Why did Rubens add a parrot to Titian's *The Fall of Man*? A pictorial manipulation of joint attention

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Almost 400 years ago, Rubens copied Titian's *The Fall of Man*, albeit with important changes. Rubens altered Titian's original composition in numerous ways, including by changing the gaze directions of the depicted characters and adding a striking red parrot to the painting. Here, we quantify the impact of Rubens's choices on the viewer's gaze behavior. We displayed digital copies of Rubens's and Titian's artworks—as well as a version of Rubens's painting with the parrot digitally removed—on a computer screen while recording the eye movements produced by observers during free visual exploration of each image. To assess the effects of Rubens's changes to Titian's composition, we directly compared multiple gaze parameters across the different images. We found that participants gazed at Eve's face more frequently in Rubens's painting than in Titian's. In addition, gaze positions were more tightly focused for the former than for the latter, consistent with different allocations of viewer interest. We also investigated how gaze fixation on Eve's face affected the perceptual visibility of the parrot in Rubens's composition and how the parrot's presence versus its absence impacted gaze dynamics. Taken together, our results demonstrate that Rubens's critical deviations from Titian's painting have powerful effects on viewers' oculomotor behavior.

Introduction

In September of 1628, the Flemish painter Peter Paul Rubens arrived at the court of King Phillip IV in Madrid and remained there for over half a year, until April of 1629. Rubens did not travel to Madrid to paint for the king; rather, he was there on a diplomatic mission—to smooth relationships between Spain and

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England at a time when both countries were in a situation of conflict (Auwers, 2013; Lamster, 2010).

At this point in his life, Rubens had just turned 51 years old and was at the peak of his career, as he was widely recognized as the most important painter in Europe. Though Rubens had his share of emulators and exerted a substantial influence on younger artists—most notably Velazquez—he spent much of his time in the Spanish court copying the large collection of works by the Venetian artist Titian in the royal residences (Belkin, 1998; Freedberg, 1998).

Art historians have posited that the role that Titian occupied in the 16th century, as a central pillar in the history of painting, is one that Rubens aspired to occupy himself 100 years later. Rubens copied Titan, more as a rival to measure against than as a master to learn from. From this perspective, it is fascinating to consider the instances in which Rubens reproduced Titian's pictorial composition to the most minute detail (*The Rape of Europa* is a good example) and, even more, the cases in which he did not.

Titian's *Adam and Eve,* also known as *The Fall of Man*, depicts the story from the Book of Genesis in which a serpent (pictured with the upper body of a human infant) persuades Eve to eat fruit from the tree of knowledge. Rubens's version portrays the same scene, albeit with significant departures from the work of the older master. For example, whereas Rubens's Eve is an almost identical replica of Titian's, Rubens's Adam is far more substantial—portlier and more muscular than Titian's. Rubens also altered Titian's composition in such a way as to change the narrative: Whereas Adam recoils from Eve in Titian's painting, he leans toward her in Rubens's depiction. Further, Adam and the serpent gaze at each other in Titian's painting, but they both look at Eve in Rubens's. Thus, in Rubens's painting, Eve's face becomes "the dramatic nucleus of the story" (Portús Pérez, 2002).

Perhaps the most recognizable difference between the two paintings is Rubens's addition of a striking red parrot to the left of Adam. This parrot, which does not exist in Titian's original version, is said to balance and play the symbolic counterpart to a reddish fox depicted in the lower right of both paintings (Verdi, 2007).

We wondered about the effects that the above differences might have on the viewers' experience and gaze behavior. Thus, the current research aimed to quantify the eye movement dynamics of observers as they viewed the Titian and Rubens paintings, including a modified version of the latter one in which the parrot was digitally removed.

The current experiments

Eye tracking has been used to determine what visual elements of a displayed image or object are important for aesthetic experiences (for a review, see Nodine & Krupinski, 2003). Previous studies have shown that people look more quickly toward pleasing, beautiful, or emotion-eliciting artworks, and they gaze at them for longer durations than they do for disliked or neutral objects (Brandt, 1945; Fan et al., 2018; Guo, Li, Hu, Li, & Lin, 2019; Ilhan & Togay, 2023; Khalighy, Green, Scheepers, & Whittet, 2015; Yanulevskaya et al., 2012; see also Brieber, Nadal, Leder, & Rosenberg, 2014; Krejtz, Szmidt, Duchowski, & Krejtz, 2014). This is consistent with findings from our team and others that gaze fixations tend to be directed toward image regions that are informative, meaningful, or task relevant (Alexander, Macknik, & Martinez-Conde, 2020; Alexander, Nahvi, & Zelinsky, 2019; Chen & Zelinsky, 2006; Hwang, Higgins, & Pomplun, 2009; McCamy, Otero-Millan, Di Stasi, Macknik, & Martinez-Conde, 2014; Otero-Millan, Troncoso, Macknik, Serrano-Pedraza, & Martinez-Conde, 2008). People also use other people's gazes to infer their attentional focus, intentions, and goals (Kaplan & Hafner, 2004). Merely observing shifts in another's gaze toward an object can provide a social signal that alters the perceived value of an object and its importance (Bayliss, Frischen, Fenske, & Tipper, 2007; Bayliss, Paul, Cannon, & Tipper, 2006).

