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Final dissertation

What is happening to Venus, and why?

Experimental studies on the categorization of the Venus Effect and its modulating factors

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ABSTRACT

The Venus Effect (VE) is a perceptual phenomenon arising when an observer describes a scene showing a subject (usually another human figure) together with a mirror. The effect is named after a popular theme in Renaissance art, in which the Goddess Venus was depicted with a mirror. Observers commit systematic mistakes by stating that the Goddess looks at the mirror to admire her own reflection. However often the scene layout makes it impossible because the subject (i.e., Venus) and the observer look at the mirror from two different vantage points. Despite the high familiarity people have with mirrors, they commit errors when asked to predict what is visible in a mirror from another's point of view. In this thesis we conducted two experiments to explore respectively the strength of the VE for different images, and the factors influencing it. In Experiment1 we proposed and tested criteria critical for the recognition of a VE in picture perception. In Experiment2 we explored possible correlations between VE, individual differences (as measured by the Autism Quotient Spectrum Questionnaire by S. Baron-Cohen et al., 2001), and cognitive spatial skills through the Room Observer and Mirror Perspective (ROMP) task (Bertamini et al., 2010). The experiments were implemented online in Italian and Spanish.

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CHAPTER 1

1.1 Introduction

The Venus Effect (VE) is a perceptual phenomenon which relates to people's understanding of what is visible in a mirror from another's point of view. The effect was firstly observed in response to paintings depicting scenes with subjects (human figures) together with a mirror. In the original study, participants (observers) were presented "Rokeby Venus" by Diego Vélazquéz (1499-1500). In this painting the Goddess Venus lays on the bed, while her son Cupid holds up a mirror for her. Her face is visible in the mirror. When asked about what was happening in the painting, participants described the scene by stating that Venus was admiring her reflection in the mirror, even though this is impossible. From her perspective what she sees in the mirror cannot be the same of what the observer sees because they have different vantage point with respect to the mirror. The layout of the painted scene makes Venus see the observer's reflection in the mirror, not hers. The struggle to report what can be seen in a mirror from the viewpoint of another person is called "Venus Effect" (Bertamini, Latto, & Spooner, 2003). The effect has to do with people's difficulty in understanding image reflection, as well as the ability of visual perspective taking. Although cognitive research explored the VE across different modalities and contexts, the literature presents many limits to date.

We made an attempt to overcome them by proposing new research strategies. First, we focused on the representativity of the sample by testing the VE on 150 participants, a sample much larger than the ones reported by the studies so far. The cross-cultural variability was enhanced by testing people of two different nationalities: Spanish and Italian. We also adapted new research modalities. In line with the increasing popularity of online research, we conducted web-implemented experiments. Finally, we decided to take a step back in the study of VE by focusing on in its original context: picture perception. Although previous findings had already explored the VE in relation to paintings layouts of figures and mirrors, no evidence specifically reported what was crucial in those paintings to elicit a VE. Besides, given that artists have been representing different scenes of mirrors-and-figures by changing configurations parameters, we thought that a comparative study of different layouts was needed to

understand whether different configurations generate a VE equally, or with different grades of strength. For this reason, we collected a total of 330 images containing artworks and mirrors, and we classified them according to categories based on different patterns of layouts scenes. The images were then reunited in the Catalogue of Artworks and Mirrors (or CAM), an open access catalogue of potential VE images. Lastly, new exploratory strategies involved a multifactor experimental design to study possible factors influencing the VE. We proposed two hypotheses. On one side we proposed the capacity of visual perspective taking, which we measured through the administration of the Autism Quotient Questionnaire. The other hypothesis involved the spatial representation people have mirrors, which we explored through the administration of the Room and Observer Mirror Task (ROMP).

This thesis aims at giving a comprehensive presentation of the VE, as well as reporting new experimental results. A general introduction will present the knowledge underlying the VE phenomenon. We will start with a general overview of Naïve Physics, a research field that investigates the way people build personal – wrong- understanding out of Physical events. People who are not formally educated in Physics (in this sense "naïve") show a systematic pattern of errors when trying to self-explain complex phenomena. Here we revise the main errors reported in Naïve Optics, a sub-field which studies people's misconceptions on reflection - especially how surfaces (such as mirrors) reflect light-rays. Following, we will discuss the role of mirrors from a cognitive, cultural, and anthropological point of view. Humans have a long history with mirrors, and this section will retrace the stages in history that made the mirror become a must-have, everyday object. The introduction will end with a report of the history of the VE, from its discovery to its current state of exploration in literature. The rest of the thesis will document the experimental aspects of the VE we decided to explore.

