense aesthetic experience) load very highly, the third indicator (creative behavior) has a low factor loading and is not adequately contributing to explaining the overall construct.

All told, as to the question of how personality and individual differences contribute to visit behaviors in OGAR, it turns out that variation in overall visit behaviors was predicted by several factors, albeit in different ways. Visit time—one of the most highly studied variables in museum research—was predicted by almost all the Big Five personality traits (conscientiousness was the exception). Perhaps unsurprisingly, openness to experience had the most extensive effects across all the outcomes measured, both between- and within-person. However, the effects that openness has on a full range of art-viewing and visit outcomes have never been so extensively studied as with the present research. More than that, they further demonstrate the capabilities of virtual gallery tools for art and museum research in the field of psychology. Introversion, interestingly, also showed a large breadth of effects. Since previous literature on this trait and museum visit behavior is so sparse, it is difficult to say whether this is a genuine predictor of art viewing and visit behaviors, or whether it is an artifact of OGAR's digital nature. Nevertheless, either result has promising implications. Even if effects of introversion do not translate to real spaces, these findings are still of use to art professionals looking to bolster engagement with virtual museum content—a rapidly growing goal of cultural institutions across the world (Agostino, 2020).

Artwork Characteristics as Predictors of Viewing Behavior

This study established that art gallery visitors tended to engage with larger works for longer and viewed them from further away on average. Although studies have rarely systematically varied artwork size to examine aesthetic outcomes, Seidel and Prince (2018) found that art images presented at larger sizes were viewed more favorably than identical images presented at smaller sizes. The behavioral effects related to image size in OGAR and the judgments brought on by experimental size manipulations in Seidel and Prince (2018) provide a solid ground for examining how similar manipulations in OGAR might affect viewing behaviors and subjective measurements.

The current work also found that representational art was normally viewed for longer than abstract art. This finding, combined with the observation that art viewing measurements tracked by human judges tend to be longer on average than those tracked by eye trackers or other similar technologies like OGAR, may explain why viewing times are on the shorter side in the current study. Most of the literature on art viewing from art museums has utilized artworks that are all representational (e.g., Reitstätter et al., 2020; Smith & Smith, 2001; Smith, Smith, & Tinio, 2017). Since visitors in this virtual gallery tended to view representational works for longer than abstract works, and the artworks used here are half abstract, shorter average viewing times may be expected. More research is needed, of course, to see if this effect is present in in-person environments, but the current findings are encouraging.

The results seen here also set the stage for more in-depth examinations of how image characteristics interact with individual differences to predict viewing behaviors. Artwork area showed main effects on both viewing time and viewing distance, and representationalness had a main effect on viewing time. To build upon these findings for image area or representationalness, formal image statistics can be used to differentiate artwork characteristics. Graham and Field (2008) examined the amplitude spectrum slope of 140 art images and found that abstract art images had significantly smaller slopes than representational art images. Later, Estrada-Gonzales and colleagues (2020) studied three image statistics—Fourier amplitude spectrum, fractal dimension, and Shannon entropy—and found that total fixation duration in a museum context increased with greater fractal dimensions and amplitude spectrum slope. Further, as amplitude spectrum and Shannon entropy decreased, participants tended to view artworks from a further distance. The promising results obtained about basic image properties in the current study, combined with OGAR's ability to capture very fine-grained behavioral measurements, suggests that an examination of how image statistics impact viewing behavior in the virtual gallery may be fruitful, and may explain why representational works were viewed for longer than abstract works in the current sample.

Limitations

The present research explored engagement with the virtual gallery through direct visit behaviors (i.e., visit time, distance traveled, artwork viewing time, and artwork viewing distance), but it could be extended to include subjective experience measures as well. Admittedly, a one-item measure of visit satisfaction, called the Overall Experience Rating (OER), was planned for participants to complete after their visit to the OGAR gallery, but this measure was not collected due to researcher error. The measure was developed by visitor researchers at the Smithsonian Institution in the early 2000s, and asks "Please rate your overall experience with this [museum/exhibition/event/activity/etc.][today]" (Pekarik et al., 2018). It was designed to "capture unmediated, top-of-mind responses" (p. 355) for quality of experience and was created to be quickly implemented and flexibly used in a variety of exhibition and institution contexts. While directly recorded visit behaviors (such as in the current study) in an unconstrained visit environment are adequate for examining engagement, validation through subjective responses on measures like the OER is a worthwhile pursuit.

