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Guiding the Gaze

An Experimental Eye Tracking Study on the Influence of Gaze Direction on the
Viewing Behaviour and Perception of Narrative Paintings

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*“The eyes are the principal inlets to the soul:
by these alone the painter may discover and
express every passion, as joy, grief, fears,
hope, and desire, in so perceptible a manner,
and so forcibly, as shall be pleasing and
satisfactory to the best judges.”*

Lodovico Dolce, *Aretin: A Dialogue on Painting*, 1557

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1. Introduction

Our eyes play an essential role in everyday social interactions. Colloquially called “the windows to the soul”, as far back as the mid-1500s,¹ their expressive nature can hold a vast amount of information that is conveyed between people without having to speak a single word. Through looking at peoples' faces, we gauge their emotions and desires, enabling us to gain a better understanding of them. Thus, the gaze of others is a highly salient stimulus. The way we communicate with our eyes has been studied extensively. Calling it “visual behaviour”,² Harper et al. describe face-gaze and eye-gaze direction as the most important communication signals, with head and body turns being considered lower on the hierarchy of non-verbal signals. Conveying something without words is an essential part of our lives and carries over to visual media as well, particularly still images that can only show moments frozen in time. The subtle influence of the gaze cannot just be found in natural scenes and everyday images, such as photographs and advertisements³ but also in the perception of artworks. Thus, the gaze of portraits has fascinated people for centuries.⁴ We feel as if a portrait's outward looking gaze is actively watching us, following our movements with their eyes. Or we trace a figure's inquisitive gaze through a canvas like a maze to find what captured their attention. Directing others through looks is deeply woven into human behaviour, and examples can be found throughout history. Unsurprisingly, the significance of looks and gaze in literature and philosophy has gotten a considerable amount of recognition.⁵ Going back millennia to Ancient Egypt, the way a sacred text was supposed to be read was indicated by the direction certain hieroglyphs faced.⁶ If figures were facing to the left, the order was left-to-right, directing the reader's eye to the starting point of the text through their gaze. The narrative would therefore only unfold for the observer if they adhered to the direction set by the ideographic characters' eyes.

The influence of gaze on telling stories has left its traces in art historical treatises throughout the centuries. When Shaftsbury ponders the ancient tale of the Greek hero Hercules choosing his future path, he makes a point to describe whereto the story's protagonist should turn his gaze to direct the narrative, without giving away too much of the unfolding story.⁷ Thus, by following the direction of his eyes, it might be revealed to us what fate will befall him. The

¹ Dolce [1557] 1770, p. 28; see also Riegl 1931, p. 20.

² Harper/Wiens/Matarazzo 1978, p. 181.

³ Hutton/Nolte 2011, pp. 890–891.

⁴ Neumeyer 1964, pp. 40–41.

⁵ See Manthey 1983 for a comprehensive study on the role of eyes, gaze, and seeing in the written arts.

⁶ Steiner 1988, p. 15.

⁷ Shaftsbury 1713, pp. 15–16.

idea of tracing a figure's gaze through the canvas is echoed by Wölfflin in his notes on Raphael's *Sistine Madonna*. Describing the path the viewer follows along the composition, he sees the gaze direction of the two attending figures as guides to lead the observer on a path deliberately chosen by the artist.⁸ This manner of including the gaze direction in the interpretation of image description can also be seen in Riegl's work on the development of the Dutch group portrait from the 16th to the mid-17th century, where he analyses the uniform direction of the sitters' gazes as conveying the idea of a common purpose.⁹ In his introductory chapter to Riegl's book, Kemp surmised the evolutionary process of this genre with the unification of figures by creating "[i]nternal coherence' [...] through the adroit and sensitive directorial control of the eye contact"¹⁰, enabling the viewer to identify with the figures, instead of just observing them. It appears undeniable that the direction of gaze is a significant factor in the perception of paintings. Despite its importance being mentioned sporadically throughout the centuries, a systematic approach towards an analysis of its effects has been lacking so far.

The following thesis is the product of several years of research on the way paintings can tell stories to their audience. What formal aspects can guide the beholder's eye through the canvas, and how does it potentially influence peoples' understanding of what they see before them. It started with a simple question: Wondering if compositions can determine the temporal order in which a visual narrative is "read". This resulted in a preliminary study, confirming the assumption based on Giotto's *Raising of Lazarus* (*Figure 1*). The artist's reliance on gaze direction and gestures in arranging the temporal moments of the story in this fresco was particularly eye-catching and lent itself to further investigation.¹¹ As the study was able to show, the hand gestures and gaze direction of the figures was replicated by the participants' viewing behaviour (*Figure 2*). Due to the limited scope of this paper, one concise and measurable variable had to be chosen to delve deeper into the issue. Therefore, the road of interest was narrowed down to one element that can be measured with the help of the experimental study methods of eye tracking and surveys: the influence of painted gaze on the viewing behaviour of its observers.¹²

⁸ Wölfflin 1899, p. 130.

⁹ Riegl 1931, pp. 86–87.

¹⁰ Kemp 1999, p. 14.

¹¹ See Imdahl 1988, p. 70.

¹² During the same time, an empirical study on the influence of deictic gestures was done at the CReA Lab by a colleague, complementing the results of the present one: Dimova/Lapique/Rosenberg 2025.

1.1 State of research

Art historical literature has discussed the depiction of eyes mainly within the context of the genre of portrait painting and its development in the early modern period, framing their eye contact as a form of silent dialogue. In his monograph *Der Blick aus dem Bilde* Neumeyer traces the outward looking portrait back to the Hellenistic Greek period.¹³ He categorises the direction of gaze as a form of body language and further as a part of the spatial construction in Early Renaissance art,¹⁴ describing a figure's gaze as crossing the border of the painting to draw the viewer's attention into the scene.¹⁵ Boehm similarly interprets the interrelationship of the portrait and the observer as a mutual act of being perceived: the portrait by the onlooker and the viewer by the portrayed.¹⁶ Larsson describes figures that are placed in the composition to establish contact through direct eye gaze, mediating between the onlooker and what is happening on the canvas as part of his writings on sign language and facial expressions in 17th-century paintings.¹⁷ Belting also focuses on the reciprocal nature between the portrait and the viewer, equating the "gaze out of the image"¹⁸ with a returning look within a natural scene. Building on Neumeyer's above mentioned writings on the canvas-transcending gaze, Schmidt-Burkhardt sees outward-looking figures as essentially fulfilling a similar function as a *repoussoir*.¹⁹ Catching the onlooker's attention and engaging them in the depicted scene.

Very few authors have approached the eyes and their gaze as a conveyor of information about the scene itself to the viewer. One of those is Kern, who positions the gaze between portraits of courting couples as an essential aspect of understanding their interactions. He mainly focuses on "proposal compositions"²⁰, in which the decoding of the gaze is critical to the interpretation of the visual narrative. The role of the eyes in a visual composition has also been discussed in the context of narrativity and the issue of how to depict time within a static image, with the direction of the gaze being able to indicate how the story might play out. Wolf describes several formal aspects of a picture that help to understand what happened before and after the pictured moment, including looks between figures, among others, such as gestures, facial expressions, and glances.²¹ Furthermore, Belting has also made efforts to

¹³ Neumeyer 1964, pp. 21–22; see also Riegl 1931, p. 15 who sees a shift towards an autonomous significance of the eyes in portraits in the Roman Imperial period.

¹⁴ Neumeyer 1964, pp. 39–40.

¹⁵ Ibid., pp. 10, 44–45.

¹⁶ Boehm 1985, p. 37.

¹⁷ Larsson 1990, p. 174.

¹⁸ Belting 2007, p. 67.

¹⁹ Schmidt-Burkhardt 2024, p. 172; see also Neumeyer 1964, p. 10.

²⁰ Kern 1996, p. 7.

²¹ Wolf 2002, p. 67.

establish an “iconography of the gaze”, calling outward looking figures “shifters” that steer the viewing behaviour, similarly to how silent movies managed to convey the narrative to their audience, partly through looks between actors.²² Despite these efforts, the topic of eyes and gaze direction in art is mostly confined to portrait paintings or scenes with the gaze directed towards the beholder. How gaze can guide attention in a painting has received surprisingly little consideration.

In his monograph *Hercules am Scheidewege und andere antike Bildstoffe in der neueren Kunst*, Panofsky describes the uncertainty of the unfolding scene in Annibale Carracci’s painting of the ancient Greek hero (*Figure 3*). The famous story tells of the difficult decision Hercules must make between a life of heroic virtue or hedonistic pleasure. Panofsky makes note to mention the position of Hercules’s eyes as one of the few hints the artist gives his audience as to what future his protagonist will decide for himself: “[E]r lauscht, wie die Stellung der Augäpfel anzeigt, mit gespanntester Aufmerksamkeit auf die Rede der [...] ‘Virtus’”²³. In the depicted moment, the hero’s choice is not yet made, but by following his gaze, the next chapter in the story is revealed to us: Hercules being pulled in by Virtue’s arguments and soon choosing the path she represents. Nearly a hundred years ago, Panofsky touched on a still rather unexplored topic: the effect gaze direction can have on how a painting is perceived and the implications of using it as a narrative tool when temporality is absent. Going into more detail, Gombrich discusses how the artist depicting the classical story has several moments to choose from the narrative, while citing another painting depicting the same story by the artist Paolo de Matteis (*Figure 4*).²⁴ The composition here is decidedly different, with the allegory of Vice being placed lower, sitting on the ground, and the hero being fully entranced by Virtue. He is turned towards her—unmistakably looking at her face—and seemingly in deep thought over her words. In contrast, the point Carracci selected is filled with considerable uncertainty. It leaves more room for doubt, thereby giving the viewer the space to infer for themselves what is yet to come from the small clue of Hercules’s gaze direction, including an almost imperceptible inclination of his head. Drawing the observer’s eyes towards the allegory of Virtue, with her arm directing him towards the winged horse Pegasus in the far back, symbolic of his future as a hero. Carracci also added an allegory of Poetry—possibly a reference to historiography—in the form of a laurel-wearing poet to Virtue’s side, emphasising how the right choice will lead to Hercules’s immortality in history.

²² Belting 2006, pp. 135–136.

²³ Panofsky 1930, p. 125.

²⁴ Gombrich 1982, pp. 40–42; see also Fowler 2003, pp. 23–24.

When considering the complexities of history paintings, such as the above cited example, the possibility of using gaze to convey information about the story becomes intriguing. The understanding of a scene, written or painted, relies heavily on the audience decoding its language.²⁵ The artist must give their spectator the necessary information to make sense of what the scene is meant to convey. There is a strong focus on formal aspects, such as expressive gestures and physiognomy, in the literature in this regard. Baxendall places an emphasis on the movements and gestures of figures to describe their emotional state and only mentions the direction of a figure's gaze in passing.²⁶ Hochberg describes the expressive characteristics of a figure as a tool to provide the observer with certainty of what the person plans to say or do: “[D]ie Ausdrucksmerkmale einer Person [dienen dazu], ihre nächsten Handlungen anzukündigen [...], also in erster Linie dazu, beim Beobachter die Ungewißheit[sic!] darüber zu verringern, was die andere Person zu sagen oder zu tun beabsichtigt.”²⁷ He states that physical expressions of the body tell the onlooker what a figure in a painting is likely to do or say next. Notably, while he does not mention the gaze direction, he does include the expression of the eyes in his use of the term “Ausdrucksmerkmale”.²⁸ A similar sentiment can be found in Gombrich's book *The Image and the Eye*: “The movement must result in configurations that can be easily understood and must stand in contexts which are sufficiently unambiguous to be interpreted.”²⁹ But, while he spends time on the use of pointing finger gestures in Medieval narrative art, which he calls “speaking gestures”³⁰ and can be widely understood regardless of people's prior knowledge, when it comes to the topic of eye contact and gaze direction as a universal expression, it is all but left out of his extensive writing about non-verbal communication and expression in Western art. Except to mention the lack of a systematic study of the subject.³¹

In his book on the silent language of pictures, Rehm positions the role of gestures as an essential tool in the storytelling ability of history painting for artists in the early modern period.³² He describes how expressive gestures have the capacity to portray a moment with the remnants of what came before and the indications of what will be.³³ Not to mention the very real-life use of sign language all over the world. Yet, he omits eye contact and gaze as a

²⁵ Gombrich 1960, pp. 181–182.

²⁶ Baxendall 1972, pp. 60–61.

²⁷ Hochberg 1977, p. 106.

²⁸ Ibid., p. 101.

²⁹ Gombrich 1982, p. 79.

³⁰ Ibid., p. 66.

³¹ Ibid., p. 101.

³² Rehm 2002, pp. 100–137.

³³ Ibid., p. 104; see also Dimova 2019.

storytelling tool in his writings. The search for gaze as a part of the connective tissue of a scene in the art historical literature canon reveals a largely overlooked topic. However, when looking beyond the borders of traditional art historical methodologies, an exciting possibility emerges. While the influence of visual attention and gaze cueing has only been brushed on in art history, it has inspired a wide field of research in the psychological fields of human development and perception.³⁴

Empirical research: The appeal of the face

In the earliest monograph on art perception and eye movements, Buswell reveals that, when confronted with paintings containing human figures, people spend most of their time looking at the faces, paying little attention to anything else on the canvas. This results in dense fixation clusters in those areas.³⁵ A fixation occurs when the eye remains still for a certain amount of time, usually somewhere between tens and hundreds of milliseconds.³⁶ When examining the saccades—which are “rapid motion[s] of the eye from one fixation to another”³⁷—for the same image, he found that the eye movements did not just stay isolated within the areas of the faces, but often moved back and forth between multiple faces.³⁸ The results also show that people are spending most of their attention on human faces, establishing connections between two faces with their own viewing behaviour. This lends weight to the general assumption that people, when confronted with them, treat figures in paintings similarly to how they would behave in a real-life social setting.³⁹ Several decades later, in his widely influential monograph on eye movements, Yarbus shows how participants focused on the parts of images that held the most relevant information for them. Exposing people to the same painting repeatedly, posing different questions about the depicted room and the figures in it each time. When it came to understanding the social aspects of the scene and relations between the people in the painting, the areas of highest interest were found to be the human figures, with a higher concentration on their faces.⁴⁰ The level of attention observers placed on a figure changed depending on the space and role it occupied within the painting.⁴¹ People also looked more at faces than the full figure, and when shown portraits, they focused mostly

³⁴ See Frischen/Bayliss/Tipper 2007 for a comprehensive research review on the role of gaze in social interactions and the direction of attention.

³⁵ Buswell 1935, p. 20.

³⁶ Holmqvist/Andersson 2017, pp. 13–14.

³⁷ Ibid., p. 14.

³⁸ Buswell 1935, pp. 62–66.

³⁹ See Belting 2007, p. 66.

⁴⁰ Yarbus 1967, pp. 172–177.

⁴¹ Ibid., p. 191.

at the eyes and less at the mouth and nose.⁴² His results have been found to hold true in a replication of Yarbus' study, conducted by DeAngelus and Pelz.⁴³ Several other eye tracking studies have since shown that human faces are by far the most looked at area. They are detected faster and with higher accuracy than other objects in a natural scene setting,⁴⁴ even when digitally manipulated to impede detection.⁴⁵

The appeal of the face has also been found to be true in studies using art as stimuli instead of photographs. Massaro et al. found that, in static paintings containing human figures, faces attracted more attention than any other part of the image. In dynamic paintings, the visual attention was more spread out over other body parts.⁴⁶ In their seminal study investigating gaze movements described in art historical literature, Rosenberg and Klein discovered that, while the eye tends to follow repeated saccadic paths along the compositional structure of paintings, which are often centred around human figures, this effect is not evident in portraits.⁴⁷ Instead, the facial area—mainly the eyes, mouth, and the nose—attracts almost all the visual attention.⁴⁸ Villani et al. conducted a study using paintings, with the goal of researching how people perceive figures in various stages of social interaction. They found that participants looked at the face of a figure engaged in social interactions faster and for a longer time.⁴⁹ Contrasting with figures involved in individual actions, e.g. a lone woman carrying a bundle of brushwood, where the entire body of the figure attracted the eyes of the participants more. The researchers conclude that participants focused on the faces if the social aspect of the depicted scene was considered to be high, to understand the meaning of the scene. While figures in a painting with a low social aspect were found to hold more valuable information about the situation within their performed action. This results in more attention being paid to the body posture to evaluate the depicted scene. There is also evidence that suggests people with higher levels of empathetic concern focus on faces sooner than others.⁵⁰ This is supportive of the interpretation that empathetic abilities play an important role in recognising someone's emotional state, which is most clearly expressed by facial expressions.

⁴² Yarbus 1967, pp. 179–180, 191; these findings are also supported by a more recent study from Kesner et al. 2018, pp. 95–96.

⁴³ DeAngelus/Pelz 2009, p. 802.

⁴⁴ Crouzet/Kirchner/Thorpe 2010, pp. 4–5.

⁴⁵ Little/Jenkins/Susilo 2021, pp. 11–15.

⁴⁶ Massaro et al. 2012, pp. 14–15.

⁴⁷ Rosenberg/Klein 2015, pp. 94–95.

⁴⁸ Ibid., p. 97.

⁴⁹ Villani et al. 2015, pp. 7–8.

⁵⁰ Ibid., p. 6.

The eye tracking studies show that human faces are critical to understanding the social context of any human interaction, including artificial scenes, of which we know the figures are not real. The face contains one of the two most important elements of non-verbal communication. The other being hands, which are arguably better suited for expressing our thoughts and feelings in the clearest manner. Still, it is the face that has an almost magnetic pull for us. One reason for that might be the unique shape of human eyes compared with other primates—being more elongated and showing a larger part of the sclera, the white area of the eyeball, which in other primates is also darker and closer to the colour of the surrounding skin⁵¹—heightens eye visibility and enhances gaze signals, which are essential in social interactions and communications.⁵² However, Birmingham, Bischof, and Kingstone were able to show that, despite this, it is not just the eyes' natural saliency that attracts us to them, but rather their social informational value, as participants were drawn to the eyes of people in a natural social scene, regardless of the task given to them beforehand.⁵³ This makes the eyes a highly salient area of the face due to their natural form as well as their ability to silently communicate with others.

Gaze perception

The social value of the eyes also strongly factors into our own behaviour when we observe another person's gaze. Not only is there reliable evidence that faces are more salient to us than anything else, but the direction of the head and gaze cues play an important role in directing social attention.⁵⁴ Orienting our visual attention in accordance with others is commonly referred to as *joint attention*.⁵⁵ It “requires that two individuals (X and Y) are attending to the same object (Z), based on one individual using the attention cues of the second individual.”⁵⁶ Emery postulated that following the gaze of another is hard-wired into the brain.⁵⁷ The attention shift triggered by the gaze direction of another person to gather information is also known as *gaze cueing*, resulting in the joint attention of two individuals on an object or a third person.

⁵¹ Kobayashi/Kohshima 1997, pp. 767–768.

⁵² Young/Bruce 2023, p. 7.

⁵³ Birmingham/Bischof/Kingstone 2009, p. 2996.

⁵⁴ Langton/Bruce 1999, p. 564.

⁵⁵ Scaife/Bruner 1975.

⁵⁶ Emery 2000, p. 588.

⁵⁷ *Ibid.*, p. 581.

Research shows that joint attention does indeed appear to be a trait that we are born with. Early studies on gaze perception have proven that infants, at just three months, can follow the gaze cues of their caregivers when the gaze direction is accompanied by a congruent head turn.⁵⁸ Presented with a digital face of an adult that changes between closed and sideways looking eyes on a screen, 3- to 6-month-olds will shift their visual attention in accordance with the eyes.⁵⁹ By nine months, babies can direct their gaze based on a head orientation without having to observe the movement first.⁶⁰ Identifying the target of an adult's gaze motivates 12- to 18-month-old infants to the point of moving to look behind a visual obstruction placed in front of the child's view, with the goal of finding out what was being looked at by the person.⁶¹ A study with newborns has also found that 2–5 day old neonates are sensitive to direct gaze and display some gaze-following behaviour when confronted with a schematic image on a screen.⁶² More recently, Simpson et al. conducted a study on the effect of gaze on face detection with infants between the ages of 2 and 6 months. They revealed that infants display a preference for averted heads and gazes, indicating a strong interest in gathering information that joint attention can reveal to them.⁶³ These findings strongly support the assumption that gaze perception and joint attention are subliminal traits already present when we are born, which we learn to use very early in our development to help us understand our environment better.

The capacity to follow another's gaze is also tied to children's cognitive development. Baldwin found that a shared focus helps 19- to 20-month old infants to identify objects by their name.⁶⁴ This is supported by the findings of two studies by Morales, Mundy, and Rojas and Morales et al., that found that the ability to engage in joint attention at 6 months predicts the size of their vocabulary one year later.⁶⁵ By age three, this ability has shown to be further developed into the understanding of the mental state of the person.⁶⁶ For example, if someone looks at an object, children understand the person is expressing a desire for it.

Baron-Cohen proposed that decoding the gaze direction of another person plays a prominent part in the “theory of mind”, which includes the understanding of the thoughts, emotions and

⁵⁸ D'Entremont/Hains/Muir 1997, p. 571.

⁵⁹ Hood/Willen/Driver 1998, p. 132.

⁶⁰ Moore/Angelopoulou/Bennett 1997, pp. 90–91.

⁶¹ Moll/Tomasello 2004, p. 4.

⁶² Farroni et al. 2004, p. 57.

⁶³ Simpson et al. 2020, pp. 10–11.

⁶⁴ Baldwin 1995, pp. 152–153.

⁶⁵ Morales/Mundy/Rojas 1998, p. 376; Morales et al. 2000, p. 235.

⁶⁶ Baron-Cohen et al. 1995, pp. 390–393.

intentions of others by observing their behaviour.⁶⁷ This is supported by a study from Calder et al., using PET scans to map the brain activity through the regional cerebral blood flow (rCBF), to show how the viewing of faces with direct or averted eye direction involves some of the same brain areas—specifically, the superior temporal sulcus (STS) and the medial prefrontal cortex (mPFC)—that are also activated in tasks pertaining to the theory of mind, while looking at closed eyes did not elicit the same reaction in the brain.⁶⁸ Interestingly, the averted gaze stimuli showed more engagement of the STS and mPFC than direct gaze. The response of the STS is also highly dependent on the existence of a visual target, i.e., when the gaze leads to an object rather than into empty space.⁶⁹ This suggests that the processing of gaze is dependent on context, in this case the goal of the action. Placing an object within the perceived line of sight of another person influences the viewer by pulling their gaze towards the object, even if the angle of the gaze direction is not exact, but only approximated.⁷⁰ Meaning that looking at a person who looks anywhere but into the eyes of the person observing them elicits a response in the observer to focus their attention towards spatial understanding of the observed person. In one of the few gaze perception experiments conducted with artwork as stimuli, Kesner et al. found that participants spent more time in the eye area of portraits with a direct gaze than with an averted gaze.⁷¹

Gaze cueing

An early gaze cueing experiment by Friesen and Kingstone, done with schematic faces and pupils pointing either left or right, showed that people were faster in identifying an object if it appeared in the location indicated by the gaze.⁷² This attention shift appears to be spontaneous and cannot be fully suppressed, as shown by Driver et al. in a study where participants oriented their gaze according to the gaze cue, even though the gaze cues were not predictive of the target location.⁷³ Furthermore, Mansfield, Farroni, and Johnson found that instinctive eye movements happen even if people are asked to fixate on something else.⁷⁴ In a study with six separate gaze cueing experiments, Hietanen and Leppänen could not find human facial expressions, such as happy, fearful, and angry, to have an influence on the participant's

⁶⁷ Baron-Cohen 1995, p. 106.

⁶⁸ Calder et al. 2002, pp. 1136–1137.

⁶⁹ Pelphrey et al. 2003, p. 167.

⁷⁰ Lobmaier/Fischer/Schwaninger 2006, pp. 120–121.

⁷¹ Kesner et al. 2018, pp. 95–96.

⁷² Friesen/Kingstone 1998, pp. 493–494.

⁷³ Driver et al. 1999, p. 520.

⁷⁴ Mansfield/Farroni/Johnson 2003, pp. 9–11.

attention orienting.⁷⁵ More recently, Dalmaso, Castelli, and Galfano reviewed several social gaze cueing experiments in which participants were shown more than one face and came to the conclusion, that only the face which received the most attention by the viewer, resulted in a subsequent gaze cueing effect.⁷⁶ While the emotional state of a face seems to have no effect on its gaze cueing ability, the amount of time spent on a face has an influence on directing the gaze.

Most studies involving the gaze cues have been using schematic drawings of faces, eyes, arrows, photographs or pictures of faces as their stimuli. In the only gaze cueing experiment undertaken with figurative paintings so far, Dukewich, Klein, and Christie have reasoned that these were less impoverished stimuli, with the gaze being a subtler component than in other stimuli.⁷⁷ Using 30 paintings from various time periods and editing the gaze direction of the central figure by manipulating the eyes only, they found that participants were indeed more likely to follow the direction of the gaze. However, the effect was only statistically significant when the researchers asked participants what the people in the paintings were doing or thinking about beforehand.⁷⁸ When asked to inspect the paintings (1) as they would normally or (2) while noting the spatial layout of the paintings, no statistically significant difference could be found. This remained true for the full seven seconds of viewing time as well as only the first two seconds. Interestingly, the significance rose slightly over the full viewing time of seven seconds, as opposed to only the first two seconds, contrary to their assumption of a diluting effect over a longer viewing period. It was higher for the block of people who saw the stimuli first in combination with the social setting question.⁷⁹ It is also important to note the relatively small number of participants used for the study (23), as well as the missing discussion as to what these findings signify for the influence on the viewing experience of the paintings overall. This is to be expected, as the study was conducted from a psychological viewpoint. Despite this, it is an essential study for the topic of this thesis, as it is the only study on gaze cueing using artworks as stimuli to date.

⁷⁵ Hietanen/Leppänen 2003, p. 1238.

⁷⁶ Dalmaso/Castelli/Galfano 2020, pp. 843–844.

⁷⁷ Dukewich/Klein/Christie 2008, p. 1142.

⁷⁸ *Ibid.*, pp. 1144–1145.

⁷⁹ *Ibid.*, p. 1145.

1.2 Research question and hypotheses

Looking at the findings of gaze cueing research done in the field of psychology and aesthetic experience, and the tenuous approach art historians have made on the topic so far, it raises the question: If and to what degree can this behaviour be found when it comes to art experience? Given how much importance is placed on compositional lines, body posture of figures, and the iconographic language of paintings, it is surprising how little gaze and gaze direction is mentioned, much less discussed in depth, in the art historical literature. Particularly when analysing the content of paintings containing figures engaged in a social scene or narrative, where gaze would naturally be considered a form of communication in any natural setting. However, gaze direction has strangely been overlooked thus far. The empirical research method of eye tracking has already made large strides in the art historical discourse towards understanding how non-tangible elements affect the viewing behaviour, such as the use of visible and invisible lines in compositions.⁸⁰ It would be almost unthinkable that faces and gaze do not factor into the equation of how paintings are perceived by their audience. Other fields involving aesthetic experience, such as print advertisements, have known and successfully used the influence of gaze cueing on their customers for decades.⁸¹ Despite marketing research being acutely aware of the gaze's ability to direct viewer behaviour and using it to their advantage, art historical studies have—somewhat naturally—focused on the eyes as an organ with which we perceive information and neglected their potential of conveying it.

The results of the various studies done on this subject so far show that gaze perception and gaze cueing behaviour lock in early in human development and are essential skills in understanding the intentions and desires of another person. Tracking the gaze can reveal important information in making sense of a social scene. It is but a small leap to the question of how this behaviour might also influence other aspects of cognition. We are inundated with images every day that we are required to be able to interpret in order to gather necessary information. How does this visual behaviour factor into how we look at artworks, which often require its viewers to understand a social scene or even decode a complex narrative? So far, the art historical landscape has been devoid of a systematic approach to the role of gaze direction in paintings. While the scope of this thesis cannot hope to rectify this by itself, the following study might be able to provide a starting point and give some incentive to future research on the topic.