The first Chapter will describe the creation process behind the Catalogue of Artworks and Mirror, or CAM. In the second chapter we will discuss Experiment 1, through which we tested a new theoretical categorization of the VE. The third chapter presents Experiment 2, which investigated possible factors modulating the VE. The following section will concern the conclusions drawn by each experiment. Finally, the discussion of the results obtained, as well as new future research directions,

will be discussed.

1.1 Naïve Physics

Naïve Physics is a field of research that studies common people's understanding of ordinary physical events. The first appearance of the term recurs to 1932, when Gestalt psychologists Otto Lipman and Hellmuth Bogen published the book "Naïve Phyisik" (Bozzi, 1958). Here, they described naive physics as a human capacity for intelligent action with tasks and objects, as well as a useful discipline in which everyone should be trained (Smith & Casati, 1994). This early evidence was brought to light in research by Paolo Bozzi, a psychologist of perception who is considered the father of naïve physics. In his innovative laboratory research, Bozzi discovered how adult people held "erroneous theorizations" which were far from consistent with the empirical laws of Physics. For instance, Bozzi's participants described motion using connotations similar to Aristotle's (obsolete) theory of inertia, rather than Newton's empirical laws of motion (Bozzi, 1958; Bozzi 1959). This discrepancy was also reported in experiments. Psychologists started asking informal questions of physics (especially mechanics) to individuals and kept discovering a high percentage of Aristotelian errors. However, when they were questioned further, there were no reasons to believe they had consciously based their responses on Aristotle's theory (Shanon, 1976). It is only when asked to fully explain something that people realize the limits of their knowledge (Keil, 2003; Rozenblit & Keil, 2002). At this point, cognitive researchers started wondering whether people used information from personal experience to build knowledge of the world. This hypothesis was extensively explored by the works of McCloskey and colleagues who, in the1980s, started submitting simple problems of mechanical physics to individuals (e.g., McCloskey et al., 1981, 1983a, 1983b). Daily life offers occasions for people to interact with mechanical systems: objects in motion; watching a baseball game, driving a car, and even dropping a pencil are all events involved with motion. Thus, researchers expected everyone to have some sort of knowledge on that. Nonetheless, many participants reported a high percentage of errors in response to the problems. For instance, they predicted that a ball exiting from a curved tube (Fig. 1a) or flying from a sling (Fig. 1B) continued its trajectory by moving curved rather than straight along a tangent. In response to another problem, participants believed that a ball carried by a horizontally

moving object and then dropped would fall straight down to the ground or backwards, instead of following a parabolic arc (Fig. 1C) (McCloskey et al., 1983a).

A B C

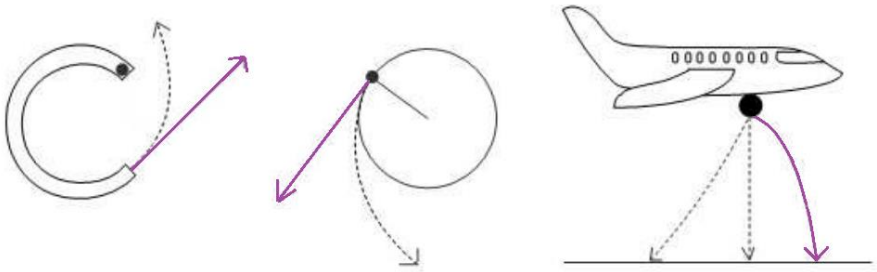

Figure 1. Many participants predicted the trajectories to follow wrong trajectories (dashed lines), instead of the correct ones (purple lines). Instructions to some of problem-solving tasks tested by Mc Closkey; **A)** C-tube problem: imagine a ball bearing inserted in the tube, and then draw the trajectory once it exits the tube. Ignore air resistance. **B)** Sling problem: ball attached to a string is twirled at high speed in a circle above a person's head – draw the path that the ball will follow after the string breaks (assume it breaks when the ball is at the point shown in the diagram); **C)** Airplane problem: an airplane is flying at a constant speed and altitude — draw the path that a ball dropped from the plane will follow until it hits the ground. [Adapted from Bianchi&Savardi, 2014]