Peripheral perceptual fading commonly occurs for stationary objects with luminance equivalent to that of the background (Alexander, Venkatakrishnan, Chanovas, Macknik, & Martinez-Conde, 2021; Costela et al., 2017; Costela, McCamy, Macknik, Otero-Millan, & Martinez-Conde, 2013; Martinez-Conde, Macknik, Troncoso, & Dyar, 2006; McCamy et al., 2012; McCamy, Macknik, & Martinez-Conde, 2014). Thus, previous work has shown that the sun in Monet's *Impression, Sunrise* (*Impression, soleil levant*), which appears bright but which has luminance equivalent to that of the surrounding sky, tends to fade upon fixation (Alexander et al., 2021; Livingstone, 2002; Safran & Landis, 1998).

Here, we tracked the eye movements of observers as they explored Titian's and Rubens's versions of *The Fall of Man*. Because Ruben's parrot has luminance equivalent to that of the surrounding foliage, we moreover investigated how fixation on Eve's face (the point of convergence for the other figures' gazes) might affect the parrot's visibility.

Consistent with our predictions, we found that the changes to Adam and Eve introduced by Rubens effectively restrict viewer interest to a narrower set of image regions (particularly on Eve's face) as compared with Titian's painting. We also discovered that sustained fixation on Eve's face led to the intermittent perceptual fading and reappearance of the parrot in the visual periphery of observer. This perceptual alternation may play a role in the greater dynamism attributed to Rubens's painting when compared to Titian's (Portús Pérez, 2002).

Methods

Participants

Thirty-three subjects (18 females, 15 males; ages, 14–58 years, with an average of 27.8 years) participated in Experiment 1. Thirty-two of these participants were naïve and were compensated $15/session. One member of our research team served as an uncompensated participant per our Institutional Review Board–approved protocol.

Twenty-two subjects participated in Experiment 2. Of these, four participants were excluded from the data analyses due to making too few button presses while viewing Rubens's painting (which made them ineligible to study the relationship between ocular events and perceptual dynamics). Thus, data analyses were completed on 18 subjects (7 females, 11 males; ages, 15–54 years, with an average of 27.9 years). Fourteen of these participants were naïve and were compensated $15/session. Four members of our research team served as uncompensated participants.

All participants self-reported normal or corrected-to-normal vision. The procedures were carried out under the guidelines and approval of the SUNY Downstate Institutional Review Board (protocol number 690152). Written informed consent was obtained from each participant, as well as written parental consent from participants under the age of 18.

Experimental design

Experimental participants rested their forehead and chin on the EyeLink 1000 head/chin support (SR Research, Kanata, ON, Canada), ~72.0 cm away from a linearized video monitor (Barco Reference Calibrator V with a 60-Hz refresh rate and 1600 × 1200 resolution; Barco, Kortrijk, Belgium).

Experiment 1 procedure

A fixation target appeared in the center of the screen before each trial, and the trial only began if a keypress was made while the participant's gaze position was within 1° of the fixation target. The fixation target then disappeared, and an image of a painting was displayed, centered on the screen. Participants were asked to view the images freely, as they would in an art gallery or museum (i.e., "free-viewing" task). Each image remained on-screen for 45 seconds. Each participant completed 24 free-viewing trials.

Experiment 1 stimuli

The Experiment 1 stimuli included 24 images of artworks (including both versions of the Rubens painting described below). We focused our analyses on two paintings, by Titian and Rubens, depicting the same biblical scene: Eve taking the apple from the serpent in the Garden of Eden. Participants viewed two different versions of Rubens's painting: one image of the original painting and an altered image with the parrot digitally removed (using Photoshop CC 2017; Adobe, San Jose, CA) (Figure 1). We presented only one image of the Titian painting: the original artwork.

To decrease the likelihood that a participant would notice the similarity among the three critical images and compare them with one another, we presented 21 other images of comparable themes and styles on interleaved trials. These additional images consisted of an assortment of classic paintings containing several human figures as the primary focus, depicting Adam and Eve and/or one or more parrots (as in Anthony van Dyck's painting of William Feilding, 1st Earl of Denbigh). Artworks unavailable in high resolution were not included (see Supplementary Table S1 for the full list of selected paintings). Stimuli were presented at the maximum possible size and resolution for our monitor. Thus, portrait-oriented paintings had a height of 1200 pixels (23.8° visual angle), and landscape-oriented paintings had a width of 1600 pixels (31.7° visual angle).

Due to a technical error, there was a small discrepancy in the size of the original Rubens painting and that of the modified version with the parrot removed: eight columns of pixels were inadvertently cropped from the vertical edges of the original version. As a result, both images were displayed with a height of 1200 pixels, but the original version was displayed with a 928-pixel width (18.5° visual angle), whereas the modified version was displayed with a 936-pixel width (18.6° visual angle).