⁸⁰ Sancar et al. 2020.

⁸¹ Hutton/Nolte 2011, p. 887.

What could the eyes of a figure be conveying to the viewer? Most obviously, it shows us how two characters are interacting with each other. For instance, by looking at each other, we understand them to be in a dialogue with each other. Naturally, facial expression, gesture, and posture are also a large factor. However, while these aspects have been discussed in more detail, gaze appears to be ignored, despite it being so intrinsically built into our understanding of the world. Which might be why it has seemingly been taken for granted in art historical discussions about figurative paintings. Hopefully, the following experimental study can serve as a tenuous first step towards an understanding of gaze direction.

Based on what we know of gaze cueing from previous studies, the question arises: What role does gaze direction of figures in paintings play in viewing behaviour and perception of the depicted scene? There are three aspects of gaze cueing that this study aims to shine a light on: visual attention, gaze following and joint attention, and their influence on the perception of the painting on the viewer. The three hypotheses are as follows:

- 1.) Participants spend more time looking at a figure if another figure is acting as a gaze cue by looking at that figure, resulting in more fixations and thus a higher dwell time in the indicated area.
- 2.) Participants follow the gaze direction of a figure, resulting in more saccades going from the gaze cueing figure towards the looked-at area.
- 3.) Changing the direction a figure's gaze has an influence on the perception of importance participants attribute to the involved figures, with looked-at figures being considered more important to the depicted story.

With the use of the empirical methods of eye tracking and questionnaires, the following study will try to answer the three hypotheses. If, and if so to what degree, they can be verified or falsified, and what factors of a painting might play a so far unnoticed role in it.

2. Methods

2.1 Stimuli

The chosen stimuli for the study consist of 10 paintings from the 16th and early 17th centuries. This decision was based on having stimuli that are stylistically similar to Carracci's *Hercules*, as it was assumed that mixing artworks from different time periods would not only create too many uncontrollable variables but also might influence the viewing behaviour of the participants and possibly dilute or distort the results. The additional nine images were selected with a focus on the number of human figures (ranging from at least two up to seven human figures) and if they depicted an unfolding story or social scene, to which the gaze of a character was important to the overall composition. The selection includes three paintings with historical narratives based on a religious Christian story, four that contain a mythological narrative, and three paintings involving a social scene between the figures, not based on a specific story but rather a common theme or motif. For all ten stimuli it was decided, based on composition, narrative content, and technical possibilities, which figure's gaze would be changed from the original to an artificial gaze point.

Several external factors had a restrictive effect on the stimuli selection. Due to the technical constraints of the display screen, the images had to be in a landscape or square format, as paintings in a portrait format would have only been able to be displayed in a very reduced size. Furthermore, the images had to be available as a high-resolution version with a minimum of 300 ppi. Except for Titian's *Perseus and Andromeda*, which was sourced from *Wikimedia Commons*, all stimuli were found in the image database *Artstor*, which provides high quality digitalisations. Each of the paintings will be presented in chronological order to give a brief overview and understanding of their content and the relevance the gaze plays in each of them.

Triple Portrait, Anonymous (Student/workshop or early follower of Titian), Triple Portrait, first half of the 16th century,⁸² The Northumberland Collection, Alnwick

While this painting is of uncertain origin concerning the artist, it displays an exemplary use of gaze direction to indicate the relationship between the figures (*Figure 5*). A 19th-century copy

⁸² There is no consensus among art historians regarding the exact dating. Hauptman 1994, p. 81, Fig. 10 is the only one to date the painting specifically to "c. 1520".

of this painting is housed in the V&A collection, which erroneously describes it as a copy “after Giorgione”.⁸³ The image database, on which the image was found, declares it as a painting of Titian, supposedly held at the Louvre Museum.⁸⁴ There is a strong possibility of it being painted by his workshop or one of his students,⁸⁵ as the face of the young woman is very clearly a copy of Titian’s early female portraits, specifically *Woman with a Mirror* and *Flora*, both commonly dated around 1515.⁸⁶ The subject of a triple portrait is not an alien one within Titian’s oeuvre. The painting *The Concert* (1510–11) bears a striking resemblance in the composition of the three figures and use of gaze between them (*Figure 6*).⁸⁷ Even the turn of the head of the central figure in it is remarkably similar to the boy on the right.

While the question of origin is a fascinating one, a deeper dive into it is far beyond the scope of this thesis. What makes it a suitable stimulus for this study is its subject matter and formal aspects. Despite their comparable compositions, the *Triple Portrait* was preferred as a stimulus, as *The Concert* pictures a figure looking out of the painting, directly at the viewer, which could be a distracting factor and bias the results. The *Triple Portrait* is the most reduced in saliency of the ten chosen images. It only shows the heads of three people, two men and one woman, who are portrayed from the hips up. This results in the faces taking up a large area of the canvas. Additionally, the background is kept in a solid black colour and the men’s clothing is similarly devoid of details that could attract attention of the viewer. The central figure’s body is facing the viewer, but his head is turned towards the woman on the left side, his eyes locked on her, while the young man on the right is excluded from the moment. By following the intense gaze direction of the man towards the woman, we immediately understand he is likely courting her, who appears to pay him no mind. If the

⁸³ Victoria and Albert Museum 2007. The museum’s attribution, however, cannot be taken at face value, as the given reference is precarious at best and no such painting could be found in *catalogues raisonné* of Giorgione; Haskell 1976, pp. 15–16, fn. 25, Pl. 22 traced back the painting’s history, once hung at the Manfrin collection, and also comes to the conclusion of a mistaken attribution to the artist, originating from before its purchase by the Duke of Northumberland around 1856, due to it being made known as under the title *Family of Giorgione* in the early 19th century; see also Whittingham 1986, pp. 53–54; another copy is housed at the Staatsgalerie Stuttgart, originally mentioned under the title *Tre Ritratti* by a student Giorgione in Zanotto 1847, p. 12, Inv. N. 14-98; however it is now being described as a “previous attribution”, with the added title *Lady with Two Admirers*, on the museum’s digital collections, Staatsgalerie Stuttgart 2024, Inv. N. 263.

⁸⁴ Jstor Artstor Collection 2017. A search in the Louvre’s public database yielded no results, and no literature can be found to support the claim. Therefore, their attribution to Titian and dating of the painting (1530–40)—taken from the Artstor database entry—should also be taken with a considerable grain of salt.

⁸⁵ Haskell 1976, p. 16, fn. 25 supports this inference, as he describes the painting as being attributed to a follower of Titian in the more recent literature; see also Hauptman 1994, pp. 81–82 who found the first mention of Titian in connection with the *Triple Portrait* in 1825, in the writings of William Hazlitt; see Hazlitt 1903, pp. 270–271.

⁸⁶ Of the first, *Woman with a Mirror*, several later copies of his workshop exist. The clear reproduction of the figure in *Triple Portrait* makes it a possibility that it could also be a workshop copy. See Pedrocco 2000, p. 101; Pozzolo 2021, p. 99.

⁸⁷ Fasolo 1980, p. 17; Phillips 2008, p. 109; Hetzer 1992, pp. 413–418 however disagrees with the commonly accepted attribution of *The Concert* to Titian.

man's attention was changed and his gaze was to land on the young man instead, we, as the viewer, might follow a different path, and the interpretation of the relationship between the three would change drastically. The varying descriptions and titles held by this artwork and its many copies—*Family of Giorgione*,⁸⁸ *Titian's Mistress*,⁸⁹ or simply *Triple Portrait*⁹⁰ to name but a few—reflect the uncertainty of the three figures relationship to each other that historians and onlookers must have felt seeing this painting. As it is the only painting neither based on a known historical or biblical narrative, nor a particularly common genre scene, the interpretation is fully up to the beholder, making it a fascinating case study on the influence of gaze direction.

Venus and Adonis, Titian, 1554, Museo Nacional del Prado, Madrid

Titian's painting of the lovers from Ovid's *Metamorphoses* is part of the *Poesie* cycle, which was commissioned by Philip II. of Spain (*Figure 7*). The story tells of the meeting of Venus and the beautiful Adonis and his ultimately tragic end when, despite her warnings, Adonis leaves her to go hunting, only to be killed by a wild boar. We can see the moment just before tragedy strikes. Venus is trying with all her might to hold back her lover as he pulls himself away from her grasp. The language of the eyes is deeply bound to the essence of this classical story. In Shakespeare's famous narrative poem about the two lovers, he describes the exact moment Titian painted in stanza 225:

“[...] Now gazeth she on him, now on the ground;
Sometime her arms infold him like a band;
She would, he will not in her arms be bound;
And when from thence he struggles to be gone,
She locks her lily fingers one in one.”⁹¹

His focus on the gaze runs throughout the entire poem. The eyes, gaze, and looks are mentioned a total of 81 times—more often than in any other of the playwright's works—and he ends the story with the word “seen”. Published in 1593, one must wonder if Shakespeare saw one of Titian's many versions or the widely circulated prints of this painting and was

⁸⁸ Byron 1818, p. 7.

⁸⁹ Hazlitt 1903, pp. 270–271.

⁹⁰ Zanotto 1847, p. 12.

⁹¹ Shakespeare [1593] 1989, p. 77.

inspired by the artist's iconographic invention.⁹² The way Titian painted Venus and Adonis with their eyes has been pointed out by Tanner as an essential component of the dramatic composition, as "his glance reveals his attachment to the goddess."⁹³ The three dogs, guiding Adonis away to the fateful boar hunt, give a hint as to what will happen to him next, as does the figure of a future Venus in the sky, looking for her wounded lover in her chariot. Yet the moment shown to us is when he is still looking at Venus as he listens to her plea. The dramatic scene is thus underscored by the intense gaze between them.⁹⁴ Without this element, the understanding of the scene could drastically change for the viewer. Taking Adonis' attention away from his lover, a heartbreaking goodbye could look more like a man looking to escape. Formally, the full-figure composition results in the faces taking up less space within the image. There is also a considerable number of details, which might prove to be more distracting. It is a stark, and thus interesting, contrast to the above example.

Perseus and Andromeda, Titian, 1554–56, Wallace Collection, London

The portrayal of Perseus's rescue of Andromeda is another painting from Titian's *Poesie* cycle (Figure 8). Taken from Ovid's *Metamorphoses* as well, the myth about the king's daughter Andromeda, doomed to be a sacrifice to the sea monster to placate the angered god Poseidon, lends itself well to a dramatic visual depiction. Compared to *Venus and Adonis*; while also featuring the protagonists as full figures, the scene is much reduced in detail and attributes. In fact, the two titular characters and the sea monster make up most of the canvas. With the spectators on the shore being so small as to be almost impossible to see and the darkness hiding smaller details from the viewer's eyes. Dark, stormy skies and waters make up most of the negative space, while the white figure of Andromeda draws the eye. She is depicted on the picture plane nearest to the viewer, her head turned back to look at her rescuer and thus bridging the gap to the middle plane, where Perseus is slaying the sea monster.

Examinations during a restoration revealed a significant change in the composition of the painting. Titian moved the figure of Andromeda from the right of the canvas to the far left.⁹⁵ Instead of having her near the action, he moved her further away, connecting her back to the scene behind her with the sharp turn of her head and an accompanying gaze towards her

⁹² See Panofsky 1969, pp. 153–154.

⁹³ Tanner 2018, p. 64.

⁹⁴ Puttfarken 2005, p. 165.

⁹⁵ Panofsky 1969, p. 166; Lank 1982, p. 402.

saviour.⁹⁶ This deliberate choice by the artist reveals the consideration given to the visual depiction of the two figures' relationship, as well as their emotional connection, through Andromeda's fearful look back at her salvation. A subtle change of her gaze might prove to break the well-balanced composition.

Venus blindfolding Cupid (or The Education of Cupid),⁹⁷ Titian, 1565, Galleria Borghese, Rome

This mythological scene with its many interpretations is particularly interesting, as X-ray examinations have revealed that the artist himself changed the central figure from a woman with a feathered hat to the ancient goddess sometime during the painting process.⁹⁸ He likely also revised the head position of Venus, showing her paying attention to the Cupid on her shoulder instead of the one she is currently blindfolding (*Figure 9*). The two female figures⁹⁹ appear to be holding Cupid's bow and quiver, ready to hand them over when Venus has finished her task of blindfolding her child. Carrying out the duty of distributing blind love.

The turn of Venus's head towards her other child implies her conversing or educating him, while the two nymphs, lavishing their attention on her, are excluded from the moment itself. A similar composition, with Cupid leaning on Venus's shoulder and their heads turned towards each other while a third person is excluded, can also be found in an earlier painting of Titian: *Venus and Cupid an Organist* (1548–49).¹⁰⁰ The deliberate way the two figures are presented underscores their relationship and marks the others as secondary characters (*Figure 10*). The differing interpretations of this subject, as either the goddess blindfolding one Cupid or as her educating the other child on his task of delivering love, raise the question of how strongly the interpretation, as to which winged child is the true focus of the scene, is tied to Venus' attentive gaze. A change of her eyes towards the nymphs could relegate the Cupid on her shoulder to an overlooked bystander, being considered inconsequential to the story instead of being the entire focus of the titular character.

⁹⁶ Nash 1985, p. 34 also mentions her gestures, along with her glances, as carrying the viewer's attention back to the action-filled scene behind her.

⁹⁷ This painting has also been titled as *Education of Cupid* by Panofsky 1969, p. 129; the English title is taken directly from the collection database of the Galleria Borghese 2022.

⁹⁸ Pedrocco 2000, p. 283.

⁹⁹ There are different interpretations as to who the two female figures represent. The commonly accepted description from the Galleria Borghese 2022 is that they are female nymphs; see also Panofsky 1969, p. 136; Pedrocco 2000, p. 283.

¹⁰⁰ See Pignatti 1980, pp. 14–15; Pedrocco 2000, pp. 218–219; Rosand 2024, p. 221.

Hercules at the Crossroads (or The Choice of Hercules), Annibale Carracci, 1595–96, Museo Nazionale di Capodimonte, Naples

As already discussed in the introduction, the gaze indicating the hero's state of mind has been pointed out by Shaftsbury and Panofsky as an indicator as to which one he considers worthy of his attention.¹⁰¹ Gilbert goes even a step further, describing the hero's gaze as a way of directly involving the viewer in the problem of Hercules' impending choice, which we recognise as a universal one.¹⁰² This painting, with its intriguing depiction of the mythological hero's dilemma, paved the way for the present study. Carracci's composition of the story is a particularly interesting version of the motif, as he places the two possible future paths—represented as the two allegories, *Virtue* and *Vice* (also described as *Pleasure* in some translations¹⁰³)—standing at equal height on either side of Hercules, with the hero himself facing neither of the two, but rather sitting frontal to the viewer (*Figure 3*). There is little indication as to what destiny he will choose for himself; only his eyes and an almost imperceptible tilt of his head tell us that he seems to be inclined towards Virtue's plea. There is also the compositional element of the light source hitting the left-facing side of Hercules's face, the one closer to Virtue. Despite these small cues, the lingering uncertainty where the depicted scene will lead results in the onlooker having to consider the smaller details, such as his gaze direction, to understand Hercules's thought process.

A study for the motif by Carracci, now held at the Princeton University Art Museum,¹⁰⁴ shows the protagonist lying to the far right of the canvas, with the two allegories approaching him side by side (*Figure 11*).¹⁰⁵ They also appear to pay no mind to Hercules, as they are engaged with each other. Meanwhile, Virtue is gazing at Vice, who is all but ignoring the hero. Ultimately, Carracci settled on the central composition, placing the two choices equally on either side of the hero. He also added the figure of the poet and the attributes of the theatrical masks to either side of Virtue and Vice, respectively. Giving the viewer even more details, hinting at the story's development, to find on the two sides of the canvas. Earning him and his heroic deeds an immortal life in the writings of the poets, or one filled with hedonism, joyful and long but soon to be forgotten by history. With all these additional suggestions, it is intriguing to ask: How much weight does the hero's gaze have within the overall reading of the scene?

¹⁰¹ Shaftsbury 1713, p. 14; Panofsky 1930, p. 125.

¹⁰² Gilbert 1995, p. 30.

¹⁰³ Shaftsbury 1713, p. 6; Gombrich 1982, pp. 40–41.

¹⁰⁴ Princeton University Art Museum 2008.

¹⁰⁵ Robertson 2008, p. 108.

The Calling of Saint Matthew, Michelangelo Merisi da Caravaggio, 1599–1600, Contarelli Chapel, San Luigi dei Francesi, Rome

The famous painting depicts the story of Christ calling upon the tax collector Matthew to leave behind his life and to follow him as one of his apostles (*Figure 12*). Caravaggio chose the moment with the highest amount of tension: just as Christ has spoken the words, with the surprise still clearly visible on the future disciple's face as he incredulously points at himself. The complex composition utilises gaze in a very particular way, which has not gone unnoticed by art historians.¹⁰⁶ Due to the display of the painting in the chapel and the use of a particularly dramatic chiaroscuro, the group of men has the strongest appeal to the viewer, while the essential figure of Christ is hidden in the shadows, as well as partly behind the figure of Peter, obscuring him largely from view. Thereby delaying the observer's discovery of Christ, arguably the most crucial figure within the scene, calling on his new follower. It challenges the temporal structure and the reading of the scene according to the biblical text.¹⁰⁷ With the group of men at the table fully illuminated being the first thing to catch the eye, their gazes point straight to the secluded two figures in the dark. Only then can we follow Christ's gesture back to Matthew at the table. Without this aid, the understanding of the scene would be impeded, as it very likely would take the viewer longer to find Christ and decipher the depicted story.

An X-ray examination has revealed that Caravaggio planned to depict Christ in a much less concealed way but changed his mind and hid him behind the later added figure of Peter during the painting process.¹⁰⁸ This supports the argument that the delay in discovery of the figures was deliberate, and makes the possible gaze cueing effect of the three figures at the table also intentional.¹⁰⁹ In addition to this, a discussion has been raised as to which figure on the table is the titular apostle. While most art historians agree on the man pointing at himself, the young man on the far left counting coins has also been identified as Matthew.¹¹⁰ The other one's gesture of "Who, me?" interpreted as "Who, him?" instead.¹¹¹ A change in the gaze of the young men with the feathered head towards the pointing man could also reveal interesting results in how people perceive the importance of these figures. Despite the reduced

¹⁰⁶ Raabe 1996, pp. 78–87; Held 1996, p. 79.

¹⁰⁷ Dubouclez 2024, p. 9.

¹⁰⁸ Friedlaender 1955, p. 179, Plate 29F; Raabe 1996, p. 81; Spike 2010, p. 96.

¹⁰⁹ Raabe 1996, p. 83.

¹¹⁰ Hass 1988, p. 247.

¹¹¹ The painting, as well as *The Sacrifice of Isaac* and their use of deictic gestures, has also been part of an eye tracking study in a recently published paper by Dimova/Lapique/Rosenberg 2025.

background, with a total of seven figures, it is the stimulus with the highest number of faces in this study, adding a lot of variables to be considered in the analysis.

The Sacrifice of Isaac, Michelangelo Merisi da Caravaggio, c. 1603, Galleria degli Uffizi, Florence

Abraham's sacrifice of his son Isaac, to show his faith in God, tells a story of extreme emotion with a highly dramatic narrative turn (*Figure 13*). When asked to prove his loyalty, Abraham obeys and does as he is asked: giving his own son as a sacrifice. Only to be stopped at the very last moment by a heavenly messenger, telling him to butcher a ram instead, as he has already proven himself. The emotional scene, shown to us by Caravaggio at its crescendo, relies strongly on Abraham's silent conversation with the angel. Still holding down Isaac with the knife dangerously close to his throat, Abraham's face displays a look of surprise as his gaze is turned towards the angel. Thus, indicating to the viewer that he has just been grabbed by his wrist at this very moment and is still in the process of listening to the angel. Just moments before, his gaze must have still been on his son. The moment of salvation was chosen deliberately by Caravaggio, as examinations of the painting revealed that he had already planned the turn of the face, as well as the placement of the eyes, for his composition precisely, with small, curved incisions on the canvas indicating the exact position of his eyes and gaze direction.¹¹² Were Abraham to ignore the angel and his gaze still focused on the incredibly expressive face of terror that his son displays,¹¹³ the understanding of the scene would likely change for the viewer.

Compared with Caravaggio's other painting used in this study, the figures, and thus also the faces, take up a larger area of the canvas. There is a possibility that this formal aspect will have an influence on the results, in contrast to *The Calling of Saint Matthew*, as there are fewer other salient areas within the painting for the viewer to focus on.

Judith and her Maidservant with the Head of Holofernes, Orazio Gentileschi, 1611–1612, Pinacoteca, Vatican

Gentileschi depicts the biblical story of Judith's triumph over Holofernes in a moment of heightened tension (*Figure 14*). While the heroine herself is still occupied with handing the

¹¹² Gregori 1991, p. 230.

¹¹³ See Vodret Adamo 2021, p. 210.

severed head of her people's oppressor to her servant, the maid has already heard the approaching guards.¹¹⁴ The artist tells us this by the sharp turn of her head, looking intently into the darkness, somewhere outside the picture frame. Formally, it bears similarities to the *Triple Portrait*, a square canvas with the background veiled in darkness. In contrast, however, it only shows two figures,¹¹⁵ and the gazes of Judith and her maid, not having a clear focal point and landing somewhere outside the painting, marks a clear distinction. A change of the maid's gaze towards her lady would result in a drastic change in the scene's content. Furthermore, the ornate clothing of the two women is highly detailed, which could also act as a distraction, taking the focus away from the faces. These compounding elements were factored into the choice to include this painting in the list of stimuli.

The Fortune Teller, Georges de La Tour, 1630–34, Metropolitan Museum of Art, New York

Georges de La Tour's depiction of a cleverly disguised theft is another commonly used subject within genre paintings, especially amongst Caravaggio's followers.¹¹⁶ In this case, an older woman, who reads a man's fortune from the palm of his hand, is distracting the richly dressed victim (*Figure 15*). All the while, her accomplices steal a golden medallion by cutting the chain and what appears to be his purse from under his doublet. His gaze tells us that his focus is fully on the woman reading his palm, unaware of what is happening. The intensity of the gaze of each figure supports the sequence of the story on the canvas, from character to character.¹¹⁷ The young man's gaze is fixed on the old woman while, unbeknownst to him, her accomplices relieve him of his possessions. Together with the intense gaze of the young woman between them, "the guile and wary watching create an exquisite tension."¹¹⁸ While similar in topic and execution, this second de La Tour was chosen as it features one crucial element that might change the effect of gaze direction, compared to the following stimulus below: between the two main characters, a third person has been placed. It will be interesting to see if this addition could interrupt the eye's path between the man and the fortune teller. In addition, due to the young woman, the distance between the two figures looking at each other is also further than in the second painting by de La Tour that was chosen as a stimulus.

¹¹⁴ Bissell 1981, p. 23.

¹¹⁵ An argument can be made for the head of Holofernes counting as a third figure, as the face is visible and therefore will be salient for the viewer.

¹¹⁶ Feigenbaum 1996, pp. 177–178.

¹¹⁷ Thuillier 1993, p. 138.

¹¹⁸ Feigenbaum 1996, p. 174.

The Cheat with the Ace of Diamonds, Georges de La Tour, 1630–34, Musée du Louvre, Paris

The cheating card player was a popular motif in the early 17th-century genre paintings. The theme of a cheerful drinking party, feasting and playing games also lends itself well to the use of glances as compositional elements to convey the relations between the depicted figures.¹¹⁹ In de La Tour's take on the topic, we see three figures sitting around a table, with a fourth (the maidservant) standing between the cheating man and the woman (*Figure 16*). The young man on the right, focused on his cards, is the target of their scheme. The central figure of the woman plays the crucial part of orchestrating the scam, signalling to the maid with her eyes to create a diversion¹²⁰ so the cheat can swap his cards with the Ace of Diamonds behind his back, while the victim, absorbed in the playing cards in his own hand, is none the wiser.

The way gaze direction has been used here has also been mentioned by Belting, who cites Georges de La Tour's painting as an example of the theatricality of a single glance and its high potential to deceive people.¹²¹ He makes note of the lady having a conspiratorial look on her face, while the young man sitting to her right is the unwitting victim of their deception. Through their eye contact, the viewer is pulled into their scheme.¹²² It raises the question: Would a change of that aspect lead the viewer's eye away from the sleight of hand and instead focus more on the young man, and thus negate the tension build up in the composition?

2.2 Participants

80 adults were recruited via the CogSciHub: Study Participant Platform of the Psychology Department of the University of Vienna as participants for this study. 59 of the participants were female, 21 were male, between 18 and 66 years old, with a median age of 25 ($M = 27.5$ years, $SD = 8.16$).¹²³ All had normal or corrected to normal eyesight. The study was approved by the Ethics Committee of the University of Vienna in August 2022. Because of the recruitment method through the university, most participants were students, which is reflected in the average degree of highest education. Two participants had finished a compulsory education, vocational school, and/or an apprenticeship. 34 people had a high school diploma, of which 30 were currently studying at a university. 44 people had completed at least one

¹¹⁹ Thuillier 1993, p. 135.

¹²⁰ Feigenbaum 1996, p. 165.

¹²¹ Belting 2006, pp. 139–140.

¹²² Neumeyer 1964, p. 60.

¹²³ Four people selected not to disclose their age; therefore, the mean and median ages were calculated from the remaining 76 people.

degree of higher education from a university. 17 (Group A: 7, Group B: 10) were students of art history and 55 people self-reported to be highly or rather more interested in art, while 15 reported to be only partly or rather not interested.¹²⁴ 29 participants had been part of a different eye-tracking study within the last 12 months, 51 had never or not recently participated in a similar study. The education and art interests of the participants had no influence on the distribution into each group, as the group placement was randomised.

2.3 Procedure

Participants were invited to participate in the study by email and were told that the study examines how people generally look at art, to avoid biasing their viewing behaviour. The experiments were conducted in the laboratory room of the Laboratory for Cognitive Research in Art History (CReA). After reading and signing a consent form, participants were tested for normal colour vision¹²⁵ and alternately assigned group A or group B. They then sat in front of the eye tracker and display screen, on which the stimuli would be shown. The screen had a resolution of 3840 x 2160 pixels. All images had either the maximum height of 2160 pixels or the maximum width of 2880 pixels, to display them in the largest format possible. The sides of the screen, which were too far to the left and right to be tracked by the eye tracker, were displayed in a neutral grey colour. Each image had an original and an edited version, in which the face of the central figure was edited to look the opposite direction, resulting in 20 stimuli in total. The manipulations were done by the author herself in *Adobe Photoshop* by flipping the head of the central figure on its horizontal axis and retouching the transitional areas. Five original and five edited versions were selected for each group, resulting in ten images shown per group.¹²⁶ No participant was shown the same painting in its original and edited version. Before the calibration, people were asked to read a Snellen chart to test their visual acuity to make sure their vision was good enough to see the display screen properly. After a 13-point calibration with the *SR Research EyeLink* Eye Tracker, participants were shown an introduction text, which explained the procedure more closely, and asked them to press any

¹²⁴ The options were as follows: *Highly, rather more, partly, rather not, and not at all interested*. None of the participants selected that they were not interested in art at all.

¹²⁵ Due to the nature of these paintings and the high saliency of colour contrasts within them, people with colour-blindness had to be excluded, as to not skew results.

¹²⁶ Attention was placed on the distribution of the paintings between the two groups. If there were two or more paintings by the same artist among the stimuli, care was taken to show at least one original and one edited painting by the same artist within the same group. This was the case for Titian, Caravaggio, and Georges de La Tour.

key to start the experiment when ready. The images were shown in a randomised order to eliminate any bias concerning accuracy of calibration, movement, exhaustion, boredom, and comparison between the paintings. Before each image, a small, black calibration dot was shown in the middle of the screen, and participants were asked to focus on it until the next image appeared.¹²⁷ Each image was displayed for 60 seconds. It was not possible to jump to the next image early to ensure that each person had the same amount of time with each image. Following each stimulus, a question appeared on the screen asking people on a scale from 1 to 5 how much they enjoyed the image (1 being the least; 5 being the most). This was done to give people something to answer, as well as to hide the true purpose of the experiment. By having participants look at the images from the aspect of their own aesthetic appreciation, an as normal as possible viewing behaviour was created, without people trying to figure out the research question of the study and possibly tainting results. The entire experiment was designed with the *SR Research Experiment Builder* by the author herself.