These and other findings support the evidence that people's accuracy in perception-action abilities (e.g., catching a ball, hitting a target) is at odds when people report descriptions about them (Caramazza et al., 1981; McCloskey, 1983a; Bertamini et al., 2004). Furthermore, these understanding errors are not improved in people with expertise in Physics (Bertamini et al., 2004). According to Proffitt (1999) naïve notions produce stereotyped knowledge much like heuristics. By acting like a mental shortcut, they lead to a superficial knowledge which is far from the complexity of reality (Bertamini & Casati, 2009). Besides, naive theories do not seem to be rigorous nor consistent; rather, they resemble a broad collection of confused ideas poorly connected (e.g., Reiner et al., 2000; diSessa et al., 1988). However, if these intuitive notions are proved wrong, why do people still rely on them?

Bertamini and Hecht (2005) proposed two lines of explanations. First, our intuitions evolved slower than scientific empiricism progress. This made humans unable to keep up with innovative theories and stuck in an immature stage of knowledge. As a result, intuitions are recalled more easily than scientific notions. The second explanation proposes naïve physics as a reflection of people's cognitive limitations in reasoning processes (Kaiser, Proffitt & Anderson, 1985; Proffitt & Gilden, 1989). People would correctly understand an event when they can isolate its relevant properties; differently, they commit mistakes. For complex events (such as physical phenomena) the understanding is based on inaccurate combination of these isolated properties. These combinations are false representations of reality, and when they are applied to new stimuli, they inevitably produce errors. Either way, the nature of the fallacy of naive thinking seems to be cognitive and not perceptual: people are accurate when they perceive an event, but they are wrong when they build distorted cognitive representation out of it (Bertamini et al., 2005).

Throughout the years, errors have been found in other physical domains. The next paragraph will take in consideration the errors found in naïve optics, a field that explores people's understanding of mirrors and reflections.

1.2. Mirror Cognition

The mirror has always been an object of wonder for humans. The word "mirror" is very similar to "miracle" in Latin: *miratorium* means 'mirror' and *miraculum* means 'object of wonder', beyond the power of Nature. The more recent *speculum* (from which the Italian 'specchio' and Spanish 'espejo' derive) is closely related to "speculate" – and indeed we speculate, and contemplate on what mirrors reflect (Gregory, 1997). Before mirrors, water was the only surface used to reflect oneself, and this element was intimately linked with the true substance of things, with their continuous metamorphoses. For this reason, the film visions of Jean Cocteau are teeming of watery mirrors that can be crossed to have access to parallel worlds. Reflecting water differed from reflecting mirrors; as he declares in Testament of Orpheus (1960), mirrors show "Death at work", namely our inexorable sliding down towards the abyss. Mirrors are not like water as they allow humans to go beyond the act of looking and

starting to observe, scrutinize, and interpret the reality.

Mirrors as objects remained small and expensive for centuries. Only during the 16th century in Venice, thanks a new method of backing a plate of flat glass with a thin sheet of metal, people got access to high-quality mirrors. More recently, in the 19th century, the process of coating a glass surface with metallic silver was invented. Today mirrors are possibly everywhere (e.g., shops, cars, houses) and come in every size. It is hard for people to go through a full day of activities without being exposed at least to one mirror and seeing their reflection. The self-reflection in mirrors may play a big role in the development of the sense of self-identity in humans. Children show this ability at around 2 years on whereas most animals fail the test - except for some of the great apes (Gallup, 1977; Povinelli, 2000). Simply by experience, one may expect people to be experts with mirrors. Instead, people not only find hard to understand how mirrors work but hold systematically wrong expectations about them. Just like naive mechanics, people report false theories on visual processes and reflection (Coucher et al., 2002). For example, in the "extramissive theory" people think vision is possible because our eyes shoot out light rays on the objects, when it is in fact the opposite (Cottrell et al., 1994; Winer et al., 1996). The intromissive theory, which replaced the extramissive one, states that vision actually comes from light rays reflecting from surfaces towards our eyes. A large proportion of adults still believes in extramission (Winer & Cottrell, 1996; Winer et al., 1996).