Experiment 2 procedure

Participants completed 252 pseudorandomly interleaved 30-second trials. Of these, 72 displayed Rubens's original *The Fall of Man* (that is, with the parrot included). The remaining 180 trials displayed two additional images for comparison: a Gabor patch

Figure 1. The three image conditions and their associated gaze dynamics. (Top row) The Titian (left), Rubens (center), and Rubens w/o parrot (right) paintings were viewed by the experiment participants. (Middle row) An individual participant's scan paths for each of the three images (on their first viewing of each image). (Bottom row) Overall gaze dynamics can be seen in the average heatmap for all participants (on their first viewing of each image; $n = 11$ participants per condition) across 45 seconds of viewing time. All heatmaps shown are visualized using the same color scale. See Supplementary Figure S1 for further details. Modified from Buendia et al. (1994).

on a blank background (108 trials) and Monet's painting *Impression, Sunrise* (72 trials) Each of these stimulus conditions appeared in pseudorandom order in blocks of seven trials, consisting of two Rubens trials (original and mirror image), two Monet trials (original and mirror-image), and three Gabor trials (of different orientation and compass position). The results for the Gabor and Monet

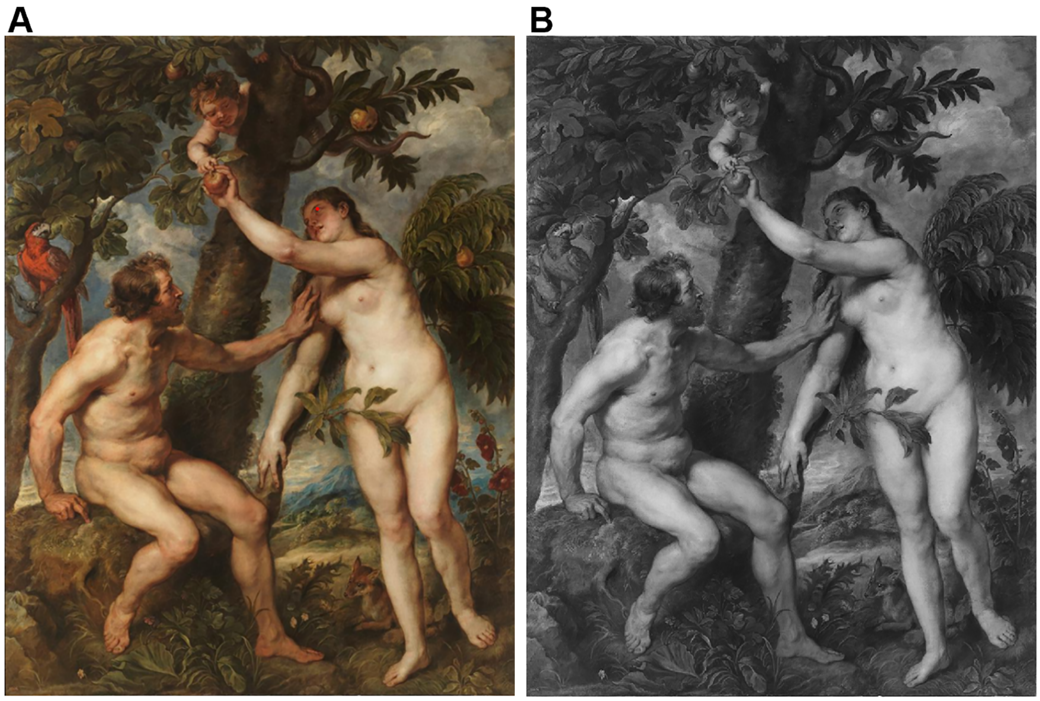

Figure 2. The stimulus for Experiment 2. (**A**) The Rubens image as it appeared in Experiment 2, including a red dot on Eve's eye that served as a fixation target during the task. A mirrored version of this image was displayed on other trials. (**B**) A grayscale version of the Rubens painting shows that the parrot has luminance similar to that of the background. Modified from Buendia et al. (1994).

conditions were reported previously (Alexander et al., 2021). In each stimulus condition, participants maintained their gaze on a small fixation target throughout the trial. During this time, participants continuously reported via button press whenever peripheral objects (parrot, sun, or Gabor patch) appeared to fade or disappear (button press) or intensify or reappear (button release) (Costela et al., 2013; Martinez-Conde et al., 2006; McCamy et al., 2012; McCamy, Macknik, et al., 2014). As in other studies of perceptual fading, these objects oscillated perceptually between visible and faded states, although they remained physically unchanged (Martinez-Conde et al., 2006; McCamy, Macknik, et al., 2014; Simons et al., 2006). After 30 seconds, all stimuli disappeared, and the trial ended. To disregard the potential effect of the initial stimulus onset transient at the start of each trial, we conducted analyses only on data recorded after the first second of the trial. We recorded eye movements throughout the experiment.

Experiment 2 stimuli

For the Rubens trials, a small red dot (0.1° diameter) was placed over the pupil of one of Eve's eyes (the eye farther away from Adam) (see Figure 2A). This red dot served as the fixation target. Participants were instructed to look at the red dot and simultaneously report whether the parrot was faded/fading or visible/intensifying throughout each trial. Figure 2B shows that Rubens's parrot blends perceptually into the foliage when the scene is converted to grayscale, just like the sun in *Impression, Sunrise* blends into the adjoining sky (Livingstone, 2002). This equiluminance between an object and its surround creates conditions previously found to enable perceptual fading (Alexander et al., 2021; Costela et al., 2013; Costela et al., 2017; Martinez-Conde et al., 2006; McCamy et al., 2012; McCamy, Macknik, et al., 2014). A high-resolution digital photograph of the Rubens painting was downsampled to 928 × 1200 pixels to achieve a 9° visual angle distance between the fixation target and the center of the parrot in order to match the viewing distance used for the Monet images and Gabor patch trials.

For the Monet trials, participants viewed Monet's *Impression, Sunrise*. The fixation target was placed over the hat of a fisherman depicted in the painting; participants were instructed to look at the red dot and simultaneously report whether the sun was faded/fading or visible/intensifying throughout each trial. For the Gabor trials, the fixation target was placed in the center of the display, and participants responded to the intensifying and fading of Gabor patches placed at an eccentricity of 9° from fixation.