After the eye tracking part of the experiment, a second part, in the form of an online questionnaire, followed. The questionnaire was created and hosted on the online survey platform *Qualtrics XM*.¹²⁸ The questions were asked in German, which participants answered with the use of an iPad provided by the CReA Lab. In the first part of the questionnaire, participants were asked demographic questions, as well as inquiries about their interest in art.¹²⁹ After that, all the previously shown images were shown again on the iPad in the form of a scroll through. For each image, people were asked to select two figures that they deemed to be particularly important in the story: “Im Folgenden sehen Sie die Bilder nochmal. Bitte wählen Sie je zwei Figuren bzw. Bereiche des Bildes aus, welche Sie für den Inhalt des Bildes als besonders wichtig empfinden.”¹³⁰ This concluded the experiment procedure. Participants were financially compensated for their time and given the possibility to be sent the end results of the study after publication.

¹²⁷ The jump from the calibration dot to the next image was controlled by the person conducting the experiment, instead of being automated by the program, to ensure that people were focusing on the calibration dot for the re-calibration. All sessions were conducted by the author herself.

¹²⁸ Links to the full online questionnaire, hosted on *Qualtrics XM*, are provided in the study documentation part of the appendix.

¹²⁹ Questions concerning art interest were taken from the VAIK questionnaire: Specker et al. 2020.

¹³⁰ The figures in the images on the iPad were provided with letters, always starting from the left, with “a” up to “g” on the right, on each possible figure, including non-human figures. By choosing letters instead of numbers and assigning them indiscriminately from left to right in each image, instead of starting with the main figures, the bias of number values and perceived importance could be reduced. The participants could then select the corresponding two letters in a multiple-choice answer box. Due to the nature of the online questionnaire, it was not possible to randomise the images. Therefore, it is possible to have some level of bias within the results of this part of the questionnaire.

2.4 Data analysis

The collected eye tracking data was cleaned up and analysed with *DataViewer*. To include as much usable data as possible, all 800 trials were checked for their quality individually and were subsequently included or excluded from the collective data based on the recalibration of each single stimulus.¹³¹ This resulted in 772 usable trials. It also means that all 80 participants are represented in the results. For each stimulus, between 37 and 41 trials were found to be high enough in quality to be used. Going forward, because of the difference in the number of data sets for the images, the data analysis was done by using percentages instead of total numbers to ensure comparability.

Defining interest areas

As a first step, heat maps were created with the program *EyeLink DataViewer* (Figure 17–Figure 36). This was used to help define interest areas (IAs) for each figure. All IAs were drawn by hand in polygon shapes around the faces of the various characters in each painting (Figure 37–Figure 56). This always included the central figure (CF), which had its gaze manipulated in the edited version of the painting, as well as the two respective areas to which the figure looked. Eight of the ten paintings had two possible gaze points: one to which the CF looks in the original version (GP1) and one that they looked at in the edited version (GP2). For example: *Hercules at the Crossroads* has three main IAs: Hercules (CF) and the two allegories of Virtue (GP1) and Vice (GP2) (Figure 45 & Figure 46), representing his possible future paths. Two stimuli have just two main IAs, as the CF only looks at a definable area in either the original version, as is the case for *Andromeda and Perseus* (CF and GP1) (Figure 41 & Figure 42), or in the edited version, as is the case for *Judith with the Head of Holofernes* (CF and GP2) (Figure 51 & Figure 52).

To make sure to include unforeseen focus points, other areas with a high number of fixations were also included as IAs, to account for any surprises. These were most often other human faces and figures, animals, hands, or attributes indicative of a character. Building on the above-mentioned example of *Hercules*, this included the allegory of a poet sitting on the

¹³¹ The quality check was also done with the help of a detailed study protocol, written down for each experiment during the procedure. The documentation included the quality of the initial calibration and validation, as well as detailed notes on the recalibrations, including any inaccuracies or issues with specific stimuli. A link to the anonymised version of the documentation is provided in the study documentation part of the appendix.

bottom left corner, the hero's winged horse Pegasus, as well as the theatrical masks on the right side of the painting, attributes belonging to the allegory of Vice. For the CFs, the IA needed to be the exact same for the original as well as the edited version, despite a possible change in the head position (due to the manipulation of the image) for some stimuli. This resulted in a slightly larger IA than necessary for some CFs. However, it allows for a direct comparison between the two versions, as the area and size of the IA stays the same for both versions. Fortunately, it was rarely an issue, with the exception of the *Triple Portrait*, in which the size of the head, in combination with the extreme twist of the neck, resulted in a large black area that had to be included in the IA (*Figure 37 & Figure 38*). Fortunately, due to the extra area included only containing the black background and no salient parts of the painting, almost no fixations were made in this dark area. Therefore, a skewing effect of the data can be excluded with reasonable certainty.

Dwell times

To analyse the attention distribution for each IA, the dwell time and fixation count was calculated with the program *DataViewer* using *Aggregate Interest Area Reports* and visualised by bar charts created with Python. This showed the total viewing time (*dwell time*) in milliseconds and in percentages that was spent within the predefined areas, as well as the number and percentages of all fixations (*fixation count*). As mentioned at the beginning of the chapter, percentages are the preferred data expression. Very little difference could be seen between the percentages of dwell time and fixation count. It was decided that dwell time was better suited for the scope of this study, as the first hypothesis relies on the duration of time spent in specific areas, which can be more accurately expressed through the form of dwell time. As fixations can vary greatly in duration, their number alone does not tell us how much attention is given to any area, obscuring an important data variable for the analysis.

A primary concern, even before the analysis of the data, was that the long viewing period of 60 seconds could have diluted the gaze cueing effect. To check if this happened, and if so at which point the gaze cueing effect was strongest, the full trial time was separated into shorter viewing periods. The time segments selected were made in 5-second steps for the first half minute, and in 15-second steps after that (0–5, 0–10, 0–15, 0–20, 0–25, 0–30, and 0–45 seconds). Resulting in a total of eight viewing periods, including the full trial time of 60 seconds. By splitting the full trial time into smaller sections, it becomes possible to show the

gradual change of viewing behaviour over time. After 30 seconds, it was decided against separating the remaining time into 5-second steps to optimise the data analysing, since by then most people would have seen all relevant IAs. This is in accordance with Yarbus, who theorised “cycles” of perception, where people—instead of looking at an area they haven’t in the beginning—went back to looking at already seen parts if they were confronted with the same image for several minutes, presumably to inspect them closer and examine them for more information.¹³² He split the viewing period into seven 5-second long segments due to technical restraints.¹³³ After analysing each of the five-second segments separately, he concluded that “the observer’s eye examined all the more important elements of the picture during the first 25 seconds, and the observer himself evidently obtained a general idea of the theme of the picture.”¹³⁴ It appears that, after a time of 25 seconds, the viewer has gathered a general idea of the content of the image. It also seems relevant to mention that the main figure was viewed at least once within each of the five-second segments. The analysing focus was therefore also put on the first 30 seconds of viewing time, on the assumption that initial viewing behaviours would be least diluted by other factors pulling the participants’ attention away. In contrast to Yarbus, however, it was decided to stack the 5-second segments additionally instead of separately, as it was of interest for this study to see how the viewing behaviour develops over time. By visualising the time segments this way, it shows the data in an additive way instead of splitting it up into separate data sets.

For each IA of each stimulus, the percentage of dwell time for all eight viewing periods was calculated and grouped by original and edited image. To show the shifting attention over time, double line graphs were created for each IA with *Python*. These visualise the percentage of time spent by all participants in the selected IAs, starting from 0–5 seconds up to the full viewing period of 0–60 seconds. Because of the uniqueness of each painting, the graphs compare IAs within each stimulus, as the paintings cannot be directly compared with each other. Each graph shows the percentage of dwell time over time, comparing original and edited versions for one IA of one stimulus. By visualising the data this way, it becomes possible to pinpoint the moment when the differences between the two versions even out or even flip to the opposite.

To ensure any differences found would not just be coincidences, but statistically significant, the numbers were run through an independent sample *t*-test. The dwell times for the fixations

¹³² Yarbus 1967, pp. 193–194.

¹³³ Ibid., p. 194.

¹³⁴ Ibid., p. 195.

within the interest areas, including all eight viewing periods, were the first data points to be checked. To make sure not to miss anything, the absolute dwell time in seconds, as well as the dwell time percentage, were run through the test. Both yielded nearly the same results. Since the percentage has so far been the preferred form of presenting the data, it will also be used in the statistical analysis to ensure better comparability over different analysing methods. To optimise the display of the results, the two visualisations were combined into one, showing the statistically significant results together with the line diagrams.

Saccades

Another important factor are the connections that participants made between the three figures, which can yield highly relevant results concerning the second hypothesis. These viewing behaviours can be analysed through saccades, the rapid eye movements going from one IA of the stimulus to another IA. To see if they would correspond with the indicated gaze direction, *Saccade Reports* for each stimulus were extrapolated from *DataViewer*. Following this, a spreadsheet was created with all saccades that started and ended in one of the IAs. Most relevant for the study are the saccades starting from the CF, going to the GP1 and to the GP2. Assuming similar results as for the fixations—that over the full viewing period of 60 seconds no obvious effect would be discernible—saccades going between the IAs were split into the same eight viewing periods. To ensure comparability, once again, instead of using total numbers, percentages were calculated. This was done by counting the number of saccades of all participants for one stimulus within each time segment and the number of saccades between the IAs. From this, a percentage of all saccades for each time segment and saccades between IAs was calculated. Before going through the results, it is important to keep in mind that there will be fewer saccades than fixations, as it takes two fixations to create one saccade. Reducing the number instantly in half. Additionally, not every fixation starting in one of the main IAs will end in one of the others. Therefore, limiting the overall possible number of saccades for the analysis. While the numbers will therefore be lower in comparison to the dwell time, they can still reveal important differences between the two versions. As with the results of the fixations, bar charts and double line graphs were created with *Python* for the saccades, and the results were run through an independent sample *t*-test to ensure any differences are more than coincidental.

Questionnaire

The analysis of the questionnaire and its visualisation of the results was done with the help of *Microsoft Excel*. After downloading all results from the 80 trials from *Qualtrics XM* as *Word* documents, spreadsheets in *Excel* were created to calculate age, gender, education, and art interest distribution among the participants. After the demographic results, the answers for the second part of the questionnaire are of particular interest. They can yield important results for our understanding of the participants' interpretation of the images, which was designed with the third hypothesis in mind. The most informative data sets for this hypothesis are the answers to the question: Which two of the figures participants considered most important for the content of the painting. The question was written in this specific format, asking to select two figures and not just one, as it was assumed that, regardless of original or edit, most participants would consider the central figure to be most important for many of the chosen paintings. To avoid this issue and yield more informative results, the question was designed to include a second figure in the painting. The thesis assumes that, at least for one figure in each stimulus, the perception of importance will shift depending on if the central character is looking at them or not. Eight participants had to be excluded, as they either selected only one or more than two answers for some of the images, making those data sets unusable for the calculation.¹³⁵ To visualise the results of the participants' answers to the second part of the questionnaire, bar charts were created with *Python*.

¹³⁵ The results of two participants from Group A and six from Group B had to be excluded, making it essential to use percentages instead of absolute numbers to visualise the results of the questionnaire as well.

3. Results

3.1 Dwell times

The dwell time analysis results for the IAs of the full trial period of 60 seconds show a trend in favour of a positive gaze cueing effect, as the percentage of dwell time decreased in the GP1s in the edited version, from a mean dwell time of 12.23% in the original version ($Mdn = 10.58\%$, $SD = 5.78$), with a mean difference of 1.38% ($Mdn = 1.48\%$, $SD = 1.68$), to a mean dwell time of 10.85% ($Mdn = 9.05\%$, $SD = 4.92\%$), with a mean difference of 1.38% ($Mdn = 1.48\%$, $SD = 1.68$).

For the GP2s, the difference between the original ($M = 15.5\%$, $Mdn = 15.91\%$, $SD = 5.22$) and the edited ($M = 15.69\%$, $Mdn = 16.44\%$, $SD = 5.25$) is much less pronounced but still leans towards expectations of a positive gaze cueing effect, with a mean difference of 0.19% ($Mdn = 0.05\%$, $SD = 1.44$). Due to the high standard deviation results, there was a concern that the overall results could dilute more conclusive results, as the paintings and their IAs are unique and difficult to compare overall. To verify if this is the case, the dwell time analysis results for each stimulus must be taken a closer look at.

Diagram 1 and *Diagram 2* show the percentage of dwell time spent in the IAs for the GP1 and GP2, respectively, for each of the ten stimuli over the full 60 seconds of the trial as bar charts. The stimuli are ranked in descending order according to the difference in time spent in the gaze cued IA. For the original version of the painting, it is the GP1; for the edited version, it is the GP2. Both diagrams only show nine stimuli, as *Andromeda* and *Judith* only have one GP each. For most paintings, only small differences in dwell time spent in the IAs can be seen for the full trial period. However, these results form a vague, overall pattern. Of the nine paintings with a GP within the painting in the original version, the percentage of dwell time within the GP1 decreased for eight of them in the edited version.¹³⁶ Meaning that when the CF was edited to not look at the GP1, this area received less attention over the full viewing time of 60 seconds. The only exception to these results is *Andromeda*, which shows an increase in dwell time for the edited version. Two of the stimuli proved to be statistically significant in the dwell time differences of their GP1: *The Fortune Teller* ($p = 0.004$) and *The Cheat* ($p = 0.0141$).

¹³⁶ The tenth painting is *Judith with the Head of Holofernes*, where the CF (the maid) looks outside of the painting in the original version and therefore does not have a GP1.

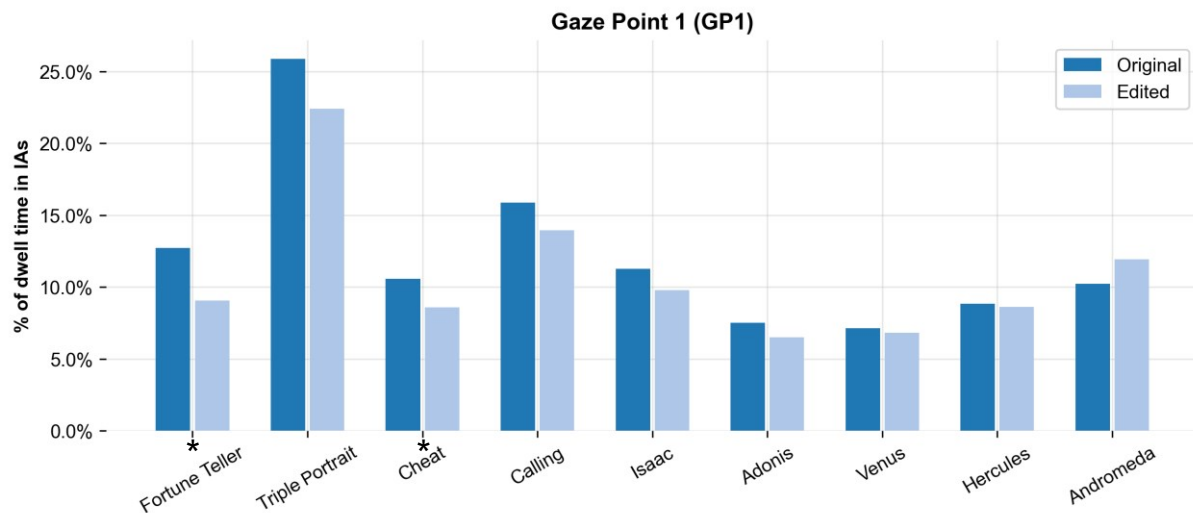


Diagram 1: Bar chart of percentages of dwell time spent in the GP1 by all participants over the full viewing time (60s); asterisks mark significance

Five of the eight paintings not only show an increase of dwell time in the GP1 in the original version, but also a corresponding increase of dwell time in the GP2 in the edited version of the stimulus. These five images are: *Triple portrait*, *Cheat*, *Hercules*, *Venus*, and *Isaac*. Three images show a higher percentage of dwell time in both IAs of the original version, and a lower percentage of dwell time for both IAs in the edited version of the stimulus. These are *Adonis*, *Fortune Teller*, and *Calling*.

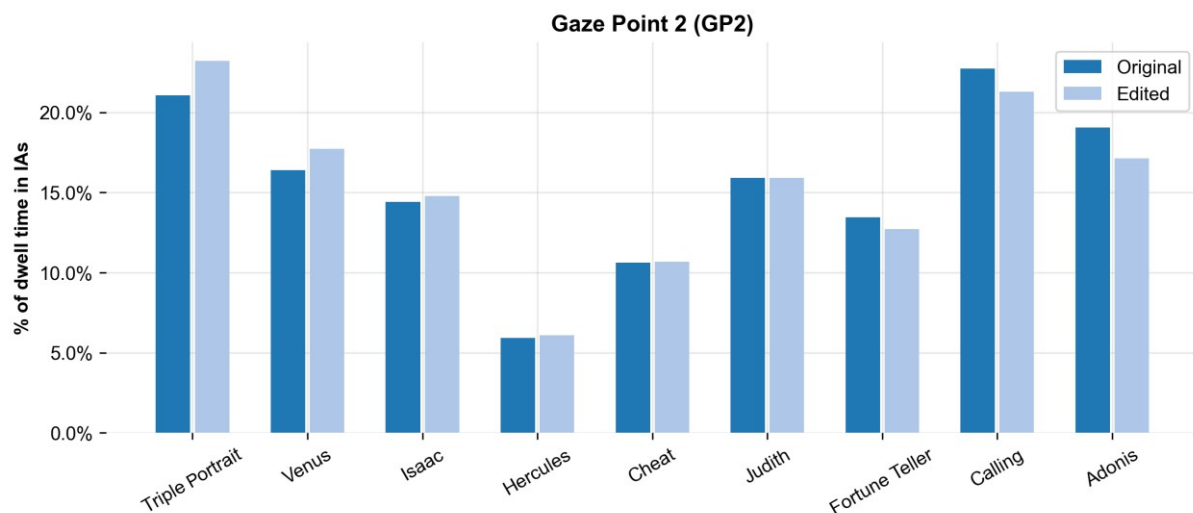


Diagram 2: Bar chart of percentages of dwell time spent in the GP2 by all participants over the full viewing time (60s)

One concern regarding the digital manipulation of the images was that the CF in the edited version might attract more attention due to people possibly noticing the edit. To see if this had any effect on the participants' viewing behaviour, the dwell times for the CF were also analysed. If the edited versions of the stimuli showed a clear trend towards an increase in

dwell time, possibly even a significant difference in the CFs, this would need to be considered when discussing the results. Therefore, a third bar chart was created to take a closer look at the CF results (*Diagram 3*).

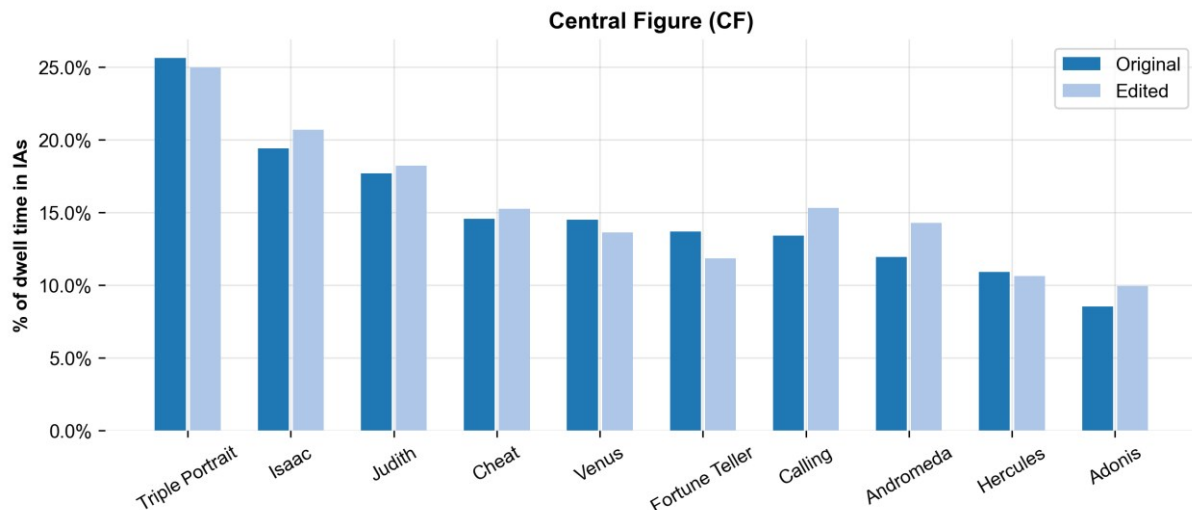


Diagram 3: Bar chart of percentages of dwell time spent in the CF by all participants over the full viewing time (60s)

For the CF, the results show no clear trend, with little overall difference between the original ($M = 15.03\%$, $Mdn = 14.1\%$, $SD = 4.86$) and edited version ($M = 15.48\%$, $Mdn = 14.77\%$, $SD = 4.68$). The dwell time increased in six images in the edited version, while it decreased for four images. The smallest change appears in *Hercules*, where the difference for the CF is 0.27%. With these diverse dwell time distributions for the CFs across the ten images, it is highly unlikely that the digital manipulation was detected by participants and consequently had any effect on their viewing behaviour.

3.2 Saccades

The overall results for the saccades going from the CF to the GP1 show a mean difference of 0.48% ($Mdn = 0.4\%$, $SD = 0.01$). The percentage of saccades decreases from a mean of 1.89% ($Mdn = 1.75\%$, $SD = 0.1$) in the original version to a mean of 1.41% ($Mdn = 1.6\%$, $SD = 0.1$) in the edited version. The mean difference for the saccades from the CF to the GP2 is 0.25% ($Mdn = 0.09\%$, $SD = 0.0$). The percentage of saccades increases from a mean of 1.84% ($Mdn = 1.66\%$, $SD = 0.1$) in the original version to a mean of 2.09% ($Mdn = 1.67\%$, $SD = 0.1$) in the edited version.

As with the dwell time analysis results above, *Diagram 4* and *Diagram 5*, in the form of bar charts, the results for each stimulus for the full viewing time in descending order of difference between the two versions. The saccades going from the CF to the GP1 are higher for seven of the nine stimuli, with a significant difference for *Triple portrait* ($p = 0.0024$) and *Isaac* ($p = 0.0372$). Two stimuli have an increase in saccades incongruent to the gaze cued figure: *Andromeda* and *Hercules*.

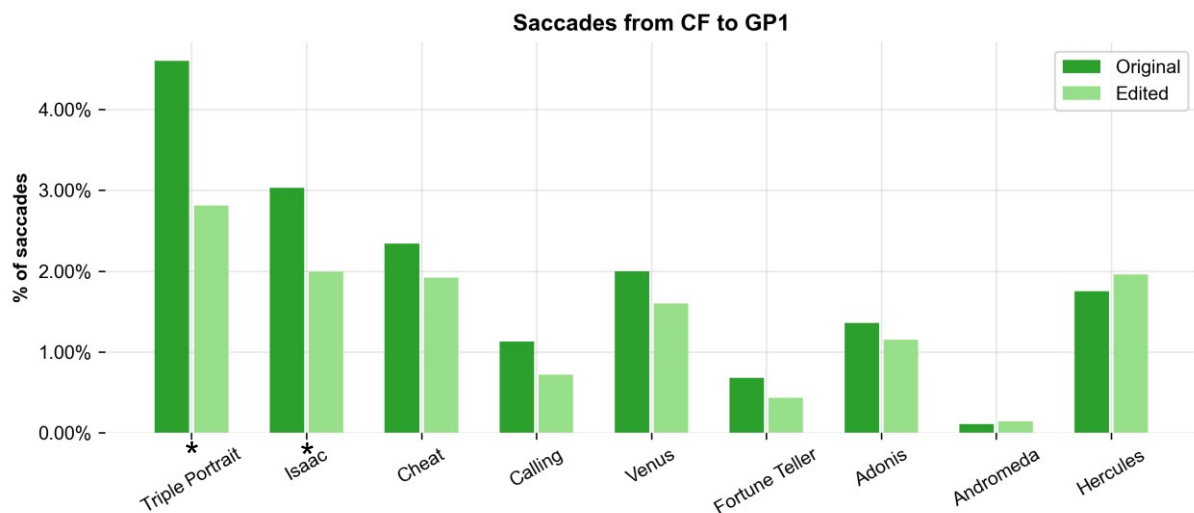


Diagram 4: Bar chart of percentages of saccades going from the CF to the GP1 during the full viewing time (60s); asterisks mark significance

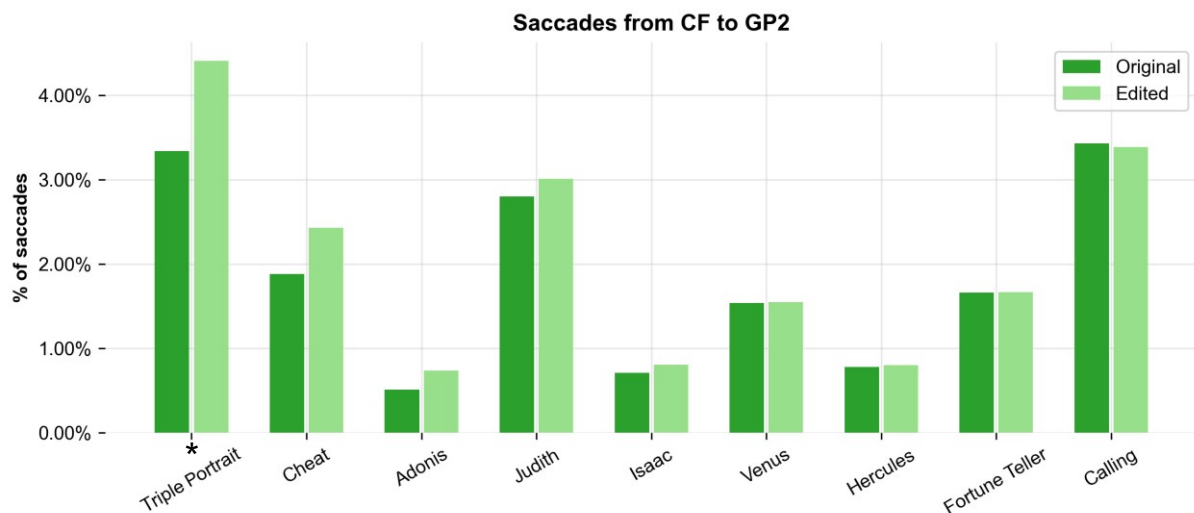


Diagram 5: Bar chart of percentages of saccades going from the CF to the GP2 during the full viewing time (60s); asterisk mark significance

The percentage of saccades between the CF and the GP2 increases for eight stimuli congruent with the gaze cued figure. Of those, the stimulus *Triple portrait* is the only one with a significant difference ($p = 0.0272$). The one stimulus where the saccades are incongruent to

the gaze cue is *Calling*, with a higher percentage of saccades going from the CF to the GP2 in the original version.

3.3 Time segments

Following the results for the full viewing time, each stimulus will also be presented with their dwell time and saccade analysis results for the separate time segment. When confronted with the few significant results for the full viewing period, it was hypothesised that only looking at the full 60 seconds given to participants to view each stimulus during the trial might conceal relevant data within smaller time segments. To optimise the visualisation of the large amount of data, for every IA, a double line graph presents the results of all time segments. The order of the stimuli goes in accordance with chapter 2.1: chronologically and by artist.