Psychological studies are always at the mercy of the participant samples from which they draw, and the current research is no exception. In this sample, the Woo scale did not meet the psychometric qualities described of it in its foundational article (Woo et al., 2014). Although the authors of the scale found six distinct factors and two superfactors, no distinct factors for openness were found with the current sample. Instead, the factors had very high correlations with each other. As a result of its high collinearity, the Woo scale was not usable to build regression models examining how each of the six described factors of openness related to the outcomes of interest for this study. Since general openness, captured by the NEO, was shown to have wide-ranging effects on visit outcomes, it may be fruitful to include the openness to experience subscale of the 100 item HEXACO-PI-R (Lee & Ashton, 2006) as an alternate measure of more detailed openness traits.

Future Directions

This work provides good justification for future exploration in multiple directions. The wide variability in distance traveled, its responsiveness to individual differences in personality, and its ability to be very precisely captured in OGAR all imply that a deeper examination of in-gallery travel may be worth-while. Prior museum work has suggested that museum visitors tend to navigate around the outer edge of gallery spaces, avoiding the center of rooms and often choosing right turns as opposed to left turns (Serrell, 1997). It has also been reported that visitors are much more likely to visit rooms or exhibitions near the entrance of museums (Serrell, 1997)—a trend that may be qualitatively suggested by the heatmap of this study (see Figure 5). These specific navigation features may be examined by creating regions of interest in an OGAR gallery, defined by a room or feature (e.g., room centers vs perimeter areas), to see when a person travels inside a specific region during their overall visit and for how long. Finally, examinations of participant movement in OGAR can take advantage of tools originally developed for studies of animal behavior, like the package *trajr* (McLean & Volponi, 2018), to examine the sinuosity or straightness of individual participant trajectories as they navigate the virtual gallery.

Despite some of the reasoning behind the current study in the first place, the most salient opportunity for further work lies within traditional, in-person field research. Following up this research with an in-person study may help clarify the effects of introversion seen in OGAR, obtain a sample that is visiting the art museum out of their own will, and offer a more direct comparison to the art experiences of most people. Although collecting personality measures in museums has historically been too resource-intensive, the results seen here may be promising to the researcher needing extra assurance that it would be worth the effort.

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APPENDIX A: TABLES

Table A1. Average Artwork Viewing Times in Selected Museum Studies

Study	Location	Sample Size	Mean (*SD*)	Median
Smith & Smith (2001)	Metropolitan Museum of Art	150	27.20 (*33.7*)	17.00
Smith, Smith, & Tinio (2017)	Chicago Art Institute	456	28.63 (*24.39*)	21.00
Carbon (2017)	Neues Museum Nürnberg	225	32.90	25.10
Reitstätter et al. (2020)	Belvedere Museum (1)	109	15.44 (*21.18*)	8.58
Reitstätter et al. (2020)	Belvedere Museum (2)	150	14.93 (*21.25*)	8.07
Estrada-Gonzalez et al. (2020)	Art Gallery of New South Wales	19	12.44 (*7.42*)	11.24

Note. Viewing times are reported in seconds. Belvedere Museum (1) and (2) represent two independent timepoints in data collection for the corresponding study. No *SD* was provided for Carbon (2017).

Table A2. Descriptive Statistics for Continuous Study Variables

Variable	M (*SD*)	Median	Min/Max
Age	33.85 (*12.30*)	32	18, 69
Visit Time	3.91 (*3.00*)	3.05	.17, 18.97
Distance Traveled	118.83 (*55.50*)	114.92	9.95, 412.38
% Time Viewing Art	0.51 (*0.19*)	0.51	0.03, 0.91
Nausea	1.49 (*1.10*)	1	1, 7
NEO Agreeableness	3.63 (*0.50*)	3.67	2.17, 4.75
NEO Conscientiousness	3.38 (*0.69*)	3.33	1.25, 5.00
NEO Extraversion	2.88 (*0.62*)	2.92	1.17, 4.92
NEO Neuroticism	3.34 (*0.82*)	3.42	1.08, 4.92
NEO Openness	3.89 (*0.51*)	3.92	2.00, 4.92
Woo Intellectual efficiency	3.35 (*0.66*)	3.33	1.56, 4.89
Woo Ingenuity	3.64 (*0.61*)	3.67	1.11, 5.00
Woo Curiosity	3.96 (*0.50*)	4	2.11, 5.00
Woo Aesthetics	3.81 (*0.73*)	3.89	1.00, 5.00
Woo Tolerance	3.90 (*0.49*)	3.89	2.00, 5.00
Woo Depth	3.71 (*0.55*)	3.78	1.67, 5.00
Aesthetic Fluency	0.59 (*0.36*)	0.50	0, 1.83
Aesthetic Responsiveness	2.09 (*0.72*)	2.07	0.21, 3.93