Eye movement analyses

In both experiments, eye position was acquired noninvasively with a video-based eye tracker at 500 Hz (EyeLink 1000). We recorded eye movements simultaneously in both eyes. We identified and removed portions of the data in which pupil information was missing (blink periods) or where pupil area was very quickly increasing or decreasing (>50 units/sample) because such periods are probably semi-blinks where the pupil is never fully occluded (Alexander & Martinez-Conde, 2019; Troncoso, Macknik, & Martinez-Conde, 2008). To eliminate the initial and final parts of a blink, in which the pupil was still partially occluded, we removed 200 ms of samples before and after each blink/semi-blink (Alexander & Martinez-Conde, 2019; Troncoso et al., 2008).

After removal of blinks, saccades were identified with an objective algorithm (Engbert & Kliegl, 2003; Engbert & Mergenthaler, 2006). We used $\lambda = 6$ to obtain the velocity threshold and a minimum saccadic duration of 6 ms. We considered only binocular saccades to reduce the amount of potential noise. Saccades that occurred <20 ms after a preceding saccade were identified as dynamic overshoots (Moller, Laursen, Tygesen, & Sjolie, 2002) and were added to the duration of the preceding saccade, thus considering these overshoots as part of the saccade.

Fixation periods were defined as the average eye position for a given period during which subjects were not blinking or making saccades larger than 1° visual angle. Microsaccades were defined as saccades with <1° visual angle in magnitude. To obtain unique fixation locations for a given period and to calculate (micro)saccadic properties such as magnitude and peak velocity, the x and y pixel coordinates of both eyes were averaged.

Fixation heatmaps for Experiment 1

We constructed fixation heatmaps and "informativeness" maps as in McCamy, Otero-Millan, et al. (2014). First, to simulate foveal range, we created individual fixation maps by convolving Gaussian kernels, with $\sigma = 0.63°$ for a half-width height of 1.5° (76 pixels), with each fixated location for each image and each participant. We defined the normalized fixation map as $F(i, j) = [f(i, j) - \min_{i,j}(f(i, j))]/[\max_{i,j}(f(i, j)) - \min_{i,j}(f(i, j))]$.

We then used Otsu's method to threshold the averaged normalized map (Otsu, 1975). This method assumes that the map contains two classes of pixels and then uses exhaustive search to calculate the optimum spread to separate the two classes such that the sum of within-class variances is minimal. We labeled these two classes of pixels the "consistently fixated region" (Ψ, the region of pixels above threshold) and the "inconsistently fixated region" (Ω, the region of pixels below threshold).

Results

Experiment 1

We studied the gaze behavior of participants as they viewed three images: Titian's and Rubens' versions of *The Fall of Man*, plus a third image in which we digitally removed the parrot from Rubens's painting (hereafter referred to as "Rubens w/o parrot"). Participants' eye movements were recorded simultaneously with high precision (see the Methods section for details).

We found that viewers directed their gaze more often to Eve's face in Rubens's painting than in Titian's, indicating that Rubens's changes to Titian's composition served to alter the attentional focus of observers. Figure 3 shows that, within a region of interest (ROI) centered on Eve's face, peak heatmap intensity was greater in the Rubens condition than in the Titian condition, $t(20) = -2.31$, $p < 0.05$. No differences in the other ROIs reached significance, indicating that the change in attentional focus across conditions was primarily centered on Eve. Heatmap activation across the entire image is visualized in Supplementary Figure S2.

It is interesting to note that, as the Rubens painting is the only one of the three that included a parrot, fixations directed to the parrot in this condition might have diminished fixations on the other characters in the scene. Instead, participants gazed the most at Eve's face in the Rubens condition, relative to the Titian and Rubens w/o parrot conditions. That is, rather than drawing the viewer's gaze away from Eve, Rubens's addition of the parrot resulted in greater viewer focus on Eve's face.

Next, we set out to quantify the spread of gaze behavior across images and to identify the image regions that participants looked at most frequently. We accomplished this by characterizing the consistently versus inconsistently fixated regions in each image. This "informativeness" analysis (McCamy, Otero-Millan, et al., 2014) (see the Methods section for details) determined which regions were gazed at the most, across participants (see Figure 4).

We found that consistently fixated (Ψ) regions were smaller for the Rubens painting than for the Titian painting, consistent with greater gaze restriction during the visual exploration of the former than the latter. Moreover, Ψ regions were further constrained when the parrot was present in Rubens's painting as compared to when it was absent (i.e., digitally removed) (see Figure 5). The smaller spread of gaze in the Rubens condition (especially when the parrot was left unaltered)