False theories are also common in the context of mirror's reflection. In a study conducted by Croucher, Bertamini, and Hecht (2002) participants were asked to predict what was made visible by a mirror in a top-down scheme drawing of a room. In the *Jane task*, a character named Jane was said to move either up or down the page along a dashed line past a depicted mirror. Participants were asked to indicate the position in which Jane would first see her reflection when moving into the visibility region of the mirror. Participants could select one of four possible locations labelled A, B, C, D, The answers reported showed a high rate of errors. Instead of predicting the near edge of the mirror as the point in

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which Jane would first be able to see herself, participants marked points in which Jane was still in some distance to the side of the mirror (before or farther the edge).

2A 2B

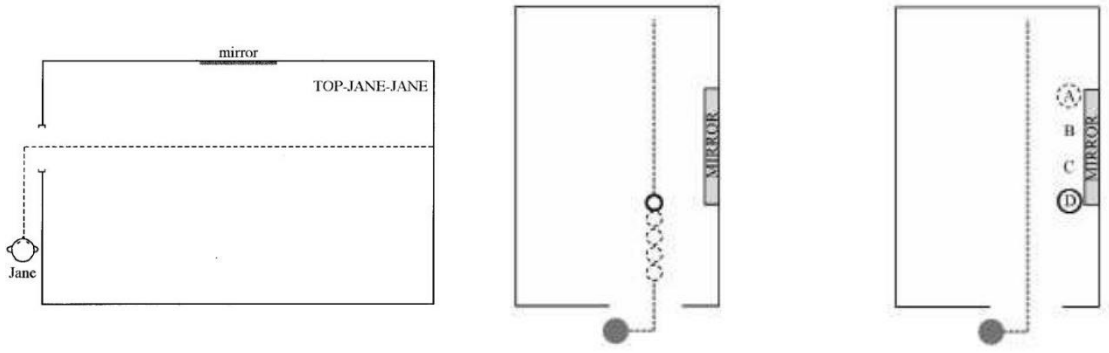

Fig.2*:* On the left: instructions from Croucher et al., 2002: "Jane walks through the door and across the room. There is a mirror flat on the wall. Please mark with a cross where she will be standing when she can first see her own reflection in the mirror (Jane is free to look around the room as much as she likes)". **2A**: people expect the reflection to be visible before reaching the near edge of the mirror (dashed circles indicate people's answer; the solid circle indicates where the reflection would in reality appear). **2B**: alternatively, they expect the person to see the reflection appear at the farther edge of the mirror (position A indicates their answer; the solid circle indicates the correct answer). [Adapted from Bianchi & Savardi, 2014]

In this type of error, people show an overestimation of what one can see in a mirror. The same errors persist even when the task is made concrete in a live "pretend task", where participants could walk in a real room with a covered-up mirror on a real wall and choose where to stop to first see their reflection (Fig 3).

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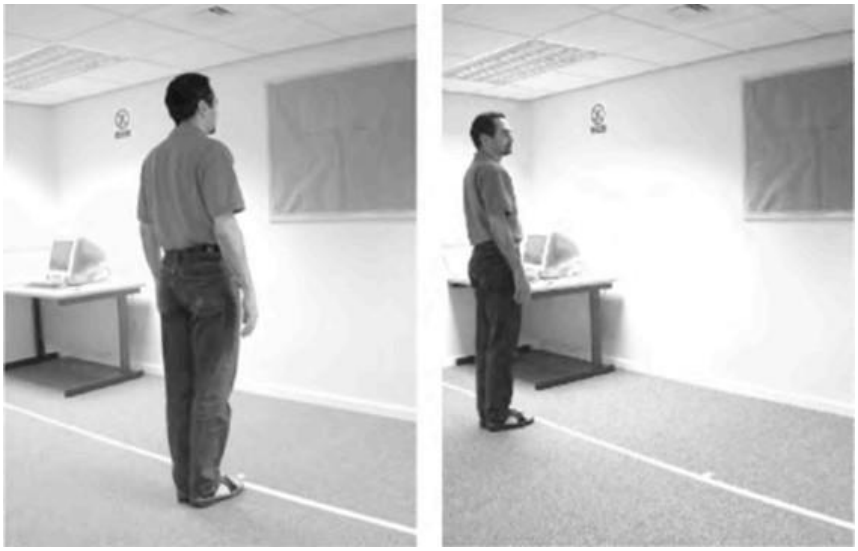