Triple Portrait

Despite no significance, the results of the full viewing period already showed some strong trends pointing towards a gaze cueing effect in this painting. A closer look at the different time segments reveals a stark difference in dwell time between the 10- and 30-second marks. There was also a significant difference at 15 (GP1: $p = 0.008$, GP2: $p = 0.001$) and 20 seconds (GP1: $p = 0.002$, GP2: $p = 0.011$) for both IAs, which is marked with an orange circle in the line charts (*Diagram 6 & Diagram 7*).

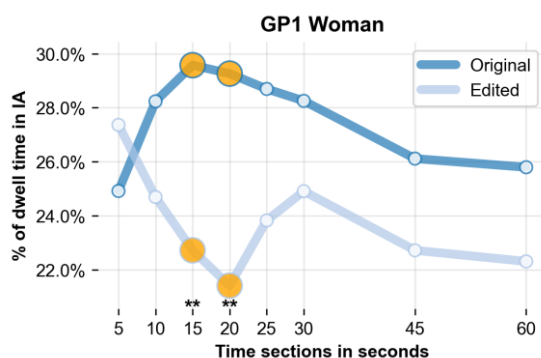


Diagram 6: Line chart of % of dwell time spent in GP1 over time; orange circles mark a significant difference

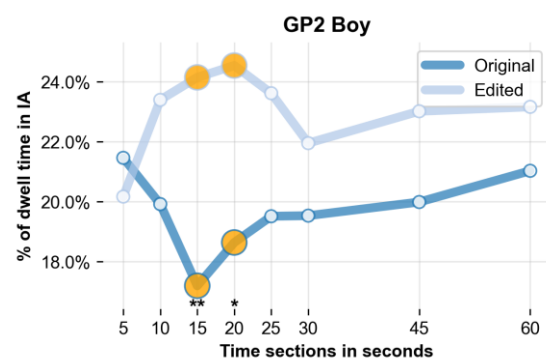


Diagram 7: Line chart of % of dwell time spent in GP2 over time; orange circles mark a significant difference

Meaning that, during this time, participants spent significantly more time in the IA of the GP that is congruent with the gaze cue of the CF in both versions of the painting. Particularly remarkable, when looking at the two visualisations side by side, is how the attention in the

two IAs almost perfectly mirror each other. Both start out with the GP that is not cued by the CF, higher in dwell time at 5 seconds, but quickly flip around at 10 seconds in favour of the gaze cued GP, reach their maximum difference between 15–20 seconds, shrink noticeably at the 30-second mark, and stay that way until the end of the trial. The significant events also show up at the same time segment for both GPs. The difference in attention, although not significant at every time segment, is clearly visible in the line charts.

The saccade analysis shows strong results for the saccades between the CF and GP1 (*Diagram 8*). Each time segment shows up as a statistically significant event, with the highest significance at 10 seconds ($p = 0.00001$) and the lowest at 60 seconds ($p = 0.002$). While for the saccades between the CF and GP2, from the 15 seconds mark onwards up to the end of the trial, the percentage of outward saccades (saccades going from the CF towards the GP2) is significantly higher in the edited version (*Diagram 9*). Of these time segments, the significance is highest at 20 seconds ($p = 0.003$) and lowest at 60 seconds ($p = 0.027$). The saccades between the two GPs were also considered and showed no significant differences, whether overall or in either direction, throughout the entire viewing period.

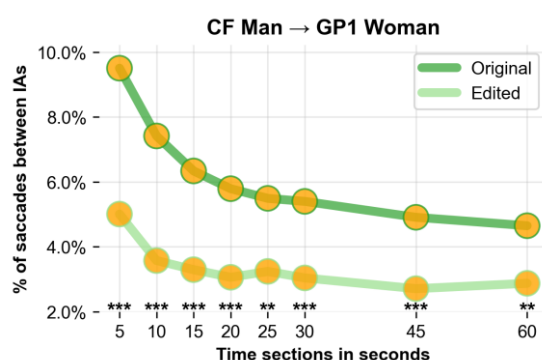


Diagram 8: Line chart of % of saccades from the CF to the GP1; orange circles mark a significant difference

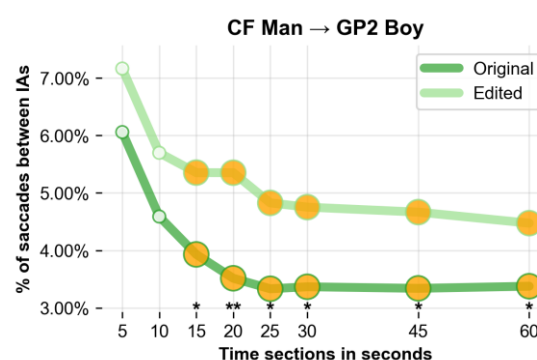


Diagram 9: Line chart of % of saccades from the CF to the GP2; orange circles mark a significant difference

Venus and Adonis

The results for the dwell time analysis in this stimulus show no statistically significant results for either of the two GPs in any of the time segments. The GP1 shows a very slight increase in the original version (*Diagram 10*), while the GP2 receives less attention in the edited version (*Diagram 11*). However, at the 5-second mark, the CF (*Diagram 12*) receives significantly more attention in the edited version ($p = 0.012$). The same is true for the bow and arrows (*Diagram 13*), hanging on the tree above the sleeping Cupid ($p = 0.004$). But in opposition to the CF, this IA shows a higher dwell time in the original version.

While neither GP proves to be affected by the gaze direction of the CF, the difference in dwell time in the GP1 is most clear towards the end of the viewing period. The GP2, in turn, receives slightly more attention in the original version, contrary to expectations, with an increasing trend at the end of the trial. The sharp increase in attention on the GP2 at 10 seconds in the edited version is noteworthy, however.

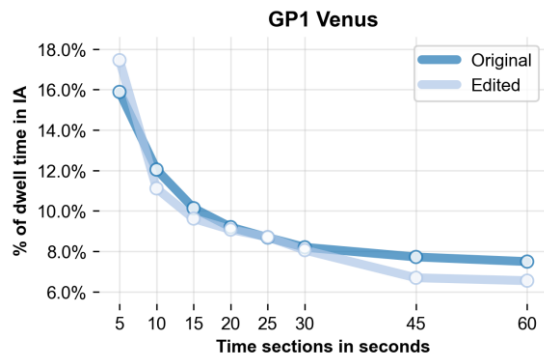


Diagram 10: Line chart of % of dwell time spent in GP1 over time

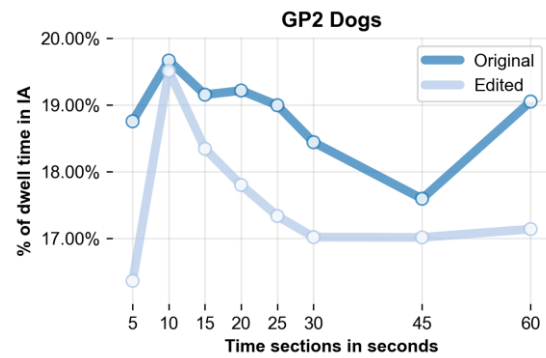


Diagram 11: Line chart of % of dwell time spent in GP2 over time

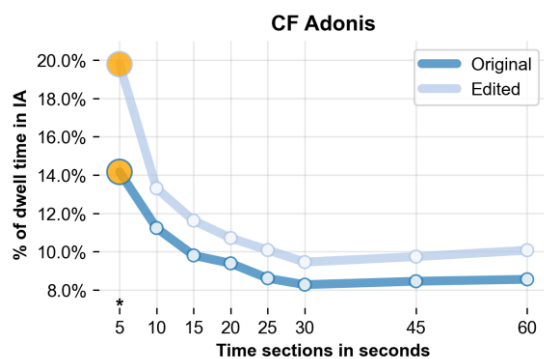


Diagram 12: Line chart of % of dwell time spent in CF over time; orange circles mark a significant difference

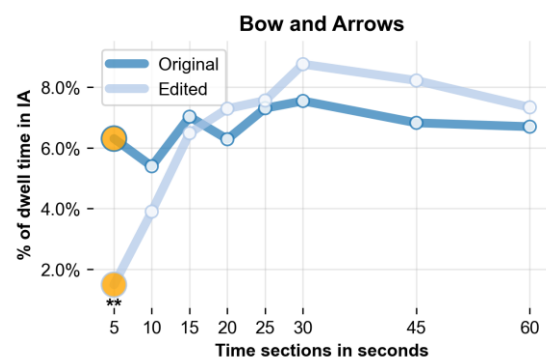


Diagram 13: Line chart of % of dwell time spent in IA "Bow and Arrows" over time; orange circles mark a significant difference

The results of the saccade analysis are inconclusive. The saccades going from the CF to the GP1 appear to have little difference (Diagram 14) but, very similarly to the dwell time results, show an increased difference towards the end of the trial. There is a pronounced increase for the saccades between the CF and the GP2 in the edited version, with the clearest difference in the first 5 seconds (Diagram 15).

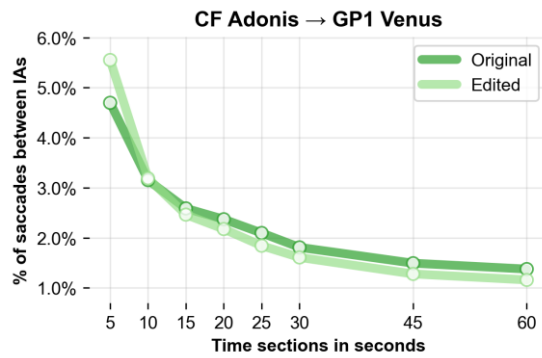


Diagram 14: Line chart of % of saccades from the CF to the GP1

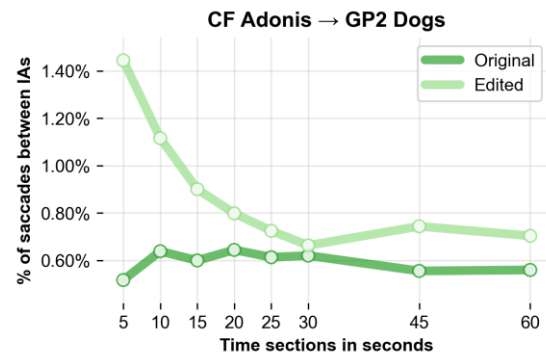


Diagram 15: Line chart of % of saccades from the CF to the GP2

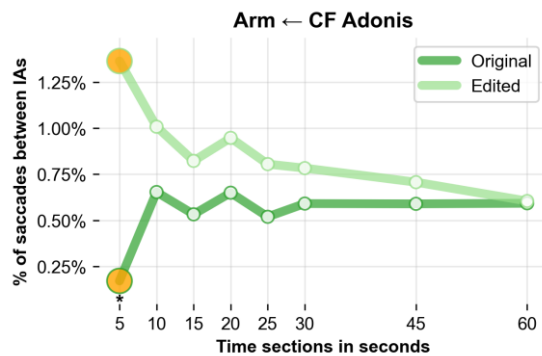


Diagram 16: Line chart of % of saccades from the CF to the IA "Arm"; orange circles mark a significant difference

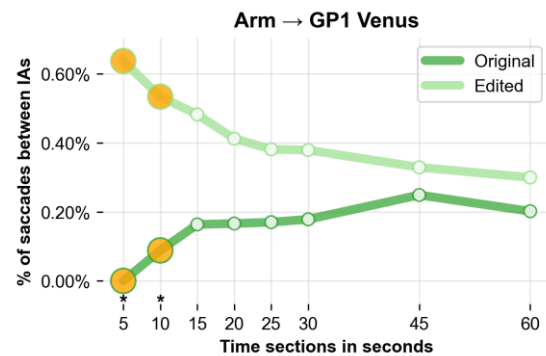


Diagram 17: Line chart of % of saccades from the IA "Arm" to the GP1; orange circles mark a significant difference

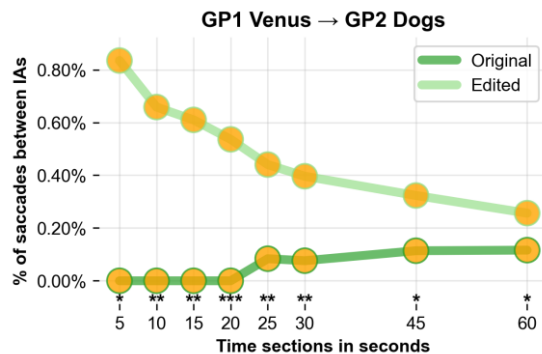


Diagram 18: Line chart of % of saccades from the GP1 to the GP2; orange circles mark a significant difference

While the results for the GP2 appear obvious in their visual appearance in the line diagrams, the statistical analysis did not find the differences between the two versions to be significant. One peculiarity was noticed, however, when going through the analysis results of the saccades between the other IAs. For three of them,

saccades were significantly more often performed in the edited version of the stimulus. The arm of Venus (GP1), with which she is trying to hold back her lover from leaving, received enough attention to show up in the heat maps (*Figure 19 & Figure 20*). Following this small hint, an additional IA was drawn around this area, and the line diagrams revealed a clear separation in the percentage of saccades going towards it from the CF (*Diagram 16*), in favour of the edited version. With the saccades in the first 5 seconds also appearing as statistically significant ($p = 0.014$). The saccades going from the arm towards the GP1 display a very similar pattern (*Diagram 17*), with significant differences at 5 and 10 seconds.

However, the strongest results of these can be seen in the saccades going from the GP1 to the GP2 (*Diagram 18*), with significant differences throughout the full trial.

Perseus and Andromeda

The results for the dwell time analysis reveal small changes in the attention paid towards the GP1 (*Diagram 19*). Between 20 and 30 seconds more attention is paid to the GP1, but this turns around for the second half of the viewing period, and no significant differences could be found. Interestingly, however, the CF—Andromeda herself—is consistently more looked at in the edited version (*Diagram 20*) and has a significant event at 25 seconds ($p = 0.039$).

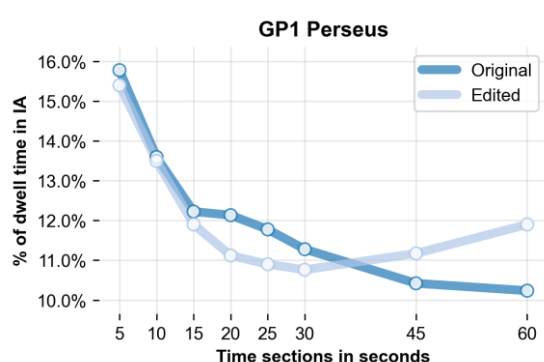


Diagram 19: Line chart of % of dwell time spent in GP1 over time

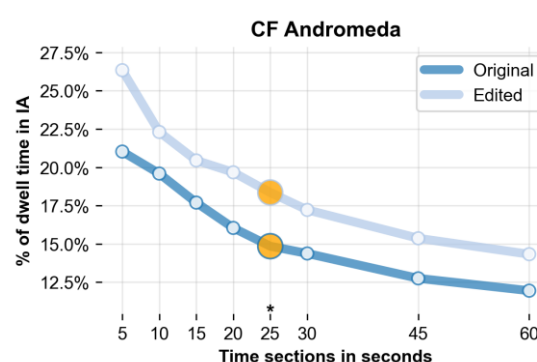


Diagram 20: Line chart of % of dwell time spent in CF over time; orange circles mark a significant difference

Saccades from the CF to the GP1 are performed more often in the beginning, particularly between 10 and 25 seconds, in the original version (*Diagram 21*), but the differences do not reach the threshold of being significant.

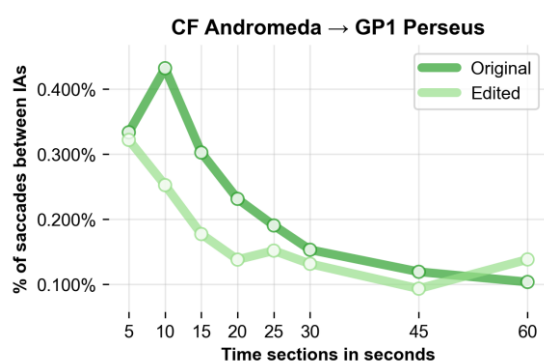


Diagram 21: Line chart of % of saccades from the CF to the GP1

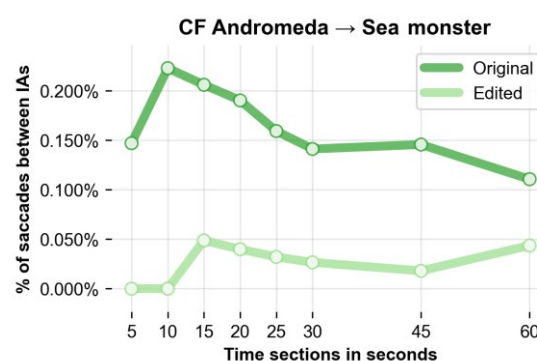


Diagram 22: Line chart of % of saccades from the CF to the IA “Sea monster”

As the heads of Perseus and of the sea monster are very close together in the composition, it is hard to identify with absolute certainty which figure is the gaze cued point, as the CF looks in

both their general direction. Therefore, the saccades between the CF and the additional IA of the sea monster were also calculated. While the overall percentage of saccades is low, it shows a clear difference, with more saccades being performed towards the sea monster when the CF looks in its direction (*Diagram 22*). Despite this, no significance could be found for the saccades ($p = 0.07$ coming the closest at 45 seconds).

Venus blindfolding Cupid

The dwell times analysis results show an increase in dwell time for the GP that corresponds with the CF's gaze in both versions of the stimulus. So does the GP1 receive more attention in the original version (*Diagram 23*), while the GP2 is looked at more in the edited version (*Diagram 24*). The results of the statistical analysis mark the differences of the GP2 as significant for the 25 ($p = 0.009$), 30 ($p = 0.031$), and 45 second ($p = 0.03$) time segments. Despite the GP1 following expectations for nearly the full viewing period, no significance could be found.

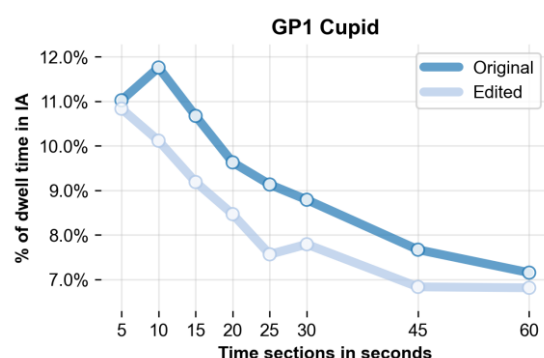


Diagram 23: Line chart of % of dwell time spent in GP1 over time

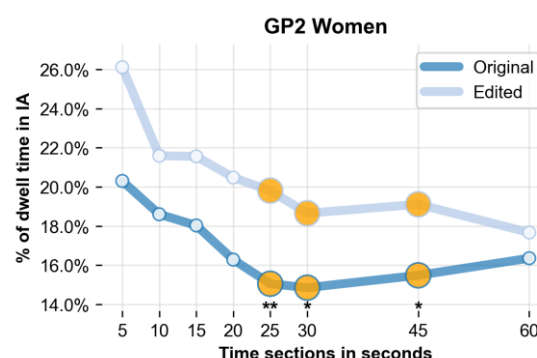


Diagram 24: Line chart of % of dwell time spent in GP2 over time; orange circles mark a significant difference

There was no clear trend found for the outward going saccades between the CF and the GP1 (*Diagram 25*), but the results show a slight increase for the saccades between the CF and the GP2 (*Diagram 26*). This is similar to the dwell time analysis results, also showing a stronger trend in the GP2. None of the saccades between the CF and either of the two GPs were found to be significant, but the nearest result to the threshold could be seen for the saccades from the CF towards the GP1 at the viewing time of 45 seconds ($p = 0.064$).

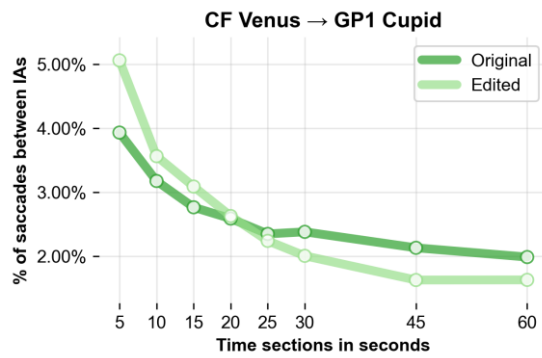


Diagram 25: Line chart of % of saccades from the CF to the GP1

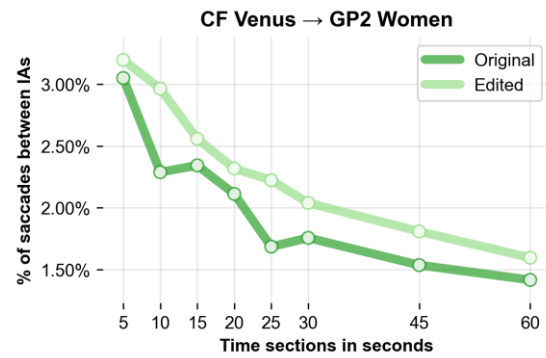


Diagram 26: Line chart of % of saccades from the CF to the GP2

Hercules at the Crossroads

In both versions of the painting, the dwell times for the fixations increase in the GP that is cued by the CF. The GP1 receives considerably more attention in the original version (Diagram 27), as does the GP2 in the edited version (Diagram 28). However, as can be seen in the line diagrams, this effect only occurs in the first half minute of viewing time. After that period, the differences for both GPs are negligible.

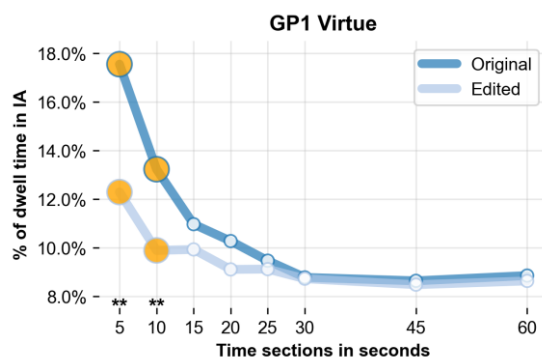


Diagram 27: Line chart of % of dwell time spent in GP1 over time; orange circles mark a significant difference

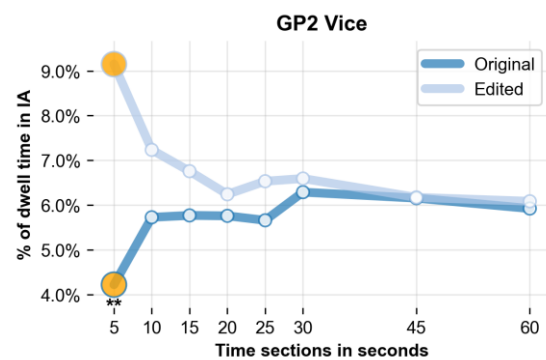


Diagram 28: Line chart of % of dwell time spent in GP2 over time; orange circles mark a significant difference

The results of the two versions roughly mirror each other. There is a difference of about 5% in the first 5 seconds. After that moment, the gap in attention closes faster for the GP2, which is just below 1% at 15 seconds. As for the GP1, this threshold is crossed after 25 seconds. This is also reflected in the statistical analysis results. While the differences in dwell time for the GP1 are significant for the 5- and 10-second periods ($p = 0.009$ and $p = 0.008$, respectively), for the GP2 this only applies to the first 5 seconds, albeit to a higher degree ($p = 0.003$).

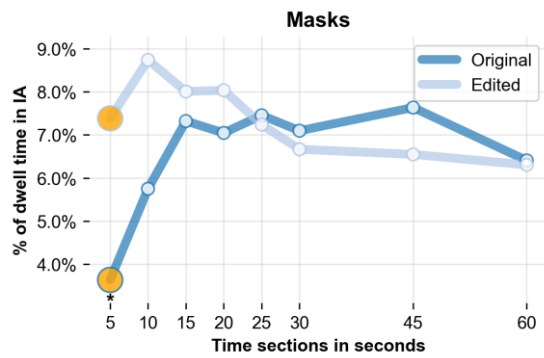


Diagram 29: Line chart of % of dwell time spent in IA “Masks” over time; orange circles mark a significant difference

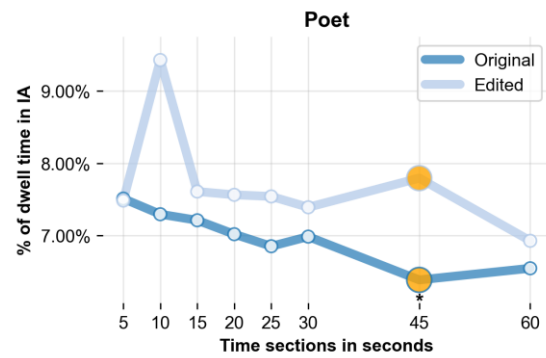


Diagram 30: Line chart of % of dwell time spent in IA. “Poet” over time; orange circles mark a significant difference

Two more IAs show significant results: the masks to the right of the allegory of the GP2 (Diagram 29) at 5 seconds ($p = 0.044$), and the poet, sitting to the left of the GP1 (Diagram 30) at 45 seconds ($p = 0.036$). Both received more attention in the edited version. The only additional IA in this stimulus, not showing any significance throughout the entire viewing time, is Hercules’s winged horse, Pegasus, towards which Virtue is pointing the still undecided hero. Although the differences between the two versions are not significant, this IA receives 3% more attention in the first 10 seconds of the original version; an increase of nearly 50% compared to the edited version. The dwell time results for the CF show a similar distribution in both versions.

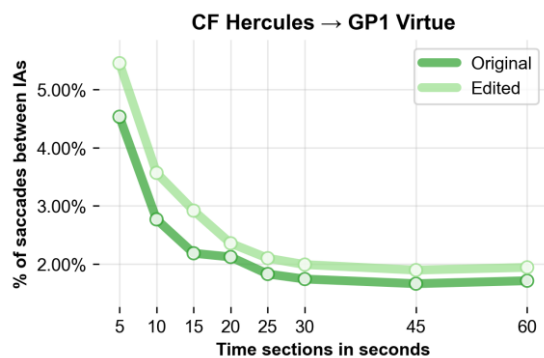


Diagram 31: Line chart of % of saccades from the CF to the GP1

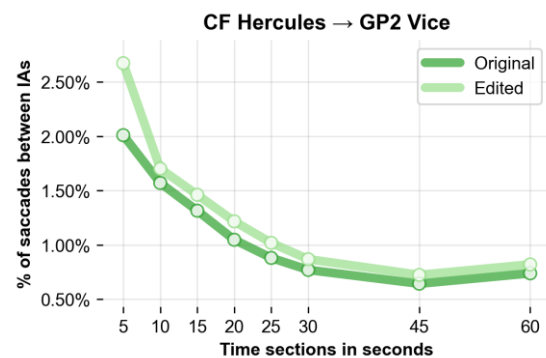


Diagram 32: Line chart of % of saccades from the CF to the GP2

The saccade analysis results are less promising. For both GPs, the line diagrams show that there are slightly more saccades happening between the CF and both GPs in the edited version (Diagram 31 & Diagram 32). With little difference throughout, no significant differences were found.

The Calling of Saint Matthew

The dwell time analysis results for the GP1 show a stark decrease in the edited version between the 10–30 seconds time segments (*Diagram 33*). The GP2 shows less difference in attention, with the biggest divergence between 10 and 15 seconds in favour of the edited version, where the CF is gazing towards the GP2 (*Diagram 34*). Of the two, only the GP1 receives a statistically significant increase in attention at 20 and 25 seconds of viewing time ($p = 0.043$, $p = 0.045$). It is also worth noting how the dwell time for the GP1 falls off drastically after the first 5 seconds in the edited version. In the original, it increases at the same point in time.