Note. n = 264. The descriptive statistics are for the raw scores; for the analyses, transformed versions of visit time and distance traveled were used. The NEO items were completed using a 5-point, 1-5 scale. The Woo items were completed using a 5-point, 1-5 scale. Aesthetic fluency was completed using a 3-point, 0-2 scale. Aesthetic Responsiveness was completed using a 5-point, 0-4 scale.

Table A3. Correlations for the Continuous Variables

Variable	1	2	3	4	5	6	7	8	9	10
1. Age	1									
2. Visit Time	.31	1								
3. Distance Traveled	.19	.70	1							
4. % Time Viewing Art	-.40	.17	.22	1						
5. Nausea	.08	.03	.02	-.22	1					
6. Agreeableness	.10	.17	.16	-.02	.02	1				
7. Conscientiousness	.20	.02	.02	-.04	0	.13	1			
8. Extraversion	-.12	-.17	-.15	-.08	-.11	.07	.29	1		
9. Neuroticism	-.31	-.01	.05	.10	.11	-.13	-.53	-.39	1	
10. Openness	-.03	.21	.19	.11	.01	.20	.09	.07	.10	1
11. Intellectual Efficiency	.19	.02	0	-.02	-.08	-.02	.48	.15	-.43	.23
12. Ingenuity	.09	.15	.16	.03	-.07	.08	.28	.12	-.13	.56
13. Curiosity	.03	.08	.14	.10	-.05	.19	.27	.17	-.05	.58
14. Aesthetics	.08	.23	.22	-.02	.05	.24	.06	.10	.07	.72
15. Tolerance	-.15	.03	.11	.06	.07	.36	.06	.15	.07	.50
16. Depth	-.03	.12	.16	.11	.06	.19	.11	.10	.05	.69
17. Aesthetic Fluency	.23	.18	.11	-.05	.03	.14	.04	.03	.07	.42
18. Aesthetic Responsiveness	-.03	.16	.09	.02	.08	.13	.07	.17	.12	.63

Variable	11	12	13	14	15	16	17	18
11. Intellectual Efficiency	1							
12. Ingenuity	.42	1						
13. Curiosity	.41	.54	1					
14. Aesthetics	.14	.46	.47	1				
15. Tolerance	.15	.35	.54	.49	1			
16. Depth	.24	.48	.62	.58	.56	1		
17. Aesthetic Fluency	.16	.31	.26	.54	.27	.33	1	
18. Aesthetic Responsiveness	.09	.48	.38	.78	.43	.54	.54	1

Note. Pearson *r* coefficients are reported. Correlations of .10, .30, and .50 represent small, medium, and large effects, respectively (Cumming, 2012). Variables 6-10 represent the NEO factors. Variables 11-16 represent facets of the Woo scale.

Table A4. Predictors and Outcomes for the Linear Regression Models

Predictors	Outcomes
NEO FFI	Visit Duration
Neuroticism	Distance Traveled
Extraversion	Nausea Rating
Openness to Experience	% Time Spent Art Viewing
Agreeableness	
Conscientiousness	
Art Specific Predictors	
Aesthetic Responsiveness	
Aesthetic Fluency	
Gender	
Age	

Table A5. Predictors and Outcomes for the Multilevel Models

Predictors		Outcomes
Between-Person (Level 2)	Within-Person (Level 1)	
NEO 5	Image Area	Viewing Time
Neuroticism	Abstract/Representational	Viewing Distance
Extraversion		
Openness to Experience		
Agreeableness		
Conscientiousness		
Art-Specific Predictors		
Aesthetic Responsiveness		
Aesthetic Fluency		
Gender		
Age		