Fig.3: Recreation of the pretend task used by Croucher, Bertamini Hecht (2002). People could walk in a room, in a line parallel to a covered mirror on the wall. They stopped when they thought they would first be able to reflect themselves in the mirror. In the second image the position of the person is at the average distance chosen by the participants (70cm away horizontally from the mirror edge), Pretend task led to greater overestimation mistakes. [Images adapted from Croucher et al., 2002]

The claim that a person can see their reflection in a mirror before it is possible is defined "early error" (Croucher et al., 2002). The early error is compatible with an overestimation of what is visible in a mirror from left and right, as people expect that a cone of visibility for a given mirror is largely independent of the viewpoint of an observer and of distance (Bertamini et al. 2010; Bianchi & Savardi 2012b). Croucher et al., proposed four possible hypotheses to explain the early error:

1. Egocentric mirror rotation: Observers may show a tendency in considering the orientation a mirror as rotated orthogonally to their line of sight ("observer-centric rotation" bias). Therefore, when people are asked to consider another point of view different from theirs, they would activate by default a mirror orientated more towards them than the person.
2. Capture: Observers may think of a mirror as a stable device that captures and records whatever is in front of it, regardless from where it is being looked at. This hypothesis would explain those cases in which people think that an image in the mirror is the same regardless of different perspective. Mirrors in reality are solid objects with appropriate perspective, that critically depend upon points of observation.

3. Boundary Extension: Observers may broaden the boundaries and judge a larger part of the world to have been captured by the mirror image than was the case. As a result, when people recall a previously presented image, they tend to overestimate its spatial extent. This hypothesis has been especially explored in photographs (Intraub & Richardson, 1989).
4. Left-right reversal: Observers may only overestimate what they can see from the left or the right of a mirror, not from above or below. People may extrapolate from this to expect a reversal of the imagined visual space around a vertical axis, thus misplacing objects in the mirror reflection. As a result, people may predict an observer's reflection to appear from the left as the observer approaches from the right, and in turn this might lead to an overestimation of what is visible from the side.

A common feature of these hypotheses is that people have generally a poor understanding of the role of viewpoint with mirrors (Bertamini & Wynne, 2009). This would be consistent with the idea that they also do not have a fully scientific conception of mirror reflection or use a single consisting method to predict what will be visible in a mirror (Croucher, Bertamini, & Hecht, 2002).

Closely related to the early error is the Venus Effect, a visual perceptual error typical of the pictorial art context. When viewing paintings including a mirror and a person (or actor), people would be inclined to predict that both them and the actor see the same image in the mirror, even if they look at it from two different perspectives (Bertamini et al., 2003).

1.3. Naive optics in visual art: the origins of the Venus Effect

An oft-cited demonstration of human fascination with mirrors is their use in art. Artists have exploited the opportunities offered by mirrors for playing games with and on the spectator. Possibly, the most famous mirror in art is the one appearing in the "Arnolfini Portrait" (1434) by Jan Van Eyck (1421-1441). The artist, strategically, used a convex mirror to reveal the opposite side of the room – the same side from which we observers see the painting. However, in the mirror Van Eyck represents only figures who must be behind the viewpoint of the observer, and not the observer (Fig. 4). The artist,

while re-creating the world has omitted the viewer through a perceptual ambiguity.

Fig. 4. The "Arnolfini Portrait" by Jan Van Eyck and a close-up detail of its convex mirror in the background. The mirror reveals what would be seen by looking at the couple from behind, i.e., two figures on the doorstep, but not the observer. [Credit: Jan Van Eyck. (1421-1441). *The Arnolfini Portrait*. [Oil on oak]. National Gallery, London]

Most people not only are able to distinguish the mirror in the composition but also tolerate the ambiguity it evocates. Our perceptual ability to recognise real-life mirrors as well as those in pictures is a complex psychological process of which we are usually unaware. How can artists persuade observers that they are looking into a mirror instead of an image beyond a window? How can we tolerate inaccuracies in paintings, which in reality we would find odd? Thousands of years of questioning and experimenting lead scientists to study the interplay of mirrors across different domains of knowledge such as psychology, science and art. The neuropsychologist Richard Gregory in his book "Mirrors in Mind" (1997) discussed the role of mirror not just as an object, but as in people's minds - artists included. According to Gregory, painters considered mirrors as an expedient to represent the illusion of extra views and extension of space. But, in order to do that, they dealt with limits of geometrical optics.