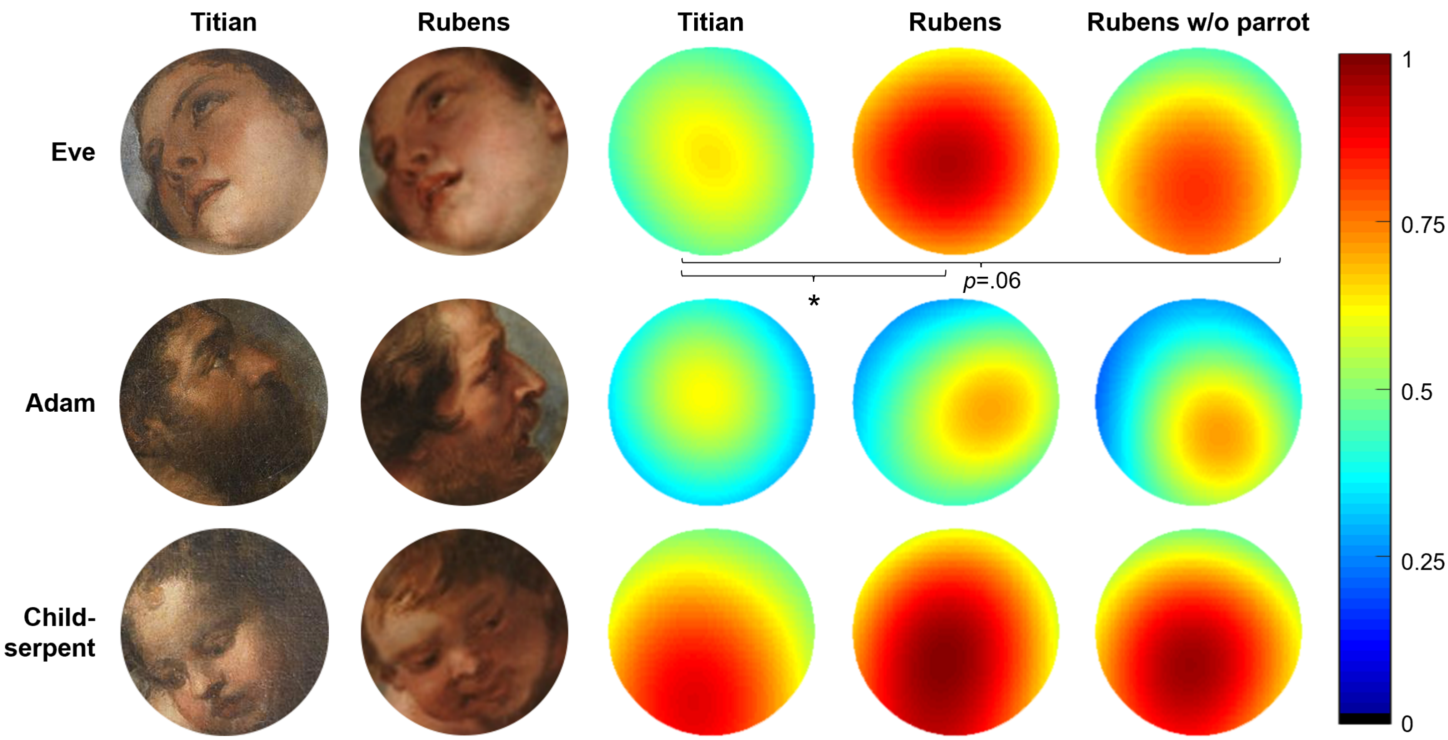

Figure 3. Heatmap analyses of ROIs in Titian's and Rubens's paintings. Column 1 illustrates the Eve, Adam, and child/serpent ROIs for the Titian painting. Column 2 illustrates the same three ROIs for the Rubens and Rubens w/o parrot paintings. Columns 3, 4, and 5 depict the average heat within each ROI for the Titian, Rubens, and Rubens w/o parrot paintings, respectively. ANOVAs revealed a marginal difference in maximum heat across the Eve ROIs, $F(2, 30) = 3.04$, $p = 0.06$. No difference was found across conditions for the Adam or child/serpent ROIs. No pairwise comparison was significant except between the Titian and Rubens conditions for the Eve ROI (*$p < 0.05$). See Supplementary Figure S1 for a visualization of the ROIs on each of the paintings and Supplementary Figure S2 for a three-dimensional visualization of intensity activity on the heatmap. The first two columns are modified from Buendia et al. (1994).

relative to the Titian condition thus supports the notion that Rubens's original composition more efficiently focuses viewer interest than Titian's.

One should moreover note that participants consistently gazed at the parrot when it was present in the image. Critically, this image region was not consistently fixated in the corresponding locations of the Titian or the Rubens w/o parrot images, demonstrating that gaze fixations on the parrot were specifically due to the parrot's presence (see also Supplementary Figure S2). These combined results suggest that, compared to Titian, Rubens was able to effectively focus viewer interest to smaller image regions and to hold that interest longer—partly by including the parrot as a novel element of his composition.

Experiment 2

While studying Rubens's *The Fall of Man*, one of the authors (SM-C) noticed that the red parrot, despite its high chromatic contrast, was equiluminant with the surrounding areas, such as the foliage of the tree. This equiluminance of the parrot and its background can be easily appreciated in a grayscale version of the original image (Figure 2B).

Knowing that Troxler fading—the perceptual disappearance of stationary images upon persistent fixation—is common for peripheral objects with luminance equivalent to that of the background (De Weerd, 2006; Livingstone & Hubel, 1987; Spillmann, 2006), we set out to investigate the effect of sustained fixation on Eve's face on the parrot's visibility. We chose Eve's face as the locus of fixation because Rubens's composition draws the other characters' gazes (and, as a result, the observer's gaze) to Eve's face (Figures 1, 3, 4). In other words, we assessed the viewer's perception of the parrot from the focal point identified in Experiment 1 (Eve's face). Therefore, we recorded the eye movements from participants as they gazed at a small fixation target placed over Eve's eye in the Rubens painting. Simultaneously, participants reported, via button press/release, if the parrot's visibility was fading or intensifying throughout the trial.