Table A6. Descriptive Statistics by Artwork

			Viewing Time			Viewing Distance		
Art Name	Area	Representational?	Mean	Median	SD	Mean	Median	SD
Sommer	0.34	Yes	4.25	2.4	6.37	1.39	1.04	1.13
Portrait of a Black Man	0.17	Yes	2.25	0.6	4.17	1.47	1.04	1.23
Abstract Composition	0.14	No	2.06	0.2	4.94	1.43	0.91	1.58
Rising Sun	0.08	No	3.06	1	7.13	1.06	0.59	1.36
Lake George, Coat and Red	0.40	No	2.93	0.8	6.32	1.87	1.34	1.54
The Pirates	0.69	Yes	4.02	2.2	5.88	1.75	1.25	1.53
Man Looking at Woman	1.46	No	5.82	2.1	27.86	2.6	2.13	1.83
The Passage from Virgin to Bride	0.32	No	3.18	1	6.18	1.58	1.05	1.5
Vienna seen from the Belvedere	2.91	Yes	10.41	6.6	13.85	2.81	2.04	2.21
Woman with a Parasol	0.53	Yes	3.45	0.2	8.19	1.95	1.48	1.4
Skull with Candle	0.56	Yes	3.39	0.8	5.65	1.73	1.39	1.28
Composition	0.43	No	2.35	0.4	4.12	2.03	1.53	1.56
Subway	0.18	Yes	3.48	1.8	4.66	1.15	0.73	1.2

Barbecue	4.19	Yes	9.32	6	12.13	3.89	2.85	3.02
Lysander I	7.78	No	5.92	3.6	7.54	5.38	4.66	2.73
Bather	0.17	No	2.12	0.2	4.93	1.24	0.91	1.06
Repression	3.30	Yes	6.45	4	8.02	2.62	2.09	1.64
Quattro Stagioni, Autunno	5.96	No	6.33	3.4	10.61	3.56	2.93	1.9
Soul of the Underground	2.92	No	4.95	2.6	8.96	2.82	2.31	1.63
Praise I	2.36	No	3.83	2.1	6.56	3.25	2.6	2.03
Blood with Tell	1.03	Yes	6.08	3	9.01	2.2	1.41	2
Still Life with Flowers and Oranges	0.41	Yes	2.73	1	4.4	2	1.22	2.14
Dessertfrüchte mit Elfenbeinhumpen	0.30	Yes	9.17	6.4	10.77	2.58	2.04	1.55
Dr Feel Good - Clermont Ferrand	4.14	No	6.69	4	9.29	2.94	2.4	1.61

Note. Artwork viewing time reported in seconds. Artwork area reported in square meters.

APPENDIX B: LIST OF ARTWORKS

Study Number	VAPS Number	Title	Artist	Year	Artwork Area	Representational?
1	10515	The Pirates	Slevogt, Max	1914	.70	Yes
2	11019	Repression	Rivera, Diego	1931	4.49	Yes
3	11026	Barbecue	Fischl, Eric	1982	4.19	Yes
4	20128	Sommer	Arcimboldo, Giuseppe	1563	.34	Yes
5	20309	Portrait of a Black Man (Portrait of a Negro)	Gericault, Théodore	1822-23	.17	Yes
6	20605	Woman with a Parasol	Signac, Paul	1893	.53	Yes
7	30221	Vienna seen from the Belvedere	Canaletto/Bellotto, Bernardo	1758	2.91	Yes
8	31103	Blood with Tell (La voix du sang)	Magritte, René	1959	1.03	Yes
9	31017	Subway	Estes, Richard	1969	.18	Yes

10	40405	Dessertfrüchte mit Elfenbeinhumpen	Preyer, Johann Wilhelm	1838	.30	Yes
11	40704	Still Life with Flowers and Oranges	Jawlensky von, Alexej	1909	.41	Yes
12	41024	Skull with Candle	Richter, Gerhard	1983	.56	Yes
13	50703	Rising Sun	Klee, Paul	1919	.08	No
14	50811	The Passage from Virgin to Bride	Duchamp, Marcel	1912	.32	No
15	50833	Abstract Composition	Wadsworth, Edward	1915	.14	No
16	50901	Composition	Lissitzky, El (Eliezer)	1922	.43	No
17	50940	Praise I	Riley, Bridget	unknown	2.36	No
18	51002	Lake George, Coat and Red	O`Keeffe, Georgia	1919	.40	No
19	51013	Dr Feel Good - Clermont Ferrand (Décollage)	Villeglé de la, Jacques	2000	4.14	No
20	51104	Man Looking at Woman	Gottlieb, Adolph	1949	1.46	No
21	51115	Bather	Miro, Joan	1932	.17	No

22	51215	Soul of the Underground	Dubuffet, Jean	1959	2.92	No
23	51301	Quattro Stagioni, Autunno	Twombly, Cy	1993-95	5.96	No
24	51326	Lysander I	Olitski, Jules	1970	7.78	No

Note. Artwork area reported in square meters.