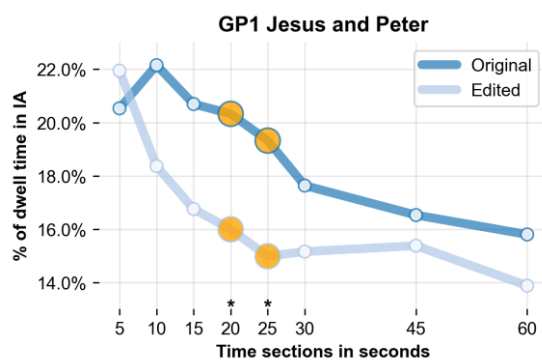


Diagram 33: Line chart of % of dwell time spent in GP1 over time; orange circles mark a significant difference

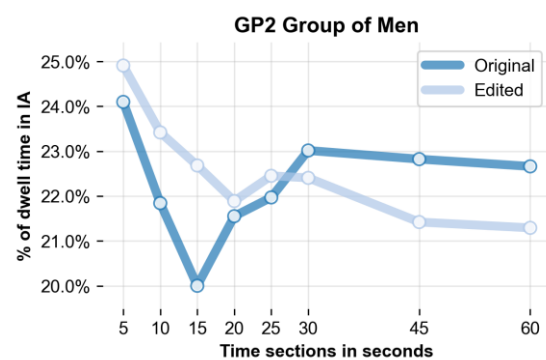


Diagram 34: Line chart of % of dwell time spent in GP2 over time

The analysis results for the saccades show an increase in saccades between the CF and the GP1 in the original and between the CF and the GP2 in the edited version, with the line diagrams appearing almost exactly inverted. However, neither of the saccade analysis results of the two GPs were found to be significantly different (*Diagram 35 & Diagram 36*).

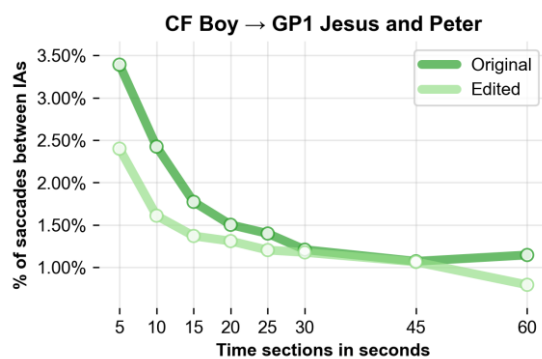


Diagram 35: Line chart of % of saccades from the CF to the GP1

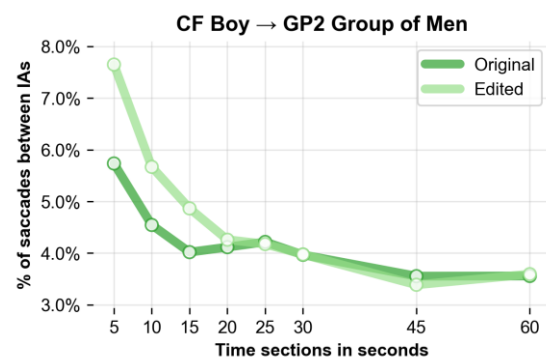


Diagram 36: Line chart of % of saccades from the CF to the GP1

The Sacrifice of Isaac

The analysis results show clear differences in dwell time, with the GP1 receiving much more attention in the original (*Diagram 37*), while participants favour the GP2 in the edited version more (*Diagram 38*). Both GPs are statistically significant. The GP1 is consistently significant between 15 and 30 seconds ($p = 0.027$, $p = 0.001$, $p = 0.011$, $p = 0.005$). The GP2 shows fewer differences than the GP1 but still follows expectations. One significant event occurs at 20 seconds ($p = 0.025$), which is also the most significant point for the GP1.

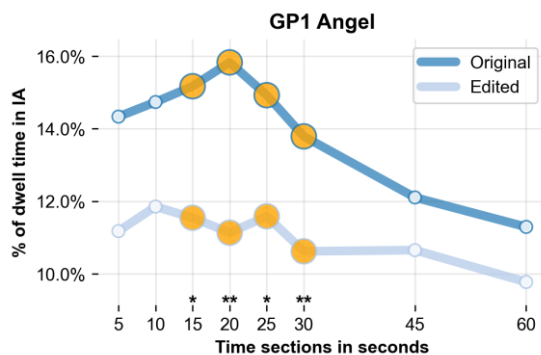


Diagram 37: Line chart of % of dwell time spent in GP1 over time; orange circles mark a significant difference

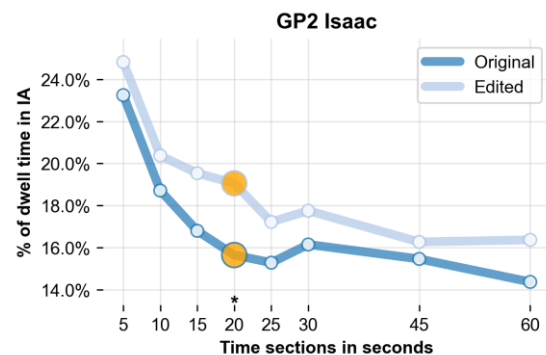


Diagram 38: Line chart of % of dwell time spent in GP2 over time; orange circles mark a significant difference

During the analysis, the results of two additional IAs stood out. More attention was paid to the knife in Abraham's hand in the edited version (*Diagram 39*), where he is looking in its direction. Meanwhile, the sacrificial ram was looked at more in the original version (*Diagram 40*). While neither IA proved to be significantly different, this is in line with expectations for the GPs, as both IAs can be seen as logical extensions of them.

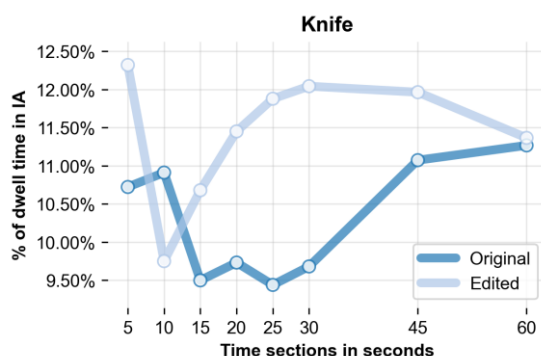


Diagram 39: Line chart of % of dwell time spent in IA "Knife" over time

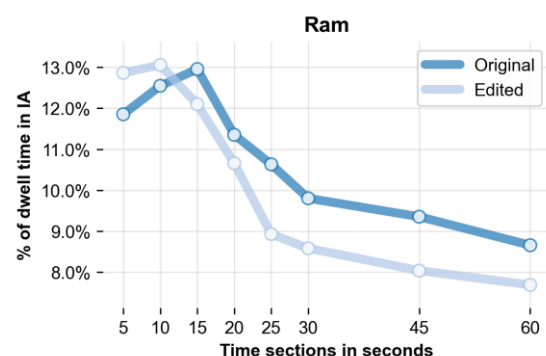


Diagram 40: Line chart of % of dwell time spent in IA "Ram" over time

The saccades from the CF to the GP1 show a clear tendency to follow the CF's gaze direction more often in the original version (*Diagram 41*). Saccades between the CF and the GP2

however, are performed at almost the same amount in both versions of the stimulus (*Diagram 42*) with a slight increase in the edited version. This is also reflected in the results of the statistical analysis, as only the difference of the saccades between the CF and GP proved to be significant. While not covering the entire trial, they are significant from the beginning at 5 seconds ($p = 0.002$) to the end at 60 seconds ($p = 0.037$). The only time segments they are not significant at, are 10 and 20 seconds, with a p -value of 0.068 and 0.075 respectively, still coming close to the threshold. This is particularly noteworthy, as the highest significant result for the dwell time of the GP1 is at 20 seconds. The differences for the saccades between the CF and the GP2 on the other hand, while being performed slightly more often in the edited version, are too small to be significant.

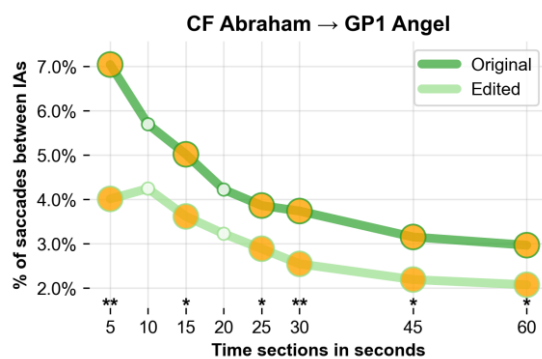


Diagram 41: Line chart of % of saccades from the CF to the GP1; orange circles mark a significant difference

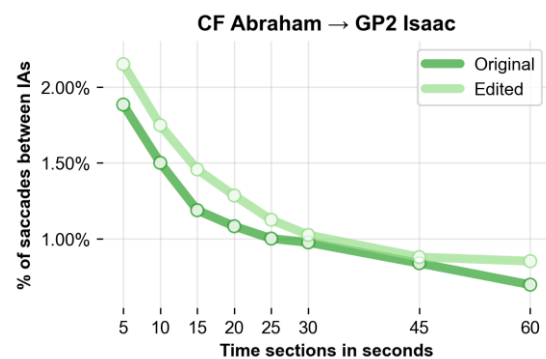


Diagram 42: Line chart of % of saccades from the CF to the GP2

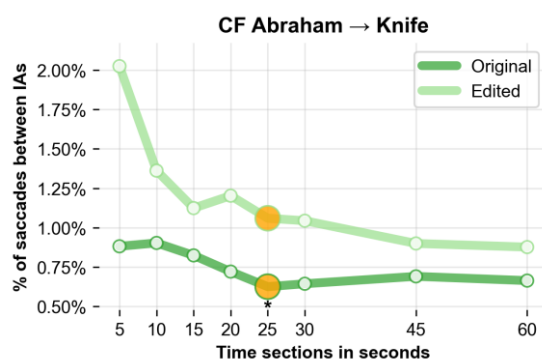


Diagram 43: Line chart of % of saccades from the CF to the IA "Knife"; orange circles mark a significant difference

While looking at the dwell time analysis results in more detail, it was found that the saccades towards the knife in Abraham's hands were performed more often in the edited version (*Diagram 43*), with a significant difference at 25 seconds ($p = 0.043$).

Judith and her Maidservant with the Head of Holofernes

This painting is the second of the two stimuli with only one GP. In this case, it is the original version, which does not feature a specific gaze cued area within the painting. The change in the CF's gaze from an unspecified area outside the canvas towards the GP2 resulted in little

change in dwell time for the GP2 (*Diagram 44*). It increases and decreases for both versions without a clear trend being discernible. Beginning at 15 seconds, the CF itself receives slightly more attention for most of the trial in the edited version (*Diagram 45*). The differences are small and neither of the two IAs was found to be significant at any point. While not a focal point of a character's gaze, the IA of Holofernes' severed head (*Diagram 46*) received more attention in the original version and showed up as significant at 45 and 60 seconds of viewing time ($p = 0.029$, $p = 0.013$).

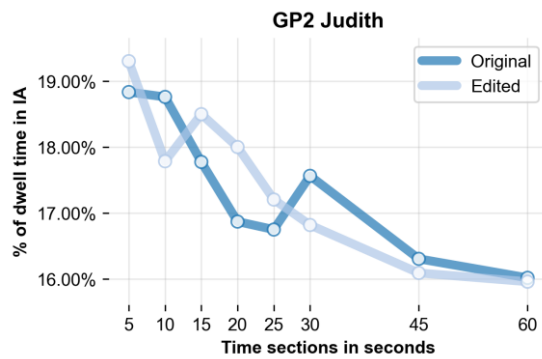


Diagram 44: Line chart of % of dwell time spent in GP2 over time"

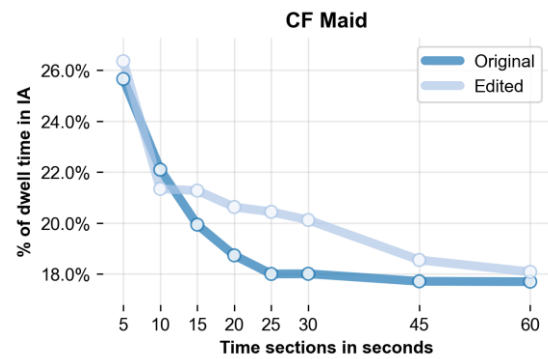


Diagram 45: Line chart of % of dwell time spent in CF over time

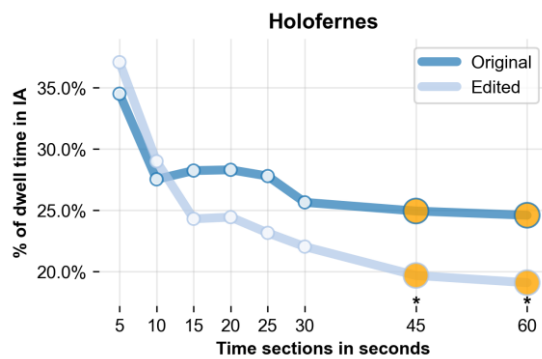


Diagram 46: Line chart of % of dwell time spent in IA "Holofernes" over time; orange circles mark a significant difference

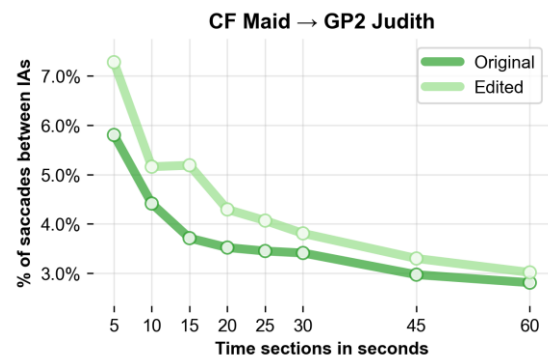


Diagram 47: Line chart of % of saccades from the CF to the GP2

The saccade analysis results from the CF towards the GP2 show an increase between the CF and the GP2 (*Diagram 47*), in accordance with the gaze of the CF. While the difference at 15 seconds is very close to the threshold of significance ($p = 0.054$), no significant differences could be found.

The Fortune Teller

The dwell time analysis results show how the attention of the participants shifted from the GP1 in the original (*Diagram 48*) to the GP2 (*Diagram 49*) in the edited version. While just barely missing the threshold of significance, the biggest difference for the GP2 is at 10 seconds ($p = 0.051$). The GP2 was found to be significant at the full viewing time of 60 seconds ($p = 0.003$).

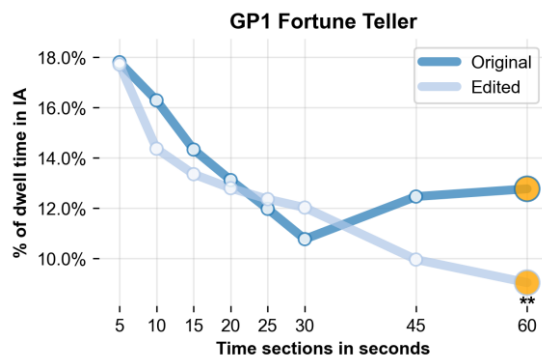


Diagram 48: Line chart of % of dwell time spent in GP1 over time; orange circles mark a significant difference

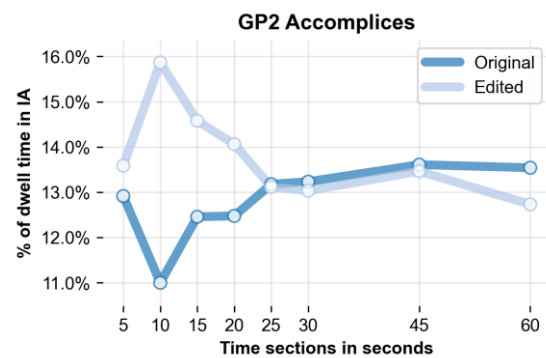


Diagram 49: Line chart of % of dwell time spent in GP2 over time

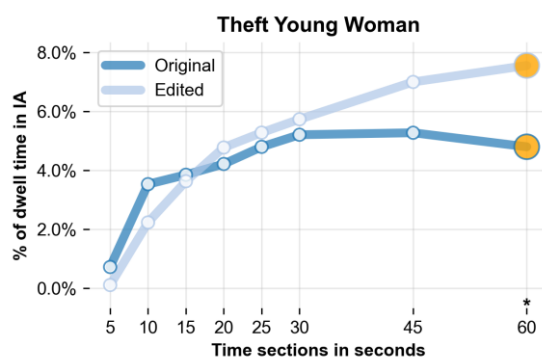


Diagram 50: Line chart of % of dwell time spent in IA "Theft Young Woman" over time; orange circles mark a significant difference

Furthermore, the IA "Theft Young Woman", which is placed between the CF and the GP1 in the painting, is also given more attention by participants in the edited version (*Diagram 50*) after 15 seconds, with a significant event at the very end of the viewing period ($p = 0.023$).

The results of the saccade analysis show an increase for those from the CF to the GP1 in the original version (*Diagram 51*), as well as an increase of saccades going towards the GP2 in the edited version (*Diagram 52*). While the line charts are visually compelling, the differences were not strong enough to be significant. It should be noted, however, that the p -value of 0.062 for the saccades in the first 5 seconds of viewing time from the CF to the GP2 is close to the needed threshold.

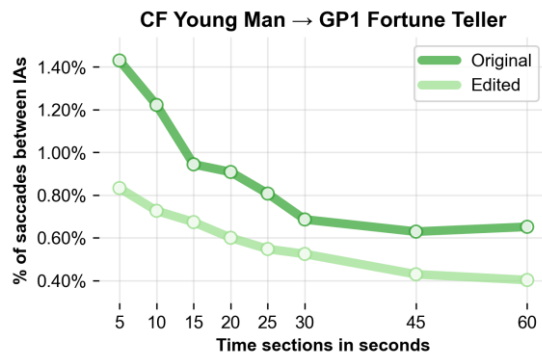


Diagram 51: Line chart of % of saccades from the CF to the GP1

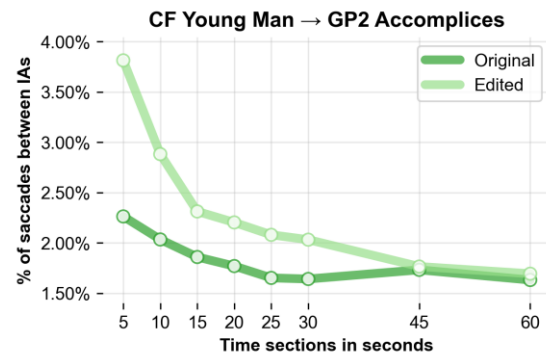


Diagram 52: Line chart of % of saccades from the CF to the GP2

The Cheat with the Ace of Diamonds

The GP1 is significantly more looked at by participants for the full duration of the trial (Diagram 53), while the GP2 receives more attention in the edited version until 20 seconds of viewing time (Diagram 54), after which the dwell time analysis results become inverted. For the GP1, significant differences in dwell time can be seen from the midway point of the viewing time onwards, across three consecutive time segments of 30, 45 and 60 seconds ($p = 0.012$, $p = 0.013$ and $p = 0.014$, respectively).

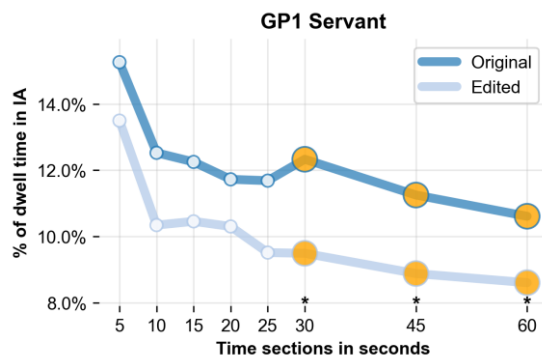


Diagram 53: Line chart of % of dwell time spent in GP1 over time; orange circles mark a significant difference

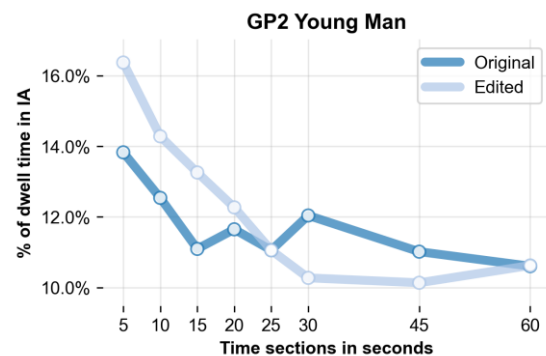


Diagram 54: Line chart of % of dwell time spent in GP2 over time

In the original (Diagram 55), saccades are consistently made more frequently when moving from the CF to the GP1, while in the edited version (Diagram 56), saccades are performed more frequently when moving towards the GP2. As with the dwell times, the trend is stronger for the saccades between CF and GP1, which also prove to be significant for every time segment of the first half minute of the trial, with the strongest at 10 seconds ($p = 0.001$). No significance could be found for the saccade between the CF and the GP2.

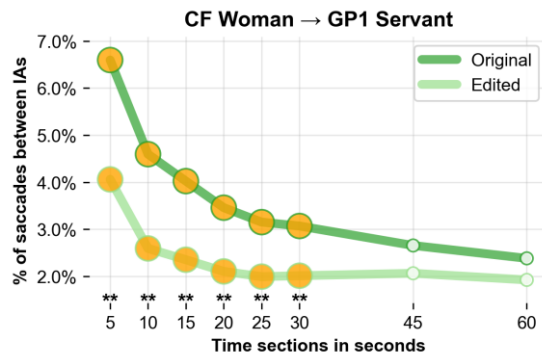


Diagram 55: Line chart of % of saccades from the CF to the GP1; orange circles mark a significant difference

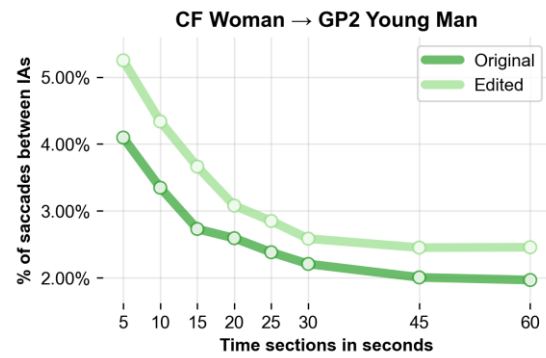


Diagram 56: Line chart of % of saccades from the CF to the GP2

3.4 Questionnaire

The questionnaire, asking the participants to select two figures that they considered being most important to the depicted story, constituted the last part of the study. Due to the way the IAs had to be drawn for the eye tracking analysis, some include a group of people as one singular GP, while for the images on the questionnaire, each figure was identified separately (*Figure 57–Figure 66*), to avoid biasing the participants by presenting them with a pre-chosen grouping of the figures. To achieve comparable results between the eye tracking and the questionnaire part of the study, the answers for figures within an IA group were added together and treated as one for the questionnaire analysis.

The results show an increase in perceived importance of the GP1 figures, with a mean difference of 6.46% ($Mdn = 10.1\%$, $SD = 0.09\%$) in the original version ($M = 30.9\%$, $Mdn = 32.4\%$, $SD = 0.14\%$), compared to the edited version ($M = 24.5\%$, $Mdn = 23.1\%$, $SD = 0.1\%$). The mean difference for the GP2 figures lies at 4.5% ($Mdn = 0.8\%$, $SD = 0.08\%$), slightly increasing in the edited version ($M = 24.2\%$, $Mdn = 20.5\%$, $SD = 0.17\%$) compared to the original version ($M = 19.7\%$, $Mdn = 15.2\%$, $SD = 0.14\%$).

Diagram 57 and *Diagram 58* provide a more detailed view of the results for each stimulus, showing the percentages of participants who answered either GP1 or GP2 for each version of the paintings. The stimuli are arranged in order of decreasing difference between the two versions. Six stimuli showed an increase in perceived importance of the GP1 among participants, which is congruent with the gaze cueing of the CF. Five stimuli show an increase in importance of the GP2 that is congruent with the CF's gaze cue. Two stimuli show a non-congruent increase for both the GP1 and the GP2.

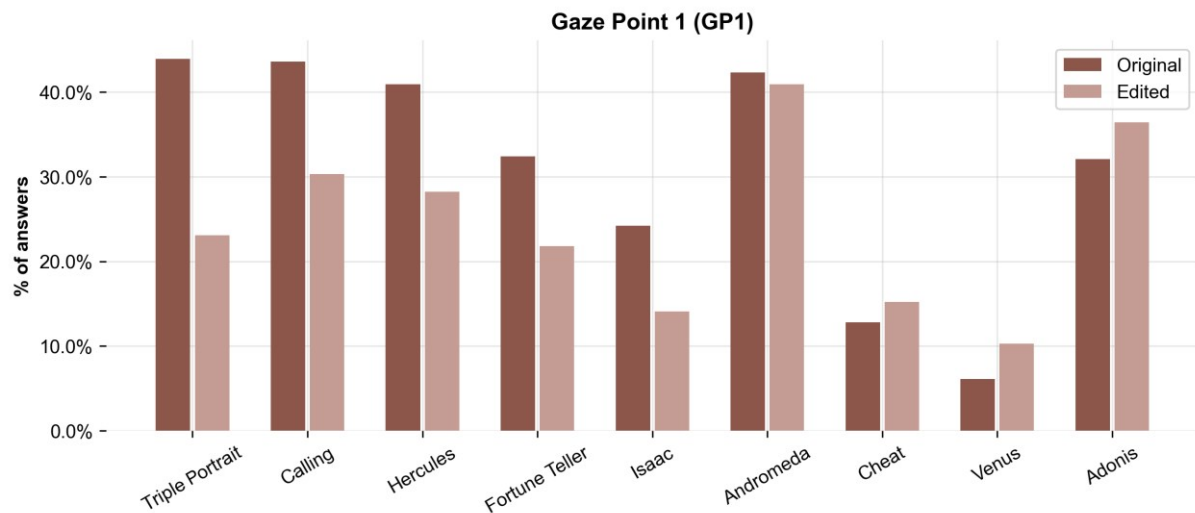


Diagram 57: Bar chart of percentages of participants answering “GP1” to the question “Which two figures would you consider to be most important to the content of the painting?”

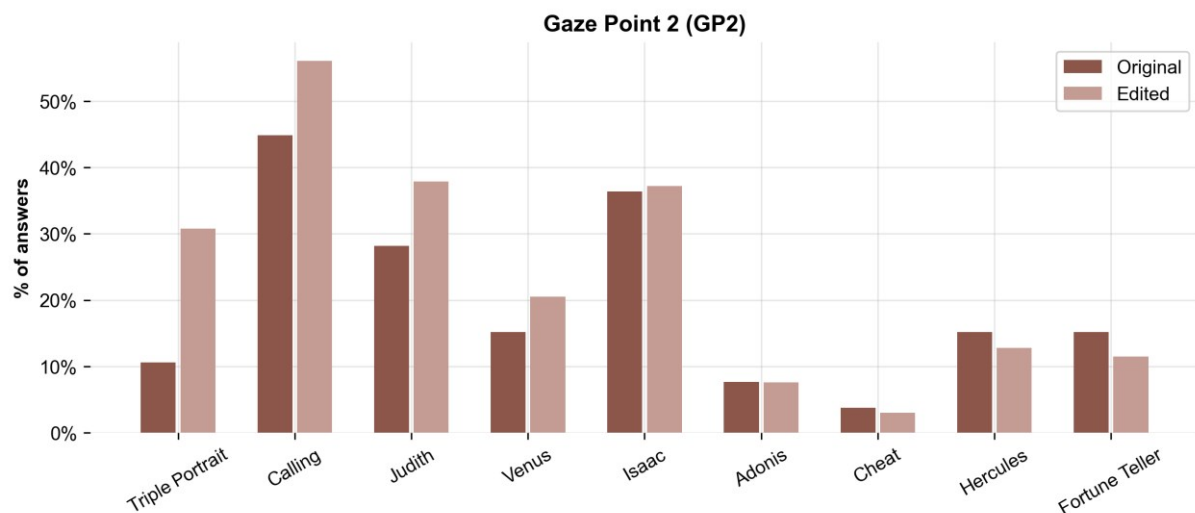


Diagram 58: Bar chart of percentages of participants answering “GP2” to the question “Which two figures would you consider to be most important to the content of the painting?”