As with other bistable stimuli paradigms (Martinez-Conde et al., 2006; Spillmann & Kurtenbach, 1992; van Dam & van Ee, 2005; van Dam & van Ee, 2006a; van Dam & van Ee, 2006b), participants

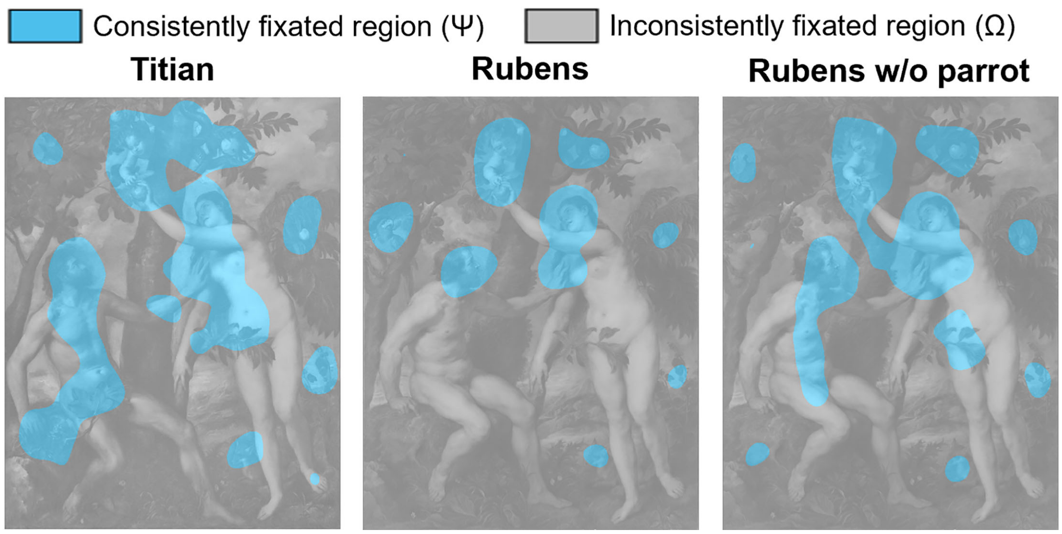

Figure 4. The regions gazed at the most across participants. Representative maps of consistently (Ψ) and inconsistently (Ω) fixated regions in each painting are shown, excluding one participant from each condition (as per the method of Otsu, 1975). These precisely quantified patterns of fixations provide a measure of viewer interest and engagement; a key difference across conditions is the degree to which viewers focus on Eve in lieu of other image elements (such differences in viewing behavior are captured by the thresholded maps). To create these regions, the normalized fixation heatmaps of all but one subject per condition were averaged. This average heatmap was then thresholded. Otsu's method assumes that the heatmap contains two classes of pixels, corresponding to Ψ and Ω regions, and applies an exhaustive search to calculate the optimum threshold to separate the two classes so that their combined spread (sum of within-class variances) is minimal ($n = 33$). The Titian and Rubens paintings are modified from Buendia et al. (1994).

found that their perception of the parrot oscillated between two alternating states (faded/fading versus visible/intensifying), even though the physical stimulus remained unchanged during each trial. The parrot stayed faded (i.e., it perceptually disappeared into the surrounding foliage) for a substantial amount of time in the trial, sometimes for more than 10 seconds (Figure 6). Further, the average duration of fading percepts was not significantly different across the Rubens, Gabor, or Monet conditions, $F(2, 51) = 1.45$, $p = 0.24$, consistent with the idea that the same form of perceptual fading underpinned the viewers' experience of all three images.

Next, we examined the time of perceptual alternations with respect to that of microsaccade occurrence by locking changes in perceptual transition reports to changes in microsaccade rates. This analysis revealed a clear relationship between microsaccade production and fading/intensification dynamics. Specifically, we found that increased microsaccade rates were related to ensuing perceptual intensification/visibility. Conversely, decreased microsaccade rates were related to ensuing perceptual fading (Figure 6). This relationship was consistent with the link between microsaccade production and the subsequent reversal of Troxler fading, previously reported for a variety of visual stimuli (Alexander et al., 2021; Costela et al., 2013; Costela et al., 2017; Martinez-Conde et al., 2006; McCamy et al., 2012; McCamy, Macknik, et al., 2014).

Discussion

Rubens's artworks have been a previous object of scientific interest (Daneyko, Stucchi, & Zavagno, 2022; Topper, 1984; Zavagno, Daneyko, & Stucchi, 2015). Here, we set out to investigate how Titian's and Rubens's differing interpretations of the *The Fall of Man* might affect viewer experience. Specifically, we focused on two main ways in which Rubens's depiction departed from Titian's original painting: the characters' gaze direction and Rubens's addition of a striking red parrot to the composition. In Experiment 1, participants freely viewed the images, allowing us to test whether the gaze consensus among the characters in Rubens's painting served to draw the viewer's gaze to Eve's face—as well as to assess the potential role of the parrot in the viewer's gaze dynamics. In Experiment 2, participants looked directly at Eve's face and continuously reported the perceptual visibility of the parrot.

Gaze dynamics in Rubens versus Titian

We predicted that viewers would be more strongly drawn to Eve's face in Rubens's painting than in Titian's, due to Rubens's compelling use of joint attentional cues—provided by the characters' shared focus on

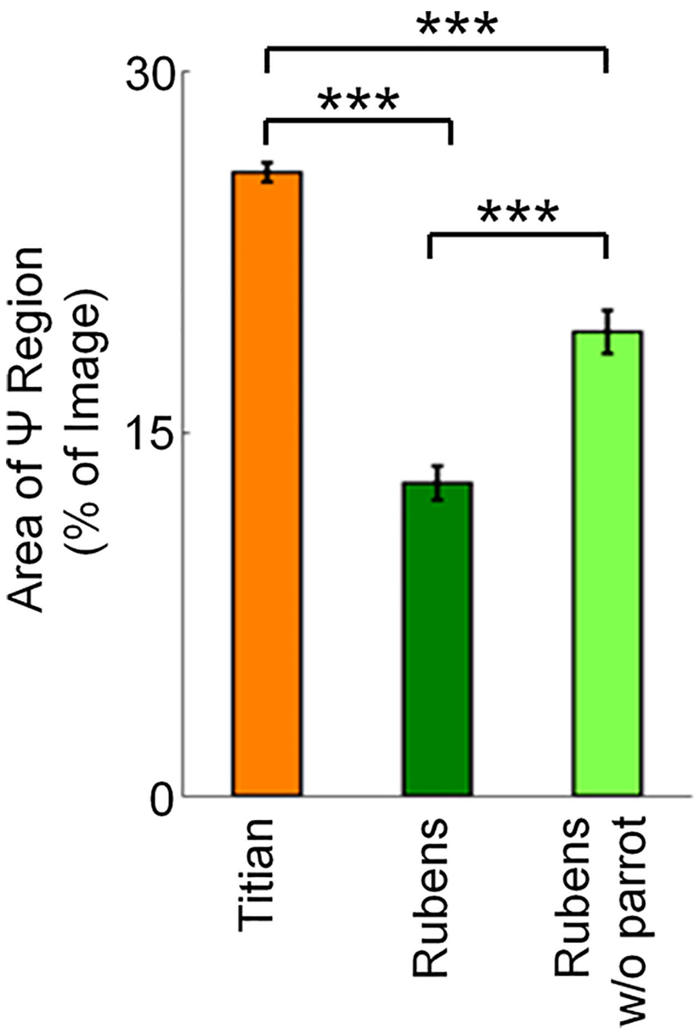

Figure 5. Percentage of the image that was informative (i.e., consistently fixated) in each condition. The Ψ regions were smaller for the Rubens painting than for the Titian painting, and they were further restricted when the parrot was present versus absent.

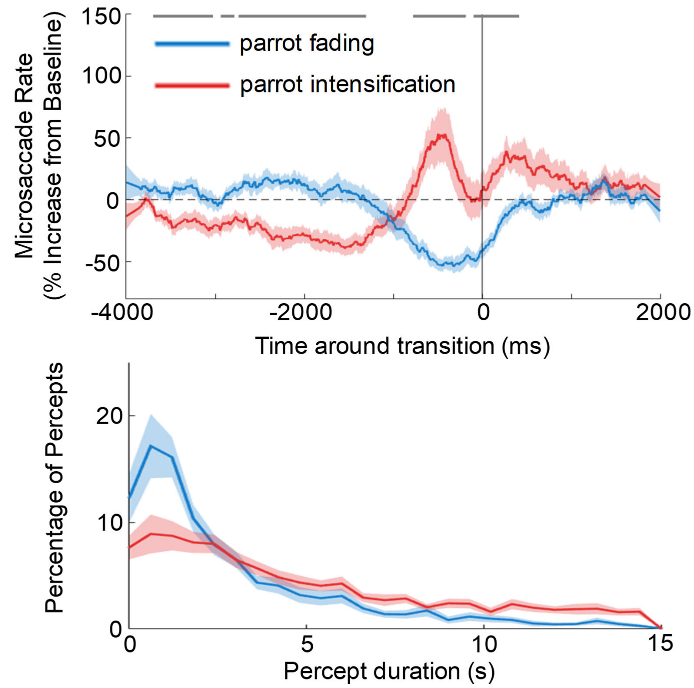

Figure 6. Perceptual fading dynamics in Experiment 2. (Top) Perceptual transitions to fading and intensification are preceded by corresponding decreases and increases in the average microsaccade rates, following a pattern previously reported for Gabor patches and Monet's *Impression, Sunrise* stimuli (see Alexander et al., 2021). The solid vertical line indicates the reported transitions (time = 0). The gray dashes along the top of the plot indicate the bins where microsaccade rates before transitions to intensification were significantly higher than microsaccade rates before transitions to fading (one-tailed paired t-tests with Bonferroni correction, bin size = 20 ms, $p < 0.01$). Red and blue shading indicates the SEM across subjects (n =18). (Bottom) Percept duration during the reported fading and intensification of the parrot in the Rubens painting (n = 18).

Eve's face. We also considered how Rubens's parrot may enhance the joint attention cues in his painting. According to Portús Pérez (2002, p. 112) Rubens introduced the parrot as a "symbolic counterpart to the fox in the lower part of the painting which also acts as a beautiful and original signature." Yet, it is possible that the parrot's presence—notwithstanding the symbolism—exerts a direct impact on the viewer's gaze behavior and perceptual experience of the painting. As others have noted, the parrot alters the relationships between the figures in the painting (Verdi, 2007). We thus speculated that the parrot might further also encourage viewer focus on Eve's face.