The stimulus *Triple Portrait* shows the largest change in perceived importance among the participants for both GPs. In the original version of the painting, the GP1 is considered as most important to the story by almost half of the participants (44.3%), nearly the same amount as the CF (45.7%). However, only 10.6% saw the GP2 as a figure important to the content of the painting. Looking at the results for the edited version, almost a third of people (30.8%) named the GP2 as important, a sharp increase of almost 300% compared to the original. Meanwhile, the GP1 is losing importance in the eyes of the participants, with positive answers dropping almost in half to 23.1%. At the same time, there is practically no change in how many people saw the CF as a central part of the story, with a negligible difference of 0.7% between the two versions.

Caravaggio's *Calling* also displays strong results. The GP1 (which includes the figures of Peter and Jesus) loses more than 13% in perceived importance in the edited version overall, with the figure of Peter displaying the higher singular difference of the two. Meanwhile, the GP2 (the group of three men at the table), including supposed Matthew pointing at himself, increases by more than 11% in the edited version. While the coin-counting boy at the far left of the table increases by only 2.56%. The third image, with congruent increases in both GPs, is *Isaac*, with a stronger effect for the GP1: the figure of the angel notably decreases in importance in the edited version (10.1%), while the GP2 (*Isaac*) has a minimal increase of 0.8%. The two stimuli with only one GP (*Andromeda* and *Judith*) also show an increase that is congruent with their respective gaze cue. Making it five stimuli in total that present congruent increases and decreases for all their GPs. Both *Hercules* and the *Fortune Teller* display a congruent increase in importance for their GP1, but the opposite is true for their GP2. For the stimulus *Venus*, however, it is the opposite: there is a congruent increase for the GP2, but not the GP1. Of all the stimuli, only the *Cheat* and *Adonis* have an incongruent increase in perceived importance for both GPs.

As the questionnaire offered more response options than just the CF and the GPs, some stimuli naturally showed differences for other figures as well. Just as can also be seen in the results of the eye-tracking analysis, the changes do not necessarily stay confined to the figures involved in the gaze change alone. As this could be an important piece in understanding how the perception of participants changed in more detail, additional diagrams were created to visualise the results of all possible figures for each stimulus separately (*Diagram 59–Diagram 68*). The changes in perceived importance of the CF increased in the edited versions of: *Judith* (+9.7%), *Hercules* (+7.3%), *Adonis* (+6.3%), *Fortune Teller* (+3.8%), *Andromeda* (+2.8%), and *Triple Portrait* (+0.7%); and decreased for *Cheat* (-4.4%), *Venus* (-4.2%), *Calling* (-2.91%), and *Isaac* (-0.5%). Looking at the paintings with additional figures, the stimuli *Fortune Teller* (Stealing Woman (d): +11.5%), *Isaac* (Ram (d): +9.8%), *Hercules* (Poet (b): +7.5%; Pegasus (a): +0.2%), *Judith* (Holofernes (b): +4.7%), *Calling* (Backwards sitting Man (e): +5.01%), *Cheat* (Cheating Man (a): +2.9%), and *Adonis* (Sky figure (f): +0.4%), all showed clear increases in affirmative answers for additional figures that were neither a GP nor a CF. Only the questionnaire results of two stimuli went against this trend: *Venus* with the figure of the blindfolded Cupid (c), being considered less important by participants in the edited version, showing a decrease of 5.4%; and *Adonis*, where the sleeping Cupid (a) lost 3.4% in importance in the eyes of the viewers.

4. Discussion

4.1 Visual attention

It was assumed that the amount of time participants spent looking at GPs would increase or decrease in accordance with the CF's gaze direction, which would be evident in the dwell time analysis results for each GP. Expectations were that the dwell time would be higher in the original version and lower in the edited version for the GP1, with inverted results for the GP2. While the study could not prove a significant gaze cueing effect for every chosen stimulus, out of the ten, seven showed significant results for at least one GP at some point during the viewing task. For three stimuli, only the GP1 had significant changes in dwell time. For another three, both GPs were affected—however, with two of those, the GP1 was more strongly affected—and one stimulus had significant differences in dwell time for the GP2 only. To put it another way, of the seven stimuli with a significant difference in dwell time, six include GP1 and four include GP2. This suggests that the original GP is more affected by any change in the CF's gaze direction.

Two stimuli displayed a significant and congruent gaze cueing effect for up to one minute of viewing time. The obvious commonality between these two images is that they are both genre paintings, painted by the same artist, Georges de La Tour, that depict a social scene with a hidden deception woven into the visual narrative, which the viewer is encouraged to discover. The parallels between the two are striking and warrant further investigation, which will be discussed in detail in chapter 4.4. Concerning the first hypothesis, as 70% of the stimuli support the assumption that the gaze direction of the CF leads to a longer dwell time in the indicated area, it can be concluded that there is a clear, albeit a temporary, gaze cueing effect. This validates the first hypothesis.

4.2 Gaze following and joint attention

It proved more challenging to answer whether the gaze direction of the CF influences the gaze direction of the viewer, as assumed in the second hypothesis, with the same level of certainty. Only three stimuli produced significant results for the number of saccades following the direction of the CF. This leaves the second hypothesis neither unequivocally verified nor falsified, as a significant gaze cueing effect could only be proven for 30% of the stimuli. However, no significant results were found for non-congruent saccades. For the non-

significant saccade analysis results, the trend still leans strongly in favour of the hypothesis. Fascinatingly, during the analysis part of the study it was noticed that particularly strong dwell time analysis results appeared to foreshadow significant results for the saccade direction. Meaning that a highly significant increase or decrease in the amount of time spent looking at a GP, in accordance with the gaze cue of the CF, indicated that a congruent change in saccade direction would be more likely than with less significant dwell time analysis results. This is the case for all three stimuli that displayed significant saccade results: both GPs of the *Triple portrait* and *Isaac*, and the GP1 in the *Cheat*. For each of them, the dwell time analysis results of the affected GPs showed a particularly high significance in their differences between the two versions. While the time segments in which the significant results appear are not the exact same for the dwell times as for the saccades, they do overlap for all of the GPs.

The lack of consistent saccade analysis results throughout the ten stimuli, in comparison to the dwell times, raises an intriguing question: Are the two variables—dwell time and saccade direction—correlated because one influences the other? Logically, an increase in saccades going from the gaze cue to the cued target would raise the visual attention in that area, i.e. the dwell time in the respective GPs. This would account for the particularly high significance in dwell time for those stimuli with significant saccade differences. However, the results show that there are significant increases in dwell time for GPs, even when there can be no such effect found for the saccades. This means that it is not necessary for participants to repeat the gaze direction of the CF for the attention in the cued area to increase. The reason for this might lie with the underlying technical issues when it comes to how saccades are calculated. The eye makes scan paths, which are then converted to saccades by *DataViewer*, depending on if the “stops” in between are long enough to be considered a fixation or not.¹³⁷ This is a prevalent problem when working with saccades, as it means that longer paths can get broken up into a series of shorter saccades when the pauses of the eye are converted into fixations by the program. Taken together with the already mentioned fact that, compared to fixations, there are (at most) only half as many saccades being made in the time frame as there are fixations—as it takes two fixations to create one saccade—these factors could reasonably explain the diluted saccade results.

There is also the possibility that people are still guided towards the GP by the gaze cue, even without having to follow the exact same gaze path as the CF. Resulting in significant dwell

¹³⁷ Holmqvist/Andersson 2017, pp. 327–328.

time differences, which are not necessarily repeated for the saccade results. However, if participants performed the same gaze direction as the figure, in addition to the already increased attention in this area due to the gaze cue, the dwell time results would add up to the highly significant differences that can be seen for the three stimuli *Triple portrait*, *Isaac*, and *Cheat*. Looking at the present results, it appears that highly significant results in dwell time differences are associated with corresponding, albeit weaker, results in saccade direction. Without a follow-up study, however, it is not possible to say with absolute certainty, if there is a causal link between these variables, and if so, which one influences the other.

Considering the precariousness of some of the figures' edited eye lines, which is up to the viewer's interpretation to a certain degree, the lack of significant results for the saccades going from the CFs to the GP2s could also be partly attributed to this factor. Two stimuli appear to support this idea: *Isaac* and *Adonis* both present with significant saccade results for areas that could reasonably be understood as the CF's GP2. In Caravaggio's painting, this would be the knife with which the father is prepared to sacrifice his son, while for Titian's artwork, it is the upper arm of the doomed hunter that is in the eye line of the CF. It should be noted that this only appears to happen in the edited version. Given that the artists painted their subjects' expressions, including their gaze direction, with much more detail than could be replicated by simply mirroring and rotating the head, it is no surprise that two edited versions have created this effect. Taking the saccade results of the alternative GP2 into account and, 50% of the stimuli support the second hypothesis. Although the differences are still less pronounced than those seen in the dwell time analysis results, when the issue of interpretative eyelines is factored in, the saccade analysis results are more supportive of the assumption of the second hypothesis and tentatively verify it.

4.3 Changing perception

The third and final hypothesis anticipated that a change in attention and gaze direction would result in a different perception of the figures involved in the manipulation of gaze direction. Expectations were that whichever figure the CF looked towards would be considered more important to the depicted story by the participants. The questionnaire showed a dramatic shift in how participants perceived the figures. The results for the ten paintings indicate a clear trend: increasing and decreasing with the gaze direction of the CF. Eight paintings display an increase and decrease in at least one of the two figures that the CF is looking at, in neither version of the stimuli, as was expected. Five of those have a corresponding increase and

decrease for all areas looked at by the CF. Only two paintings show an opposite effect (*Adonis* and *Cheat*), where both looked-at characters increase and decrease in opposition to what would be expected. With 80% of the stimuli partially and 50% fully supporting the third hypothesis, it can be concluded that gaze direction in paintings indeed influences people's perception of the depicted scene.

As with the connection between fixations and saccades results, the two stimuli that scored the highest significance in dwell time and saccade direction, were most affected in perceived importance of their figures: *Triple Portrait* and *Isaac*. This suggests strongly that changing people's attention plays a role in how they perceive a depicted scene. It can be best seen in the *Triple Portrait*. The percentage for one figure halves, while the other triples, in accordance with the gaze cue of the third figure, which is highly suggestive of gaze cueing having a corresponding cognitive effect in how paintings are evaluated by the viewer. The answers were as expected, with the CF of the man giving all his attention to his female companion in the original version. Just as she was significantly looked at more by the participants, she is also considered to be more important to the story. The reverse is true for the edited version, in which the man gazes intently on the boy instead. The CF, the only part of the image that has been changed through editing, stays almost the same in participants' considerations, negating the concern that the image manipulation could draw more attention to the edited area. As theorised in chapter 2.1, participants did indeed consider the two figures most important that were linked through the gaze. In each version, the CF and his respective gazed-at companion were higher in perceived importance than the excluded third figure. This indicates that participants were pairing them up in their interpretation of the scene, depending on which one of his companions the man looked at. The questionnaire analysis results of the other nine paintings, just as was the case with the eye tracking results, are more heterogeneous, but nonetheless offer a fascinating insight into the way people interpret figurative images based on gaze direction.

The questionnaire answers of Titian's *Adonis* are puzzling at first, as turning his gaze away from Venus did not decrease the perception of her being important, but rather, it increased it. As it did for the CF of Adonis, while the impact the dogs play in the story, pulling him away to his impending death, barely changed in participants' minds. Contrary to what was postulated, the break of the lovers' intense gaze at each other seems to have created a heightened tension, resulting in the pair being perceived as even more essential to the unfolding events, as in the original version of the painting. The little figure of the sleeping Cupid, his inattentiveness to the scene a possible reminder that their love is in peril, showed a

drastic decrease in perceived importance—cut in more than half—in the edited version. This could hint that, by shifting the focus more towards the main couple and their quarrel, any further context of the narrative is not being considered as much as in the original version that the artist intended. Conversely, Titian's second painting from the *Poesie* cycle did confirm the initial proposition. Interestingly, both figures—her rescuer, as well as the sea monster he slays—lose the same amount of percentage in perceived importance. However, as the total number of answers for Perseus are higher, despite the same percentage for both, the results for the monster are more definitive. The CF, however, when she stands alone and turned away from the scene in the background, appeared to participants to be more important to the story. The questionnaire analysis results suggest that Andromeda's isolation from the narrative was deepened without her yearning look over her shoulder, which connects her directly to the fierce battle. This is also congruent with the significant increase in dwell time within the IA of the CF. For the artist's third stimulus, of *Venus* instructing one of her children while blindfolding the other, something unexpected happened: opposite of what was suspected, the Cupid on her shoulder increases in perceived importance by a very large margin when Venus is turned away from him. The placement of the two within the composition could be a factor here. The physical closeness of Venus and Cupid leaning on her shoulder connects them, even if she is turning her attention to the two nymphs attending her and her children. While for the eye tracking analysis, the faces of the two women were counted together as one IA, in the questionnaire, each had their own response option. More scrutiny on the differences between the two showed that it was mainly the nymph in the front that increased in perceived importance for participants (3.9%), and less the one in the back (1.9%). The edited gaze of Venus does appear to land more on the one first mentioned, indicating that people were influenced by her gaze direction in deciding who was more important in the painting.

The stimulus *Hercules* undoubtedly proves its prevalence in the literature. The hero's gaze towards a path of virtue and glory falls in line with participants considering the figure of Virtue to be much more important to the narrative laid out in front of them. In the edited version of the story, Hercules himself, as well as the poet sitting to his right side, are instead considered more important when the hero is gazing at Vice instead, while Vice herself loses slightly. The interpretation of the scene changed to put more emphasis on the hero himself. His inner conflict, as described by Shaftsbury,¹³⁸ appears much more pronounced when it is not yet certain that Hercules will choose the right path, due to his regard of Vice. The strong preference of the poet sitting at his feet as an important figure in the image is intriguing and

¹³⁸ Shaftsbury 1713, pp. 6–8.

could indicate that his contribution to the story—quite literally, writing the hero's legend into history—weighs more when Hercules' decision is not as clearly made as it is in the original version of the painting.

Caravaggio's depiction of Christ calling on Matthew shows congruent changes in perceived importance for both GPs. Considering the debate around who Matthew is supposed to be, it seems prudent to point out that, while the questionnaire results of the three men were counted together in *Diagram 58*, it was the figure pointing at himself—who, in the literature, is also more commonly accepted to be the title-giving apostle—that showed the most drastic increase in perceived importance in the edited version (*Diagram 64*). Meanwhile, the increase for the coin-counting boy was less than a fourth in comparison and the bespectacled man in the back displays almost no change at all. The results of the second Caravaggio painting, *Isaac*, also show a clear change in perception that correlates to the eye tracking results. The angel is suddenly not considered to be important as to the story anymore in the edited version, while Isaac is seen as slightly more important when his father looks at him. Intriguingly, this replicates the dwell time results, as it is also the same figure, the angel (GP1), that sees significant changes in dwell time, while the difference between the two versions for Isaac (GP2) is notably weaker. This shows that, while Isaac himself is clearly recognised as an essential part of the narrative, without the connection to the heavenly messenger through Abraham's gaze, the angel—who still clearly intervenes in the edited version by grabbing his wrist and pointing to the ram—is not being considered by the viewer as important to the story anymore, as they were in the original composition. It is also intriguing that the ram is being seen as drastically more important in the edited version. This indicates that viewers interpreted the replacement sacrifice as much more essential to the scene, maybe due to Abraham's missing realisation of his son's salvation, as it heightens the gravity of the scene.

The brutal scene of *Judith* followed the expectations postulated in the description of the painting: the figure of Judith—as well as the maid herself, albeit to a much smaller degree—increased drastically in importance. This supports the idea that the intense gaze of the maid transforms the scene into one where the two women are being considered more important to the story, while the actual indication of what happened, Holofernes' death, is passed over in favour of what is happening between Judith and her maid. Interestingly, the bloody head of Holofernes decreases in perceived importance to the story, which is congruent with the eye tracking results, as the IA decreases significantly in dwell time in the edited version as well.

Of the two de La Tour paintings, only the questionnaire results for the *Fortune Teller* show a change in perceived importance, as was expected. Notably, congruent results can be seen for the GP1, which is also the only GP that had significant dwell time differences. However, while the questionnaire analysis results for the accomplices on the right side do not follow expectations, the young woman between the man and the older woman are considered decidedly more important. As she is one of the pilferers lightening his purse, her part in the story seems of more consequence to the viewer when the robbed man notices the thievery. The unexpected questionnaire analysis results of the *Cheat* could be explained due to the servant and the cheating man being considered as a scheming pair, excluding the CF due to her gazing away from them, as both the CF and the GP2 lose importance in the eyes of the participants in the edited version, while the GP1 and the cheating man increase. Despite the non-congruent results, by changing the gaze direction of a single figure, the viewers' interpretation of the scene undoubtedly changed.

For six of the paintings, perceived importance increased or decreased congruently with an increase or decrease in dwell time for the GP1 or the GP2. The same is true for the saccade analysis results; however, it is not the exact same six paintings. Still, two stimuli showed a congruent increase and decrease in dwell time and saccade analysis results for both the GP1 and GP2: *Triple Portrait* and *Isaac*. Just as with the two variables of the eye tracking analysis results, dwell time and saccades, possibly influencing each other, so could be the interpretation of the figures' roles and their importance in the depicted story. Meaning that, by manipulating the gaze cue, either the perception of importance leads the participants to spend more time within the GPs, or the increased attention on the respective GP creates the perception of it being more important.

In summary, it can be said that the gaze cueing of the CFs not only influenced where participants focused their attention but also affected how viewers perceived the content of the image. While it is impossible to read a person's mind when they look at an image, through the method of eye tracking alone, the questionnaire answers are a strong indicator as to how the cognitive understanding of the visual story in front of them changes in accordance with a single gaze cue. Looking at these results, 80% of the stimuli support the expected effect of gaze direction on the perceived importance of figures within a painting. Most interestingly, the change in the answers of the questionnaire tend to mirror the shift in dwell time. Such is the case for 5 of the 9 GP1s (*Triple Portrait*, *Hercules*, *Calling*, *Isaac*, and *Fortune Teller*), 6 of the 9 GP2s (*Triple Portrait*, *Adonis*, *Venus*, *Isaac*, *Fortune Teller*, and *Cheat*) and 6 of the 10 additional figures, that were considered IAs (*Adonis*: Sleeping Cupid, *Venus*: Blindfolded

Cupid, *Hercules*: Pegasus, and Poet, *Judith*: Holofernes, and *Fortune Teller*: Woman).¹³⁹ The question left now is, did the fact that the participants looked at one figure more than the other result in them considering it more important? Or is it *because* one figure appears as more important due to the gaze cue, that it is then looked at more? Here is where this study starts to push against its own limits. It cannot be fully ruled out that participants already perceived the gaze cued GP as more relevant to the depicted scene during the viewing trial, thus resulting in the significant eye tracking results. However, as the questionnaire part of the trial—asking the question about perceived importance—followed the eye tracking part, it is more likely that most participants only consciously thought about this after the viewing. This means that the questionnaire results speak for the conclusion that being guided to certain areas through the gaze cueing influences participants to perceive the cued figure as more important. But, without an in-depth, qualitative interview, trying to answer this question conclusively will be difficult. What can be said with reasonable certainty is that, when looking at artworks, gaze direction and the perception of importance are undeniably linked.

4.4 Deviations

As brought up above, not all the ten stimuli confirmed the three hypotheses. The strongest significance can be seen in the dwell time results. There is also a clear tendency for the GP1 to show more definite results than the GP2. This discrepancy between which GP is more affected by the change in attention indicates that making participants pay attention to an “artificial” GP, opposite of what the artist intended, is not as easily achieved as simply taking attention away from the original GP. It raises the question: Why is it so much easier to distract the viewer from an important element within the composition of the painting, but directing attention towards another targeted area proves to be more challenging? It might very well be that there are additional cues built into the composition by the artist that account for the varying results. Since the scope of this study was narrowed down extensively, to shine a light on the gaze cueing effect of a single figure, it is difficult to say to what degree other parts of the composition played a role. It is an intriguing conundrum why some paintings elicit a stronger gaze cueing effect than others. To try and answer this riddle, it will be beneficial to take a closer look at the results of stimuli that had particularly strong results, as well as the ones that defied expectations, and find possible commonalities or differences. Examining why

¹³⁹ If only considering the first half minute of viewing time—which will become apparent why in the following subchapter, *The time element*—another IA, the backwards sitting boy in *Calling*, can also be counted as a seventh IA, falling in line with the questionnaire analysis results.

some paintings proved the hypotheses by behaving as expected, and some did not, or even showed counterintuitive results. Raising the question: What elements can positively or negatively influence the gaze cueing effect of a painting?

Number of faces

As laid out in the introduction, faces are highly salient for us and retain visual attention more efficiently than other visual targets.¹⁴⁰ There have been several studies that showed the undeniable attraction of human figures in paintings for the viewer, particularly faces¹⁴¹—even when instructed to perform a different task while viewing the image.¹⁴² To the point that any other parts of the canvas will get barely scanned over. A higher number of faces within a composition would therefore spread the visual attention among them, as more faces would take attention away from the three main IAs and scatter fixations. Fewer faces would mean a higher concentration of fixations in the relevant areas. The assumption that this variable consequently influences the degree of a possible gaze cueing effect appears to hold true, as the two stimuli with the highest significance in dwell time analysis results are both paintings with three human faces: *Triple portrait* and *Isaac*. While the lowest significance can be found in the stimulus with the highest number of faces: *Calling*.

The highest significance for the saccades can also be seen in *Triple Portrait*. Followed by *Cheat* and *Isaac*. All three stimuli have their strongest analysis saccades results in the saccades between the CF and the GP1. *Triple portrait* and *Isaac*, both paintings with three human figures and faces, also show some significance for the saccades from the CF to the GP2, but the results are weaker than for the GP1. The third stimulus *Cheat*, which shows one more human face, has no significant results in the saccades from the CF to the GP2. All other stimuli, which includes the paintings with four, five, and seven faces, have no significant saccade results at all. Supporting the idea that the number of human faces in a painting influences attention and gaze direction. The stronger dwell time and weaker saccade analysis results could indicate that the gaze direction appears to be more affected by the scattering effect of multiple faces. There is a caveat, however, as the three stimuli not showing significant results include the only two with only two human figures (*Andromeda* and

¹⁴⁰ Bindemann et al. 2005, p. 1052.

¹⁴¹ Massaro et al. 2012, p. 15; Villani et al. 2015, pp. 7–8; Kirtley 2018, pp. 60–61.

¹⁴² Flechsenhar/Gamer 2017, pp. 14–15.

*Judith*¹⁴³), and one with three (*Adonis*). It is noteworthy that both stimuli that have only one GP, in either the original (*Andromeda*) or the edited version (*Judith*), did not behave as expected. The reason for this disruption in the overall pattern of the results might be due to the missing second GP for the first two stimuli, as it could be seen with several stimuli that only one GP proved to be significantly affected. Additionally, the painting *Adonis and Venus* is the only stimulus that has non-human figures as one of the two GPs: the dogs in the edited version. It might very well be that animals do not hold the same saliency for the observer as human figures.¹⁴⁴ While this is a precarious idea, it stands to reason to at least consider it, as the other seven stimuli provided the viewers with a human figure for both GPs.

Size of figures

Based on how the number of faces in the paintings resulted in vastly different results, another element should be considered: the size of the figures. First and foremost, it directly influences the area a face occupies on the canvas. Naturally, larger faces present a clearer view of the eyes and thus the gaze direction of figures, as well as draw more attention due to their size on the canvas. Larger figures also allow for a lower number of faces than smaller figures within a composition, as they take up more of the canvas surface, directly influencing the above-discussed factor. Of the ten stimuli, six images show their characters in a $\frac{3}{4}$ - or half-portrait format, while four show them as full figures, which reduces the relative size the face and the eyes take up on the canvas. Two of the three stimuli with the weakest results are full figure paintings: *Andromeda* and *Adonis*. While of the six with larger figures and faces, five show significant results in dwell time. Of the four stimuli featuring full-figure compositions, only *Calling* and *Hercules* were found to elicit significant changes in viewing behaviour. Between these two, *Calling* had the lowest statistically significant dwell time differences of all GPs. As discussed above, this is likely because *Calling* has seven human figures and therefore more faces than any other painting in its composition. This combination of full figures and a high number of relatively small faces reduced the gaze cueing effect. The paintings with opposite qualities, fewer faces that occupy a larger area of the canvas, on the other hand, have the highest significance in their dwell time analysis results: *Triple portrait* and *Isaac* both show half figures, with the faces taking up a large area of the paintings. In both paintings, the eyes and gaze direction of the figures are clearly visible. The tendency seems to be that, in addition

¹⁴³ The stimulus of *Judith* shows two human figures, but three faces, as the severed head of Holofernes can also be counted as a third face.

¹⁴⁴ See Alexander et al. 2024, p. 4.

to the number of faces, larger figures—and thus larger faces and eyes—directly impact the gaze cueing effect. Considering that a smaller area means the percentage of time spent on the figures and faces is reduced, it follows that the viewer scatters their time more throughout the painting.

One outlier, *Judith*, is the only $\frac{3}{4}$ -figure painting without a clear gaze cueing effect that also shows only two figures. However, it should be considered a special case, as a third face can be seen: that of the dead general Holofernes. Gentileschi's depiction of the biblical heroine with the severed head of her people's oppressor is not completely unaffected by the change in gaze direction, however. The IA of Holofernes' head received significantly less attention in the edited version, where the maid is intently looking at Judith instead of outside the painting's frame. It appears surprisingly late in the viewing time, at the 45 and 60 second viewing periods, with the *p*-values getting smaller—and thus the significance increasing—towards the end instead of dropping off. No such effect can be found for either the CF or the GP2. When looking back at the percentage of time spent in the three IAs, it becomes clear why this might be the case. The severed head of the Assyrian general attracts the most attention from the participants throughout the entirety of the viewing period. It can be explained by the exceptionality of the brutal scene, which could have caught most viewers unaware. Resulting in a high amount of overall attention spent in this area of the painting, overwriting any cueing effect the maid's gaze direction might have had otherwise on the GP2 of Judith. However, some influence must be there, as the head is significantly less looked at in the edited version. While the *p*-value only shows a significance at 45 seconds and onwards, the full dwell time data shows that this trend already starts around the 15-second mark. There is also the fact that, at 15 seconds, the analysis results for the saccades going from the CF to the GP2 are very close to a significant result, congruent to the gaze direction. Despite barely missing the threshold of 0.05, the gaze cueing effect can clearly be seen. This indicates that while this stimulus defies expectations, it still shows that the change in gaze direction, from an undefined point outside the canvas to Judith, creates a disturbance in the viewer's attention. Arguably, because by making the maid gaze at Judith, instead of looking out for the soldiers who might arrest her and her companion, it shifts the attention from the women working together to survive, to a tense moment of disagreement between the two women. It takes the focus away from the central indicator (the head) of the important event that precluded this moment in the story: Holofernes's death by Judith's hand. This example shows that the simple change of the gaze direction of a single figure can fracture the composition, possibly even impede the viewer's understanding of what is happening between these figures.

Turn of the head

After considering the effect of size and number of faces, another obvious factor must be mentioned: the congruent turn of the head. Even a slight horizontal turn of the face can change the perception of the gaze, despite the eyes being unchanged.¹⁴⁵ As every painting used in this study showed the CF's head in at least a very slight turn, nine of them in accordance with their gaze, it must be assumed that it had a positive influence on the gaze cueing effect, as a congruent turn of the head increases the clarity of the gaze direction.¹⁴⁶ Resulting in a compounding effect on the viewer.¹⁴⁷ This would mean that the stimuli with the most extreme head turn would show the clearest results. Of the stimuli used, *Triple Portrait* and *Andromeda* both show the CF in a profile view. The CF in *Judith* also appears in a near profile view. While the *Triple Portrait* strongly suggests a cumulative gaze cueing effect of the gaze and head direction, the other two stimuli are less supportive of this. Their dwell time and saccades analysis results do suggest a trend towards it but did not show any significant differences. This makes it difficult to determine to what degree the effect of a congruent head direction did influence the gaze cue, as an extreme turn of the head could also have reduced the accuracy with which participants determined the gaze direction.¹⁴⁸ The dark shadows on the face of *Andromeda* could also have made it difficult to determine her eyeline. Looking at the six other paintings that show the CF in less extreme angles, but still clearly congruent with the gaze direction, five of them were proven to have significant dwell time analysis results for at least one GP. Only the stimulus of *Adonis* did not. This indicates that a moderate turn of the head that corresponds with the gaze direction can act as amplifier.

Carracci's *Hercules* is the only stimulus where the CF is facing the viewer almost directly while still glancing to the side. But even here, the head is at a slight angle.¹⁴⁹ However, it is non-congruent with his gaze, as the left side of his face is ever so slightly turned towards Vice. Yet, for both GPs, a significant dwell time difference was found. The frontal view of the CF's face makes it very clear where the hero is looking towards, as the pupils are well visible. It is likely that, as the non-congruence of the head turn is so slim, rather than having a subduing influence, it was overridden by the stronger influence of the gaze cue.¹⁵⁰ As none of

¹⁴⁵ Wollaston 1824, pp. 250–251.

¹⁴⁶ Cline 1967, p. 50.

¹⁴⁷ Klutetz et al. 2009, p. 1990.

¹⁴⁸ Ibid., p. 1987.

¹⁴⁹ Using only paintings with the CF's face looking straight ahead was considered but ultimately decided against, as it would have severely restricted the stimuli selection. This is because the type of painting typically showing a directly forward-facing figure tends to be a portrait and can only rarely be seen in narrative or genre paintings. See Dukewich/Klein/Christie 2008, p. 2 of the supplementary material.

¹⁵⁰ Perrett et al. 1992, pp. 25–26; Langton 2000, p. 838.

the stimuli displayed a distinctive, non-congruent head turn, a conclusive juxtaposition is not possible due to not having a control group for this variable. Considering the significant eye tracking analysis results, in combination with the unambiguity of the gaze direction, which is reinforced by a head turn, it does support the assumption that, by also editing the direction of the head, significant eye-tracking results occur. The idea of a congruent head turn aiding in a better identification of the target is further supported by the questionnaire analysis results, which show that affirmative answers for GP1 are more often in support of the gaze direction. This could be due to the original turn of the head tending to be clearer where the focus point of the CF lies than the edited one, where some imprecision had to be accepted.

Background saliency

Aside from the more apparent distractions concerning the depiction of the faces in a composition, another variable throughout the paintings is the difference in the backgrounds, which also seems to have an influence on the gaze cueing effect. Except for *Judith*, most of the paintings with a unicoloured or very reduced background (*Triple portrait*, *Fortune Teller*, *Cheat*, and *Calling*) tend to show stronger results compared to the five paintings with more detailed backgrounds. Of those, *Adonis* and *Hercules* are arguably the two with the most details, while *Isaac*, *Andromeda*, and *Venus* have less intricate backgrounds and details. *Isaac* also utilises a strong chiaroscuro, veiling most of the details, as well as a large part of the landscape in the background, in darkness. A strong argument can be made that the salience of backgrounds and other details distracts the eye from the main figures in the composition. Thereby reducing their share of attention, resulting in a less pronounced or no gaze cueing effect at all. The more details there are to see and understand, the less time can be spent on the CF and the GPs. Additional compositional elements, such as attributes, detailed landscapes, and animals, would distract from the attention placed on the main figures. Having fewer such details would concentrate the viewer's attention within smaller areas.¹⁵¹

Stimuli with fewer visual distractions (i.e. fewer figures and background details) did indeed tend to show a larger difference in dwell time. In combination with the number of figures and size of their faces, it is unsurprising that the *Triple Portrait*, with its small black background area and few details aside from the clothing, has proven to be the stimulus with the clearest and strongest gaze cueing results for the dwell time, as well as the saccade analysis results. This can also be seen when looking at the overall heatmaps of this painting (*Figure 17 &*

¹⁵¹ Alexander et al. 2024, p. 9.

Figure 18), where almost nothing but the faces was looked at. Only the whites of the central man's undersleeves, poking through the slashing and the area around the front closing of his doublet, show up in the heatmap. This painting is also unique among the ten selected stimuli regarding content, as the artist is solely focusing on the three figures and their relationship to each other. The background is almost completely black, even their clothes are dark and rather reduced in detail compared to the other images in this study. Additionally, the faces occupy a large portion of the canvas, due to the half-portrait style of the painting. This creates a larger area for the IAs and automatically increases the possible number of fixations. There are no distractions from the three figures. There are no distinctive attributes visible and no additional information is given to the viewer. If one wants to understand the meaning of this painting, the three figures and their relation to each other are the key. While in the original version the painter emphasised a connection between the man and the woman by positioning him in a way that he is looking intently on her, the edited version reverses this and creates a relationship with the boy on the right instead. Either way, the object of the man's attention is not paying him any attention in return. Both the woman and the boy are looking outside the frame of the painting, ignoring him completely. This was ideal for the purposes of this study, as neither of the two GPs is looking back. Consequently, only the CF's gaze indicates any direction the viewer should follow within the painting. As shown in the statistical results for the dwell times, the GP2 has the highest degree of statistical significance of every GP, of all stimuli, over all possible viewing periods, at the 15-second period, with a p -value of 0.001. Reinforcing this even more is the fact that the GP1 stands at the third highest place overall, at 20 seconds, with a p -value of 0.0026. Especially when compared to the less consistent trends in dwell time distribution for the CF, which shows no statistical significance at all. This means that this IA was not affected by the change of its gaze direction. Whereas the areas he looks at increase and decrease in attention paid to them by the participants depending on his gaze cue. This provides the strongest support for a correlation between the gaze direction in a painting and the gaze direction of the beholder.

Caravaggio's *Isaac* also ranks very highly in significance, with the second strongest overall results of dwell time at 20 seconds, with a p -value of 0.001. The saccades between the CF and the GP1 are also highly significant from beginning to end, with only two of the time segments not meeting the significance threshold of 0.05. The difference in percentage of saccades going towards the figure of Isaac is higher in the edited version, but not significant. However, saccades from the CF to the IA of the knife that Abraham is holding are significantly more often performed at 25 seconds, when Abraham is looking down at his son. Since his gaze

direction could easily be interpreted as being towards the knife instead of the boy, it is likely that people following the gaze of Abraham understood it as him looking at the knife in his hands. This would also correlate with the increase in dwell time of the knife in the edited version, despite not being significant. While not as drastically reduced in detail as the *Triple portrait*, the composition in this painting has fewer distractions in the form of detailed fabrics or backgrounds, and fewer human faces, compared to most other stimuli in this study. The extreme contrast between light and shadow accentuates the faces, increasing their saliency even more in comparison to the background, which results in a highly significant gaze cueing effect.

The high salience of the background details could also account for the non-significant results of *Adonis*. In combination with the relatively small size of the characters' faces, the gaze cueing effect in this painting was not strong enough to elicit a significant change in viewing behaviour from participants for the dwell time and saccades within the three main IAs. However, one aspect of the saccade results was peculiar enough to look deeper into it: saccades from the CF to the area around Adonis's upper left arm were performed significantly more often in the edited version, at the very beginning of the viewing period. This is followed by a significant increase in saccades going from the IA of the arm to the GP1 of Venus in the first 10 seconds. Finally, for the entirety of the viewing time, saccades from the GP1 to the GP2 of the dog are continuously significant. Similarly to the above case of *Isaac*, there is a possibility that the gaze of the CF was interpreted as going towards his arm, or the eye simply stopping there when following his gaze towards the dogs, as the rope with which he holds the dogs is tied around his upper arm. By following the path of the saccades further, accounting for the extra stops, it finally lands significantly more often within the GP2 in the edited version. The saccade direction did thus follow the CF's gaze, just in a more indirect route, as was expected.

Considering the varying results depending on the stimulus, the combination of these four variables—number of faces, size of figures, head turn, and background saliency—can explain much of the differences in the degree of gaze cueing between the paintings. However, when examining the saccade results more critically, another factor must be considered: the spatial location of the figures within the composition. The impossibility of finding paintings with the same relative distances between figures hinders direct comparison. However, the tendencies of the saccadic eye movements become clearer when the figural composition is factored into the discrepancies between the results.

Position of the central figure

The line diagrams for the dwell times show that, for four of the seven stimuli with significant results, only one of the two GPs has significant differences. A similar, albeit much weaker, tendency was found for the saccades: even if none of the saccade results of either GPs were significant, at least one GP showed a visible effect in the visualisation through the line diagrams. Which GP is particularly affected by the gaze cue appears to depend on how closely the two GPs are located to the CF. This would also account for the scarce results of the saccade analysis. The results suggest strongly that the further the GP is from the CF, the fewer direct saccades made between them will be made by the viewer. Not only the distance itself is a problem, but also the existence of salient areas (additional faces, background details), that show up along the scan path between two faces, which have already been discussed above. It seems reasonable that the eye might get stuck on one of those, breaking the scan path up into more saccades and obscuring the results. This appears to happen in the *Cheat*, where an additional figure is placed between the CF and the GP1. Interestingly, it is the only painting with a compositional aspect like this, and the only stimulus that does not show any significance in dwell time until the full viewing time. The late appearance of this, especially in comparison with all other stimuli, indicates that something is impeding the gaze cueing effect, delaying it towards the end.

The position of the CF for most paintings is somewhere in the middle of the canvas. The exceptions to this are *Andromeda* and *Venus*. While the latter of the two still has a GP to the left side of the CF, to where the eye of the beholder can follow, the figure of Andromeda is placed to the far-left edge of the canvas, with nothing between her and the frame of the painting. This means that, in the edited version, she is looking somewhere outside of the canvas, to where the viewer's gaze cannot follow. However, what was found in the statistical analysis is that the IA of the CF of Andromeda herself is looked at more in the edited version. Suggesting that, if there is nothing to follow, the participants' attention stayed focused within the area of her face, instead of futilely trying to follow towards where she is looking. It is also very likely that many saccades go missing between further apart areas in a painting. The longer the potential path between two fixations, the higher the likelihood of this occurring. For example, if the CF and the GP are positioned on opposite sides of the painting, the less likely it is for saccades between them to produce strong results. Even if the viewer makes a direct connection between two IAs but naturally has a few fixations over a longer scan path, the eye movement between the two IAs will not be considered a saccade by the program if the duration of the pauses meets the threshold of a fixation. Additionally, longer saccades occur

more frequently in the initial viewing period, decreasing in length over time, while fixations are shorter in duration at the beginning and longer towards the end.¹⁵² This makes a thorough analysis of saccades more difficult than for fixations. Therefore, it is imperative to consider these factors when examining the distribution of saccades, as this is very likely to result in less usable data than fixations. However, this also means that any significant saccade results are particularly meaningful in the context of this study's research focus.

Meanwhile, saccades between CFs and GPs that are very close together tend to show the least difference between the two versions, as can be seen in *Adonis* (GP1), *Venus* (GP1), and *Calling* (GP2). In all these three stimuli, one GP is considerably closer to the CF than the other. This means that the viewer only needs to make very short saccades to connect them. While the other GP is much further away, making longer saccades is necessary to establish a link between them. When two faces are pictured right next to each other, the eye of the beholder will likely jump back and forth between them, simply because of their proximity, regardless of where their eyes are looking. This leads to in very similar results for the saccade distribution between them, making it difficult to see an undisputable gaze cueing effect in the percentage of saccades performed. However, as longer saccades are performed less often, particularly after the initial viewing period, having results that show a clear difference for the GPs further away is noteworthy, even if the differences are not quite big enough to be considered significant. Considering this, it follows that there is an area where the distance between the IAs is ideal for the emergence of a gaze cueing effect.

The stimulus *Triple portrait*, which has by far the highest significance saccade results, further emphasise this argument, as the three heads are positioned relatively closely to each other, without any distractions between them. Furthermore, the CF is positioned in the centre, with the two GPs in equal distance in their respective version of the painting. The saccadic eye movements reveal a clear gaze cueing effect throughout the full trial period for the GP1 and, to a slightly lesser extent, also for the GP2. This gives weight to the idea that the position of the CF relative to the GPs—together with a small number of human faces, larger figures relative to the canvas size, and a clear composition with a low background saliency—reduces the possibility of missing saccades.

¹⁵² Antes 1974, pp. 65–66; Over et al. 2007, pp. 2277–2278.

The time element

As shown in the beginning of chapter 3, for the full viewing period, no significant differences in dwell time distribution could be found in the GPs results of eight of the stimuli. However, the results become much clearer when looking at the progression over time. The line diagrams, separated in 5-second and 15-second intervals, illustrate how the dwell times diverge between the two versions of each stimulus, increasing and decreasing during the 60 seconds of viewing. Concerning the dwell time analysis results, no IA shows a consistent, significant change throughout all time segments. The significant differences do not arise at a concise time throughout all stimuli. However, it can be observed that most GPs have most of their significant results within the first half minute of viewing time, but rarely in the first 5 seconds (the exception being *Hercules*). With the biggest effect of gaze cues on the attention of the participants starting around the 10- and 15-second marks, while the first few seconds tend to be more similar in the distribution of dwell time in the GPs. Indicating that the gaze cueing effect takes around 10 to 15 seconds to have a statistically significant influence on the viewer, with the highest levels of significance for most stimuli being between 15 and 25 seconds. While some IAs show a lingering effect after that time frame (particularly the GP2 in *Venus*, which stays significant until 45 seconds), there are only two stimuli that have no significant event within the first half minute of the trial: the GP1 in *Cheat* and the GP1 in *Fortune Teller*. The first one proves its first significance at 30 seconds and onwards, while the other is *only* significant at 60 seconds. Most interestingly, both IAs are a GP1—meaning they are the original gaze point of the CF—and both paintings are by the same artist, Georges de La Tour. Looking at the line diagrams, both can be observed to display a noticeable trend for an early gaze cueing effect that, while not significant, shows significant differences during the latter half of the viewing time. This means that even in the beginning, there is more attention placed on them, and it increases to significant levels at or after 30 seconds.

This peculiarity raises the question: why does this viewing behaviour occur specifically within these two paintings? The similarity between them goes beyond the stylistic aspect of being created by the same artistic hand. For both paintings, La Tour chose an intriguing topic: deception and trickery amongst a group of people, with all of them working against one unassuming victim. The artist shows the viewer the deceit happening but hides it well within the composition. This results in the beholder having to spend some time looking at the scene to comprehend the situation, which could explain the delayed response to the gaze cues, as can be seen due to the late occurrence of significant dwell time differences.

The findings suggest that it takes a certain amount of time for the viewer to decode the painting and for the gaze cueing effect to unfold, which also depends on the painting's motive and complexity of its depiction. After that initial viewing period, for most stimuli, the effect disperses. This strongly suggests that, after the first half-minute of viewing time, the eye of the viewer is less influenced by the subtle suggestions of the image through its gaze cues and behaves in a more individualistic viewing pattern. This results in a decrease in difference in dwell time between the two versions in the second half of the trial.

One obvious explanation for this effect is that, after a certain amount of time, everything that has been considered important in the image by the participant they have already looked at and feel no need to pay further attention to. It also strongly indicates that the gaze cue influences the viewer as to what area of a painting is initially thought of as more interesting. Naturally, after paying particular attention to it at first, it then loses the strength of its appeal. This gradual drop-off appears to start around 20–25 seconds. After a half-minute of viewing time, the initial draw of the gaze cue seems to have disappeared for most of the paintings. Following that viewing period, one would naturally draw their focus more towards whichever area has not been given much consideration before. Wherever in the image this would have been for the individual, if the rest is then also given attention, at the end of the trial the distribution will look more similar between any two participants, regardless which parts of the paintings were looked at first and which ones last. This viewing behaviour would even out the distribution of dwell time throughout the stimulus over the full viewing time of one minute, just as it can be seen for most of the chosen stimuli. It therefore seems to be of particular importance for the subject of this study to underline the results of the first half of the trial. These findings are also supported by Yarbus' discovery of repeated viewing patterns after 25 seconds, where he postulated that, after looking at the important parts of the paintings—however, in this case, important as in pertaining to the question posed to the participants beforehand—participants tended to circle back to the beginning again.¹⁵³ In this study, this cycling back behaviour is not as clear, as it was not focused on in the analysis but the visual attention within the first 25 seconds suggests a similar underlying cause. The difference between Yarbus' results and the present ones is that, for this study, participants were instructed to look at paintings as they would in a museum and were therefore not influenced by a question that asked them to figure out something about the story of the painting. This very likely resulted in a more neutral setting, and thus a more natural viewing behaviour, than it was the case for the study conducted by Yarbus.

¹⁵³ Yarbus 1967, p. 195.

Due to the individuality of each painting, the absolute height of the gaze cueing effect happens at different times during the viewing. However, it is important to note that, for most of the IAs, the highest rate of overlap of significant dwell time analysis results occurs at the 20-second mark. Just as there were two outliers found towards the end of the viewing time, one exception can also be seen at the very beginning of the viewing time in the stimulus of *Hercules*. While both GPs prove to have a significant dwell time event, it only occurs at the first 5 seconds, with the GP1 holding out until the 10-second mark, before the results align for both versions. Carracci's painting can be considered a special case, as none of the other nine stimuli show significant dwell time analysis results for either of their GPs that early in the viewing period. There are several reasons for this painting's singularity. First and foremost, as the CF of Hercules is located perfectly in the middle of the canvas, participants are already fixating on it from the very start, as the black drift correct cross is also placed in this exact area of the screen, reducing the time it would take the eyes to find the central character of the depicted story. It is also the only painting in which the head position of CF is frontal to the beholder. The digital flipping of the head to change the gaze direction resulted in no change to the head position. The only noticeable change is the side from which the light source is illuminating the face. This means the head direction had little influence on the cueing effect for this painting, as it likely did for all the stimuli, as already pointed out above. Considering that a congruent head position supports the gaze cueing effect, one would assume that the results for this image would therefore be diluted. However, it appears that the effect is not completely subdued, but instead simply dispersed more quickly. Since Carracci's painting was the initial starting-off point of this study, it is fitting that it is the only painting that displays an *immediate* gaze cueing effect for both versions of the stimulus. These findings must be highlighted, as the importance of Hercules' gaze direction has been pointed out by authors for centuries, validating the writings of Shaftsbury and Panofsky on the subject when they assert the direction of the hero's gaze as an indicator of what's to come in the unfolding narrative.

An argument can be made that some stimuli could have seen clearer results with a longer viewing time. Despite the trend that a gaze cueing effect appeared most often in the first half minute of the trial, it was not exclusively so for all stimuli, as can be seen with the two paintings by Georges de La Tour, as well as *Judith*, where the head of Holofernes is the only IA that shows a significant difference from 45 seconds onwards. It strongly suggests that, for some images, it may take more time for any gaze cueing effect to unfold. The results of stimulus *Adonis* also tentatively support this tendency, as the GP1 starts trending more

towards set expectations in the end of the full viewing period, suggesting that further experiments on the topic could benefit from a longer viewing exposure. In the case of *Andromeda*, it is not as certain, as the GP1 increases in dwell time even more towards the end, opposite to what would be expected. Suggesting it would only increase more with a longer viewing time. It might be more revealing for the GP2 in *Judith*, where the back and forth in difference between the two versions stays undecided at 60 seconds. A longer viewing time could show a clearer leaning towards one of them.

It can be surmised that the time spent looking at an image, in combination with the individual elements of the stimuli, determined if and how strongly the results supported the first two posed hypotheses. Paintings with more figures and a higher saliency in the background details proved to create more diverse viewing behaviours, which resulted in less focus on the main figures. This, in turn, reduced the gaze cueing effect and the level of significance in differences between the two versions of the stimuli. Guiding the eye towards certain areas then translates into a change in perception of the figures. It was also found that the influence of gaze cues is also concentrated within a very limited, often initial, period during the viewing time. If given more time to observe a painting, participants will also look at the areas not indicated by gaze cues. This finding leads directly into the last, and already anticipated, question this thesis asks: if the gaze cue of a figure has only a short-term effect on the beholder when it comes to eye movement patterns, can it still change people's understanding of the paintings' narrative? While this query can only be partly answered, as an in-depth, qualitative interview would be required to reveal a deeper understanding of people's interpretation of the depicted scenes, the answers given in the questionnaire after the viewing task strongly suggest that the perception of importance given to a figure within a painting can be shifted by changing the gaze cue. It would be of great interest to explore this effect in more detail. Particularly, how this translates to the individual understanding and interpretation of the paintings by each participant, to discover if and how the way the scene is interpreted changes in correlation to individual viewing behaviours.

The findings of this study are reflected in the fact that, for each analysis—dwell time, saccade direction, and perceived importance—the stimulus *Triple Portrait* has shown a clear influence of a gaze cueing effect on the viewer. The painting is the prime example that affirms all three hypotheses, being the stimulus with the strongest results in each analysis. However, in their differing results, the other stimuli are equally as important to show as to *why* exactly this

painting verifies the hypothesis that a gaze cueing effect exists in figurative paintings and plays an important part in the interpretation of the depicted stories. It is this question of why that this study was built around to give an answer to and create new avenues of analysis into complex narrative compositions and how paintings can influence the visual and interpretative perception of their beholder.

4.5 Limitations

Due to the time restraints of this thesis, the scope of the study had to be reduced to the essentials to be manageable in the time given. The relatively small number of stimuli can only give us a first insight into trends that hopefully can be investigated further in the future with a study on a larger scale, including more stimuli from other time periods, artists, and genres. Ideally, further research into gaze direction might also benefit from including a control group of stimuli with only the eyes mirrored horizontally. As this is only achievable with straightforward-looking faces, it was not possible here. To achieve a seamless manipulation of the image that would avoid people noticing the edited part, the entire head had to be flipped horizontally. Another factor limiting the results that could be included here was the time-intensive process of data analysis. Several forms of analysis were approached and concluded but could not be included here. Such as a closer scrutiny of the saccade results, especially returning saccades going the opposite direction. IAs were also created using a bottom-up method that could not be fully finished due to time restraints but might hold even more insights into the gaze behaviours of participants compared to the hand-drawn IAs. Lastly, the results of the questionnaire were not run through a *t*-test, like all other results, and should therefore be considered with more scrutiny. Considering the uniqueness of every painting, it is almost certain that there are even more factors that could possibly influence the viewing behaviour of people than have been discussed in chapter 4.4. For instance, how many figures are directing their gaze towards the same area. Ideally, a second study including more stimuli categorised in more rigid groups of complexity that were discovered through this study and were outlined in the discussion of this paper (number and size of faces and figures, background saliency, spatial composition), as these variables were found to strongly influence the viewing behaviour in the present study, in combination with a longer and randomised questionnaire, would help verify these first results on the subject of gaze direction in paintings, and hopefully also expand on them.

Conclusion

The purpose of this study was to dive into a so far mostly overlooked aspect in the perception of narrative paintings: the influence of gaze direction within a figurative composition on the viewing behaviour and interpretation of a scene by the beholder. Concerning the first part, the two most fascinating insights this study revealed are the roles that viewing time and image saliency play in the intensity of the resulting gaze cueing effect. There is a strong indicator that the length of viewing time is a main influence on the impact a gaze cue has on the viewer. The dwell time analysis results support the first hypothesis, with a moderate to strong gaze cueing effect in the early viewing period of up to 25 seconds for 70% of the ten chosen stimuli. This verifies the idea that gaze cues in paintings have an initial influence on the viewing behaviour of the onlooker. The remaining 30% showed that the change in gaze direction of the CF still had a measurable influence, even if not significant. Furthermore, all of them had some significant changes in dwell time in other areas, as many stimuli also showed significant changes in dwell time in areas other than the GPs, with the significant results showing up overwhelmingly in the first 25 seconds, as well. Either the CF (*Andromeda* and *Adonis*) or another area (*Adonis* and *Judith*) in the composition, which—while not happening in the areas of the stimuli that were presumed—still indicate that gaze direction in the composition has a quantifiable influence on where in a painting the viewer spends more or less of their visual attention. The overall trend of a lessening gaze cueing effect over time shows how and when individual viewing patterns overtake the visual guide on where the viewer should place their attention that is being suggested by the gaze direction that the artist originally chose. Even the clearest gaze-based guidance will lose much of its persuasiveness after a certain time. However, while the viewer's attention cannot be held in a single area for an unlimited time, there is a lasting effect on the interpretation of the painting. As well as an intriguing correlation with the path the eye takes through the painting, as can be seen in the saccade analysis results.

The direction of the viewers' gaze path was the central issue of the second hypothesis, which was regarding the assumption that participants would follow a figure's gaze cue by mirroring the eye movements with saccades going in the same direction. This turned out to be harder to prove without any doubt, as the saccade analysis results paint a more diverse image compared to the dwell time analysis results. In contrast to the attention given, which is measured through the dwell time, the change of the participants' saccade paths, in line with the figures' gaze direction, happened for fewer of the stimuli. However, for those that had significant

results, it was more likely to be so throughout most of the trial and not confined to the first 25 seconds, as clearly as it was for the dwell time results. This indicates that the performance of saccades influenced by the direction of a gaze cue is not as restricted by the viewing time. While the general attention, measured through the dwell time, is being pulled away after a short time, if the gaze cue is strong enough to elicit a significant change in saccade direction, the repetitive saccade behaviour stays more constant relative to the dwell time. Or it might simply take a longer time to fade than the given trial period of 60 seconds once it is triggered in the beholder. This might happen due to the eye following the same path repeatedly but with less time spent in the already looked-at areas. This can be seen in the GPs, which only show significant dwell time events in the first half of the trial but have significant saccade analysis results consistently throughout the full trial, such as the angel (GP1) in *Isaac* and both GPs in the *Triple Portrait*.

The fundamental issues with the analysis of saccades have been pointed out in the chapter above. But, as some stimuli verified the second hypothesis, discerning why this still happens, despite so much working against it, appears to be crucial for a broader understanding of the issue. To pursue this, several different formal aspects of the ten stimuli were looked at to see if commonalities could be found among them. The key findings from the results are how background saliency, number of faces, gaze-congruent head turns, and position and size of figures can factor into the gaze cueing effect that can be measured in the form of saccades, as well as the dwell time. The fewer distracting elements are present in the painting, the more the gaze of the depicted figures factors into the viewing behaviour of the onlooker. This happens due to the lack of other salient areas, such as additional figures and faces, attributes, and detailed backgrounds, which, otherwise, would draw the viewer's eye away from the central figures and the object of their gaze. This also ties directly into the time aspect. The clear tendency for the gaze cueing effect to present itself early in the viewing period for the dwell time analysis results and subside after 25 seconds, to the point of not being significant anymore, is likely due to the participants' eyes being drawn to other parts of the painting, whether salient or not. Looking at the same figure for more than that period, without also examining other areas, would be a highly unnatural viewing behaviour, regardless of the stimulus. This conclusion of the results is supported by the fact that it was two paintings, with very few distractions, a dark background, and only three human faces taking up much of the canvas, that had the highest significant dwell time and saccade analysis results: *Triple Portrait* and *Isaac*. These stimuli also show a possible correlation between significant saccade analysis results and a very high significance for the dwell time results. The limitations of the

study set-up do not make it possible to determine if there is a causation between these two variables, and if so, which one influences the other. The results were unexpected but make a compelling case for further study into their intercorrelation. Identifying whether highly significant dwell time differences predict saccade behaviour, or if the significance in saccade analysis results is followed by a particularly high significance in the dwell time analysis, could reveal more about the intricacies of joint attention in the perception of artworks.

With the viewing behaviour part of the hypotheses conclusively answered, the second main insight into the perception of gaze in paintings is revealed by the questionnaire results. Eye tracking results can only give answers pertaining to any shifts in visual attention, but less so concerning possible changes in the interpretation of the depicted scene. Most of the answers given in the questionnaire reflect the change in gaze direction, which is a strong indicator that visual attention translates into how a figure is perceived within an image. If the eye is guided towards a certain figure or area by the gaze cue, the perception of that figure or area shifts congruent with the CF's gaze. Even in instances where the results do not follow the expectations, it is undeniable that gaze direction can change the perception of a scene and is therefore an essential element in the composition. As can be seen in the change in consideration of other figures. The discovery of visual attention and perception, not only both being influenced by gaze cueing but also possibly influencing each other, is strongly supported by the overlapping results of both analyses. With the clearest and most persuasive results belonging to *Triple Portrait* and *Isaac*. Considering that these two stimuli come up as the leads in every type of analysis in this study is remarkable and speaks to the significance that compositional elements play in their perception.