Consistent with our predictions, participants looked at Eve more frequently when viewing the Rubens versus the Titian painting. Interestingly, observers' gaze focus on Eve's face was especially pronounced when the parrot was present than in an alternative version of the Rubens painting, in which the parrot was digitally removed (see Figure 5). In other words, the parrot's presence contributed to the viewers' gaze patterns, biasing them to gaze more frequently and for longer durations at Eve than in the parrot's absence.

Our data also showed that observers consistently foveated a smaller portion of the Rubens painting than they did of the Titian painting. That is, whereas the viewers' gaze was more strongly focused on Eve's face for the Rubens painting, it was more dispersed around the image for the Titian painting.

Troxler fading in Rubens's *The Fall of Man*

Troxler fading has been described for a variety of visual objects, including the painted sun in Monet's

Impression, Sunrise. Gazing for a few seconds at the head of the sailor in Monet's painting causes the rising sun to seemingly fade away (Safran & Landis, 1998). Yet, Troxler fading has not been previously reported for any of Rubens's works (or for other paintings from the same period). Here, we report the perceptual fading of Rubens's parrot and we quantify its characteristics, including its relationship to oculomotor dynamics.

We previously showed that microsaccades—small, involuntary eye movements occurring one or twice per second during fixation—reverse Troxler fading and restore visibility during fixation. This relationship extends to the art domain, as increased microsaccade rates restored Monet's sun's visibility after perceptual fading (Alexander et al., 2021; Safran & Landis, 1998), much as they did for simpler, contrived stimuli such as Gabor patches (Costela et al., 2013; Costela et al., 2017; Martinez-Conde et al., 2006; McCamy et al., 2012; McCamy, Macknik, et al., 2014).

Our current study demonstrates that microsaccade dynamics likewise drive the fading and reappearance of the parrot in Rubens's painting while observers look at Eve's face—the focal point of the painting, as established by Experiment 1. Thus, our results indicate a much earlier manifestation of Troxler fading (and the oculomotor kinematics behind it) in representational art, predating Monet's masterpiece by 250 years.

We should note here that the perceptual fading of the parrot's in Rubens's *The Fall of Man* is not constrained to digital reproductions of the art, such as displayed during our experiments. While viewing the original painting in person during a visit to El Prado Museum, author SM-C confirmed that focusing her gaze on Eve's face caused the parrot to perceptually vanish and that relaxing her gaze caused the parrot to reappear, in line with our experimental findings.

Focusing on Eve

Decades of research have demonstrated that a handful of visual features are important for directing attention and gaze to visual objects (Wolfe & Horowitz, 2004). These include motion, shape (Alexander et al., 2014), color (e.g., Alexander et al., 2019; Williams, 1966), and texture (e.g., Alexander, Waite, et al., 2020; Alexander & Zelinsky, 2011; Waite et al., 2020).

As Rubens created his portrayal of *The Fall of Man*, he may have intuitively changed some of these features (excepting motion, which is not applicable to a static painting) to better direct attention toward Eve. However, our results show that not only did Rubens deviate from Titian's masterpiece through changes in standard bottom-up elements such as those listed above, but he also effectively directed viewer gaze through higher level compositional changes, by creating shared gaze—and, thus, powerful joint attentional cues—among his depicted characters. This is an impressive feat of perceptual expertise and artistic talent, because not all shared gaze drives behavior in this way. For example, substantial efforts have been made to create robots that attract human attention through mutual gaze and pointing gestures (e.g., Imai, Ono, & Ishiguro, 2001), but these referential strategies fail as frequently as 73% of the time when attempting to direct viewers to paintings or details of paintings (Pitsch & Wrede, 2014). Even though all of the characters in Rubens's depiction are inanimate, the striking attentional cues they share command the viewer to direct their gaze to the central focus of the composition: Eve's face.

When the observer's gaze has lingered on Eve's face for a few seconds, the eye-catching parrot that Rubens added to the tableau seems to fade from view, blending into the surrounding foliage. We provide the first report and quantification of this perceptual fading, and we moreover showed that it results from the viewer's own oculomotor behavior.

Four hundred years ago, was it Rubens's artistic choice or merely happenstance that the luminance values of parrot's plumage should not differ from those in the immediate background, despite the intense chromatic contrast between the bird and the surrounding foliage? It is tempting to speculate, but impossible to prove, that Rubens could have wittingly designed the parrot to direct the viewer's gaze to Eve, and then to become less salient upon the foveation of Eve's face, thereby contributing to the legendary dynamism of Rubens's composition (Portús Pérez, 2002). Or, perhaps Rubens merely intended for the parrot to be subtly noticeable and not draw excessive attention from the viewer. Whether intentionally or intuitively, Rubens may have worked to adjust the visual qualities of the parrot to minimize the luminance contrast between the bird and its surroundings, thus making it prone to fading upon fixation.

We note that this perceptual vanishing does not occur when looking directly at the parrot but arises instead when viewers sustain their gaze on Eve's face—the very location that Rubens's composition directs one's attention to. When the viewer gazes at Eve's face, the parrot fades into the background and no longer impacts their perceptual experience of the painting. Thus, not only does Rubens's parrot design provide an element of visual interest when one examines the painting's background, but it also perceptually removes an object that might otherwise compete for attention when one focuses on Eve's face.

Keywords: joint attention, renaissance art, microsaccades, fixational eye movements, artwork analysis, shared gaze, troxler fading, viewer interest, gaze behavior, eye movement patterns, oculomotor dynamics

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