With the discovery of all these many moderating factors, it is particularly fascinating that Carracci's *Hercules at the Crossroads*, despite much working against it in its formal composition—i.e., full figures, additional faces, a non-congruent head turn, a highly salient background, and an abundance of details—still displays how strong the influence of gaze can be on the viewer's viewing behaviour and perception of the painting. As it was this painting whose story sparked the first inkling of this study, it is particularly fitting that it is the only one that proves an immediate, congruent, and significant gaze cueing effect within the first five seconds for every GP. As well as a significant difference for all other IAs, apart from *Pegasus*—although it still shows a clear influence, even if not significant. Furthermore, the fact that these eye tracking results translate into a congruent shift in perceived importance for nearly every figure in the painting gives much weight to Shaftsbury's assertions on how the depiction of Hercules' choice is aided by his regard for either of the two allegories. As he

rightly postulated over 300 years ago, it was indeed the position of the undecided hero's eyes that told the viewer where to focus their attention and which of the two paths before him will shape his future. Hopefully, these results will encourage future art historical research to consider gaze and gaze direction as an important compositional element in the field of image analysis. It was proven that not only the visual behaviour and eye movements of the beholder but, most importantly, the cognitive perception of the painted story can be altered with something so essential as the direction of a pair of eyes.

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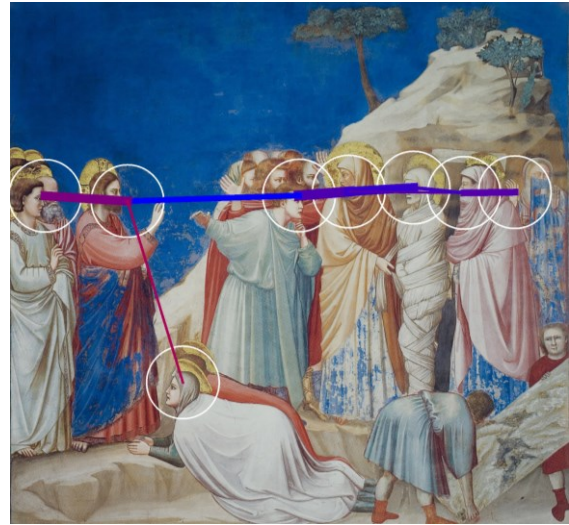


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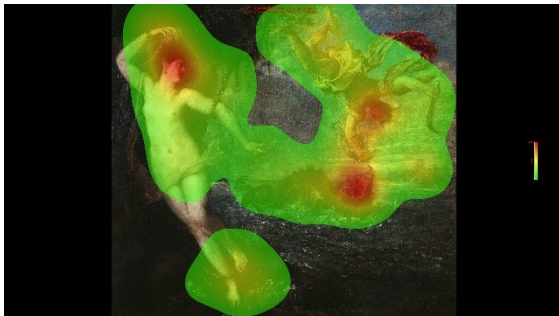


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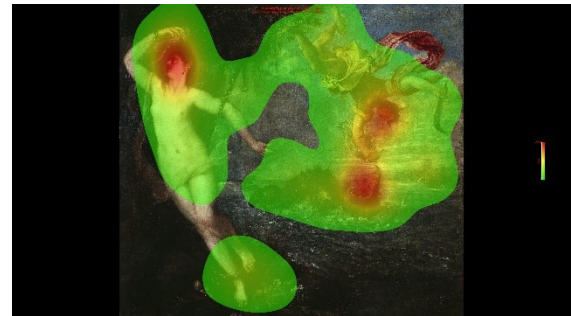


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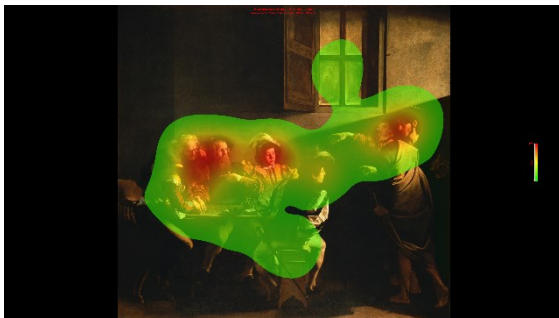


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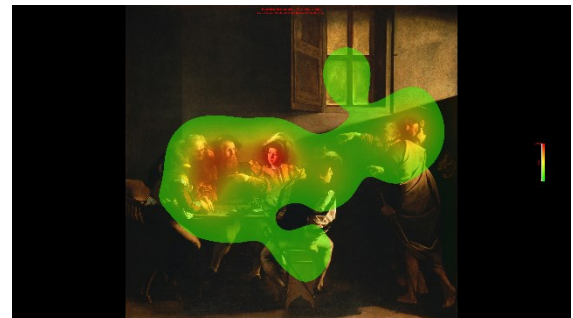


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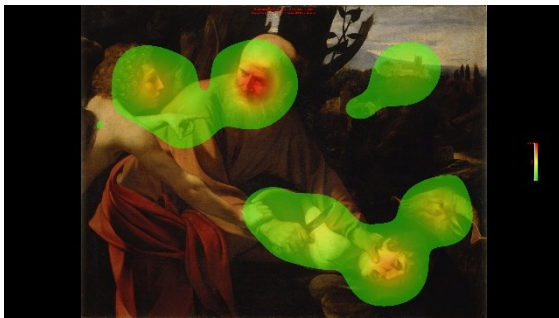


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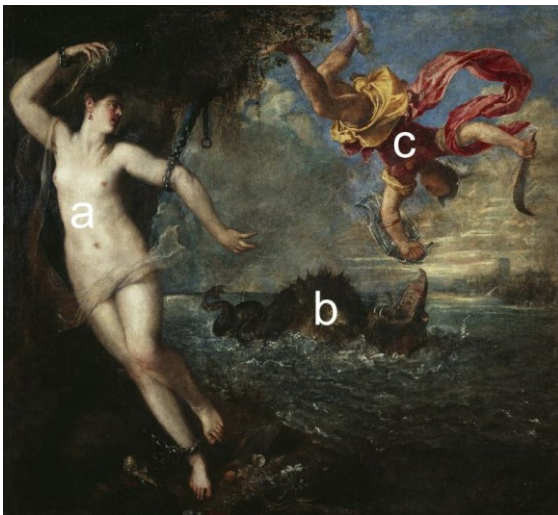


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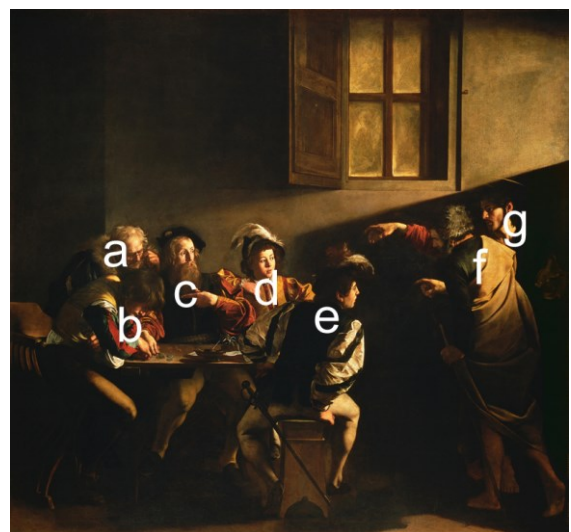


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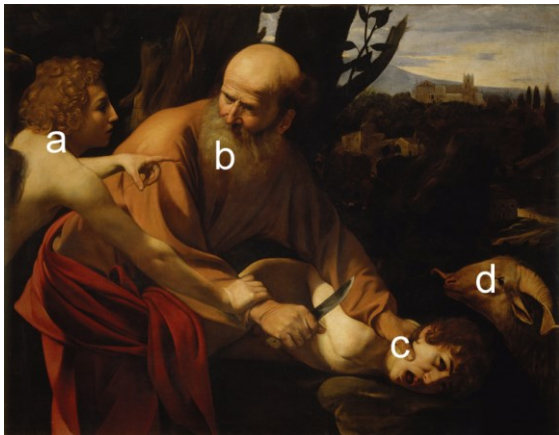


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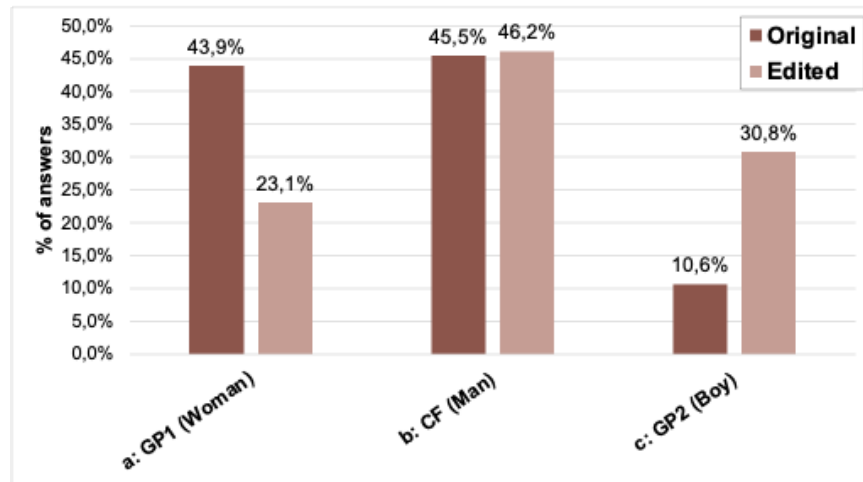


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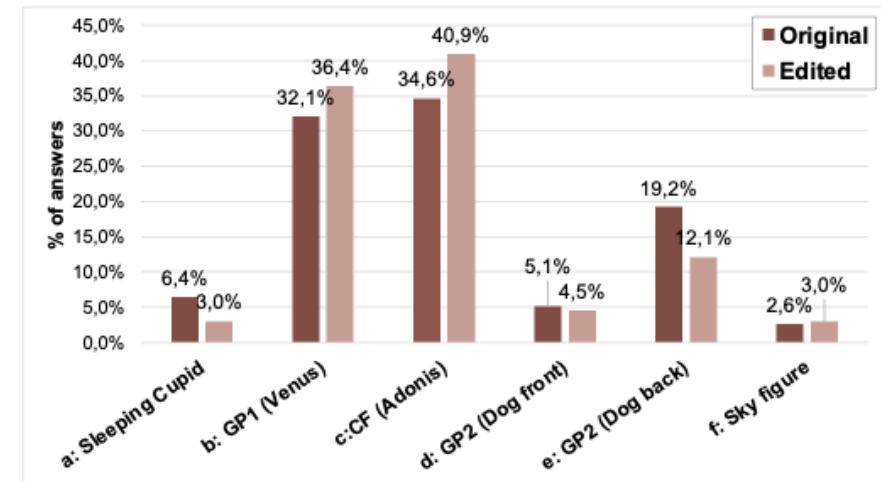


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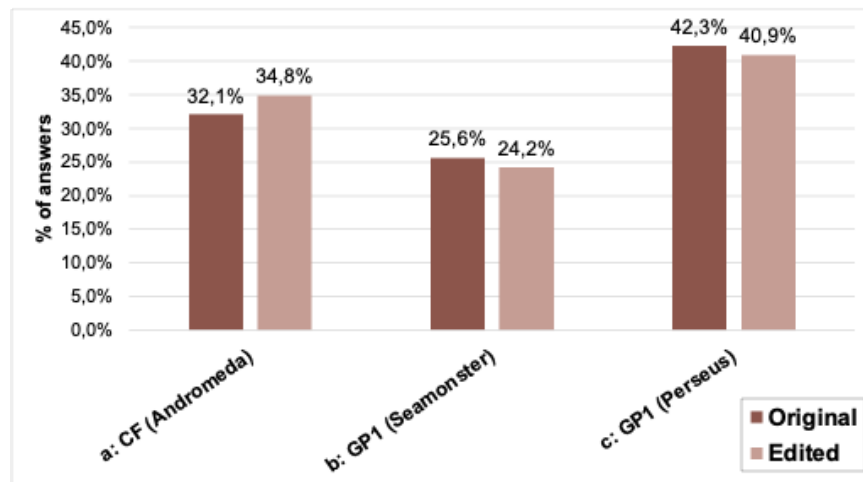


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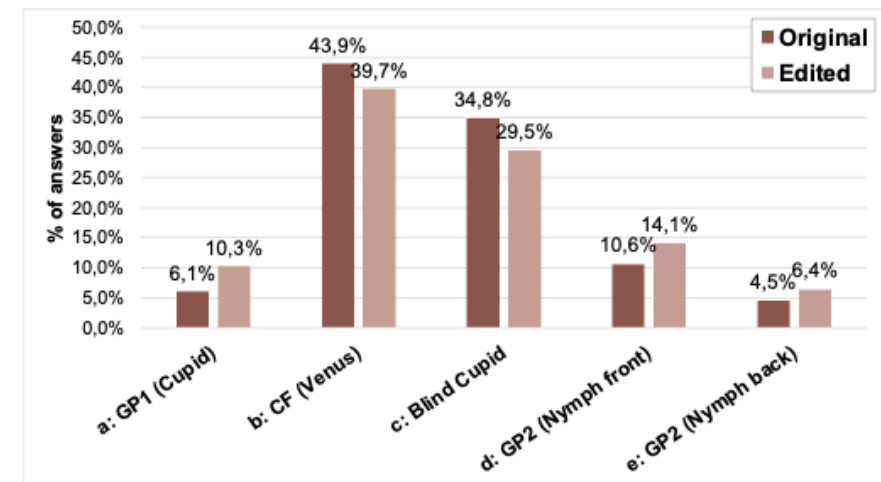


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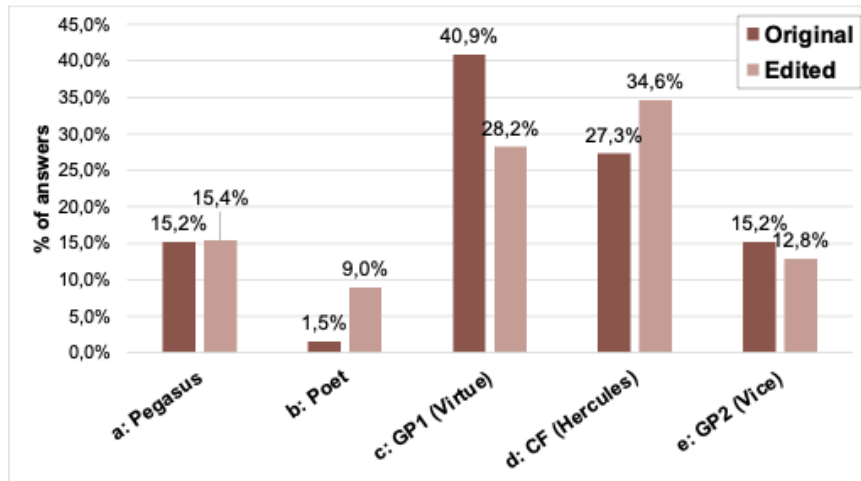


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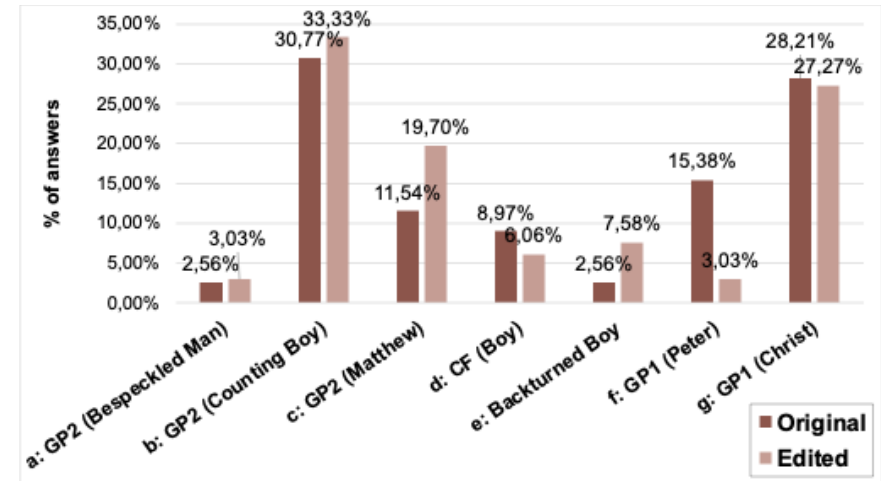


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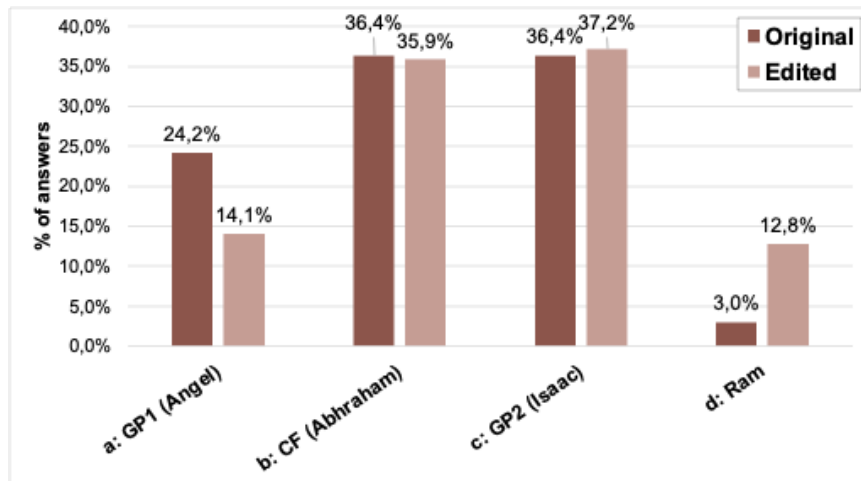


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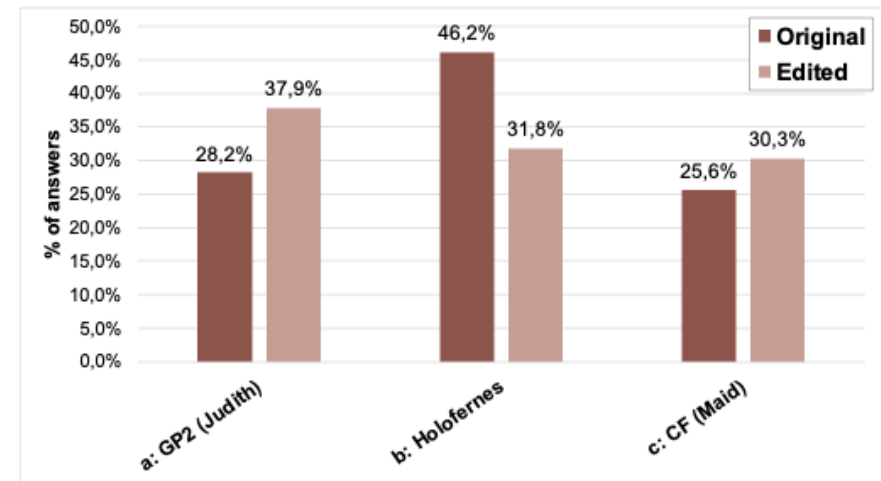


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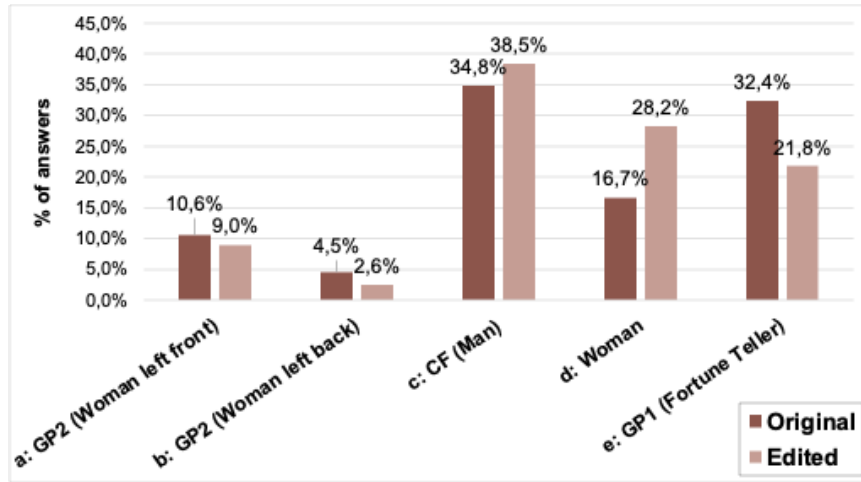


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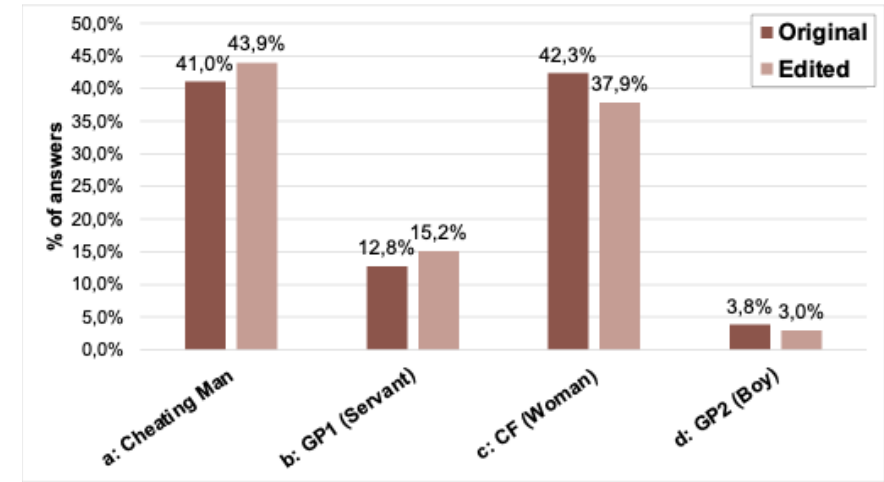


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https://qfreeaccountssjc1.az1.qualtrics.com/jfe/form/SV_cHIPtNsFFPVYR1A

Questionnaire Group B:

https://qfreeaccountssjc1.az1.qualtrics.com/jfe/form/SV_d13yAX9q1TeRqKy

Study Protocol:

<https://docs.google.com/spreadsheets/d/1fF711sOJtTKi1pLgyzgkAY7MQx2UyMP-s173VGjGjMU>

Abbreviations

CF: *Central figure*; the figure chosen to edit their gaze direction with image manipulation software.

GP: *Gaze point*; the area towards which the central figure is looking.

GP1: The original *gaze point*; the area towards which the central figure is looking in the original version of the painting.

GP2: The edited *gaze point*; the area towards which the central figure is looking in the edited version of the painting.

IA: *Interest area*; a predefined salient area within the image; a central figure, a gaze point, or other figures and attributes.

List of Stimuli with Abbreviated Titles

Number of human figures	Stimulus (boldened parts mark the abbreviations used)	Artist
2	<i>Perseus and Andromeda</i> <i>Judith and her Maidservant with the Head of Holofernes</i>	Titian Gentileschi
3	<i>Venus and Adonis</i> <i>Triple Portrait</i> <i>The Sacrifice of Isaac</i>	Titian Anonymous Caravaggio
4	<i>Hercules at the Crossroads</i> <i>The Cheat with the Ace of Diamonds</i>	Carracci La Tour
5	<i>Venus blindfolding Cupid</i> <i>The Fortune Teller</i>	Titian La Tour
7	<i>The Calling of Saint Matthew</i>	Caravaggio

List of Aids

Tool	Function	Use	Comment	Link
DeepL Translate	Translation from Italian to German	Chapter 2.1: Sources of footnotes 106 (Gregori) and 107 (Vodret Adamo)	Single paragraphs of the original sources were translated to ensure a content-accurate reading of the text	https://www.deepl.com/en/translator
DeepL Write	Correction of grammar and punctuation	Throughout text	Corrections only	https://www.deepl.com/en/write
DeepL Write	Correction of phrasing	Chapter 1 & 4	No styles set	https://www.deepl.com/en/write
Scribbr	Punctuation check	Throughout text	Corrections only	https://www.scribbr.de/kommasetzung-pruefen/

Abstract

The following thesis investigates how figures' gaze direction in narrative and genre paintings of the 16th and 17th centuries influences people's viewing behaviour and understanding of a depicted scene. Based on the research done in the fields of art perception, non-verbal communication, and joint attention, it was postulated that the gaze of figures in paintings has a cueing effect on the beholder, directing attention towards wherever the figure is indicating through their eyes. The empirical experiment was conducted using ten figurative paintings—each with an original and digitally altered version—and included the qualitative methods of eye tracking and questionnaire data from 80 participants. The results of the eye tracking trial revealed a significant influence of the figures' gazes on viewer behaviour. Participants spent significantly more time looking at a gaze cued area in 70% of the selected stimuli. For 43%–71% of those stimuli, participants also mirrored the figures' gaze direction through the direction of their saccades. The clearest influence of gaze was found to be in the interpretation of the paintings: for 80% of them, participants changed which figure they considered most relevant to the depicted story, congruent with the gaze direction of the central figure. Furthermore, it was found that the gaze cueing effect was primarily present in the initial viewing period of 10–25 seconds and subsided for most stimuli after a half minute of being exposed to the images. Some varying results between paintings raised the possibility of further research, as there are strong indicators that certain aspects of the compositions, such as background saliency, head turn, size, number and position of figures, influence the degree of gaze cueing observed.

Abstract German

Die vorliegende Masterarbeit untersucht, wie die Blickrichtungen von Figuren in narrativen Gemälden aus dem 16. und 17. Jahrhundert das Blickverhalten der Betrachter*innen und deren Verständnis der dargestellten Szenen beeinflussen können. Basierend auf bisherigen Forschungsergebnissen in den Bereichen Kunstbetrachtung, nicht-verbaler Kommunikation und *Joint Attention*, wurde die These aufgestellt, dass die Blicke in Gemälden einen direkten Effekt (*Gaze Cueing*) auf die Betrachter*innen haben und durch deren Richtungsangabe die Blickrichtung lenken können. Zur Untersuchung dieser These wurde ein empirisches Experiment aufgestellt, welches die quantitativen Methoden von Eye-Tracking und Fragebögen für die Datenerhebung verwendete. Zehn figurative Gemälde, je in originaler und editierter Form, und 80 Proband*innen kamen dabei zum Einsatz. Die Ergebnisse des Eye-Tracking Teils ergaben, dass die Blickrichtung von Figuren einen signifikanten Einfluss auf das Blickverhalten hatte. In 70% der Stimuli verbrachten die Proband*innen signifikant mehr Zeit in den Bereichen der Bilder, dessen Richtung durch den Blick der zentralen Figur indiziert wurde. Zwischen 43–71% der Gemälde hatten ebenso einen signifikanten, kongruenten Einfluss auf die Sakkadenrichtung der Proband*innen. Der deutlichste Einfluss von Blickrichtung fand sich in den Ergebnissen des Fragebogens. In 80% der Bilder adaptierten die Teilnehmer ihre Einordnung der Relevanz der dargestellten Figuren in Bezug auf die Blickrichtung der zentralen Figur. Die Studie fand zudem heraus, dass der Einfluss auf die Aufmerksamkeit der Betrachter*innen einen starken zeitlichen Faktor besitzt, da für die Mehrheit der Stimuli die höchste Signifikanz zwischen einer Betrachtungszeit von 10–25 Sekunden festgestellt wurde. Unterschiede in den Ergebnissen zwischen den zehn Gemälden lassen auf weitere Faktoren schließen, welche den Grad des *Gaze Cueing* Effektes stark beeinflussen können. Darunter formale Aspekte der Komposition, wie die Salienz des Hintergrundes, Kopfdrehung, Anzahl, Größe und Position der Figuren, welche einen spannenden Ansatzpunkt für weitere Forschung in diesem Bereich geben.