The fundamental difference between a mirror image and a painting was very clear in Leonardo da Vinci's notes, and it was one reason for his dissatisfaction with his art ("Painters often fall into despair of imitating nature when they see their pictures fail in that relief and vividness which objects have that are seen in a mirror"; as quoted in Ono et al, 2002, p. 85). One of the major problems with the pictorial representations of mirror images concerned their size, which remained very small until the early 1900s. Because the images reflected were even smaller than the mirror itself, artists often had to 'cheat' to make mirror images effective in a painting by, for instance, enlarge the reflection. This can be clearly seen in the subject matter of "Venus", the goddess of beauty and sexual love whose figure was extensively painted by artists throughout Renaissance and the Baroque. In the popular theme "Venus at her mirror" or "Venus at her toilette" Venus is repeatedly cast as a nude giving the idea of reflecting herself in a mirror at her toilette, usually attended by mythological creatures such as the devil, putti, or her wayward offspring, Cupid/Eros. The representation of Venus in the act of admiring herself in the mirror as an allegory for her Beauty, revealed the mirror's strategic role not only of mediation, but also of visual access to what cannot or should not be seen with one's own eyes. Artists like Vélazquéz, Rubens, and Veronese created different variations of the theme by experimenting several technical aspects of reflections —the composition's "self-reflexivity", the way that light reflects off metallic objects (first convex and then planar), or foreshortened views in a mirror (Fig.5), and distorted representations of anatomical proportions. For instance, in the painting Rokeby Venus, the size of Venus's face in the mirror does not correspond to reality: as the mirror is further away than the face of Venus, the image is with larger than it should be (Gregory 1997).

Estimations errors on the size of a reflection are very common among people. In his pioneer work "Art and Illusion" (1960), the art historian E.H. Gombrich noticed that people commonly hold a "projection size" with mirrors, meaning that they have the impression that the outline of their face is the same size of the one they see reflected in the mirror (when, in fact, it is half the size). So whether in art or in real life, the understanding of mirrors and reflection represent a genuine cognitive challenge for our minds.

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Fig 5. Examples of artworks showing Venus surrounded by putti holding a mirror for her. The reflection of the faces in the mirror is distorted as it is larger than reality.
From left: Paolo Veronese. (1528-1588). *Venus with a mirror.* [oil on canvas]. Joslyn Art Museum, Omaha, USA; Peter Paul Rubens. (1577-1640). *The Toilet of Venus.* [oil on canvas]. Liechtenstein Museum, Vienna, Austria; - Diego Vélazquéz (1599-1660). *The Toilet of Venus (The Rokeby Venus).* [oil on canvas]. National Gallery, London.

In cognitive research, the perception of mirrors in art was first explored by Bertamini, Latto and Spooner (2003). In their experiment, the authors tested participants' understanding of mirrors by presenting famous paintings that included a person-mirror layout. Participants saw the paintings, and then were asked to describe them spontaneously; eventually many mistakes emerged. For instance, in response to the painting "Rokeby Venus", participants described the scene by stating that Venus is portrayed in the act of self-admiration in the mirror. However, the layout of the painting is made so that only the observer can see Venus's reflection in the mirror and not Venus. The only case in which they could both see her reflection in the mirror would be if they shared the same line of sight, that is if the observer stood right behind Venus. Differently, they must see different images. In this specific case what they see is reciprocal: we observers see Venus in the mirror, whereas Venus sees us (or the painter).

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A reconstruction of the perspective dynamics of "Rokeby Venus" is illustrated in a diagram in Fig 6. Here Venus is placed in front of a mirror: this is necessary for her to see her face centred in the mirror (independently of the orientation of her head). If the observer moves from right to left, they will start seeing Venus's left ear at position A and Venus's right ear at position B. Therefore, only after the observer has moved beyond position B can they see the full face of Venus. The offset depends on the distances between the items and on the size of the mirror, but the reader can extrapolate the effect of these variables from figure 6. The important point is that when an offset is present, the observer and Venus must have a similar vantage point if they are to share a similar view in the mirror.

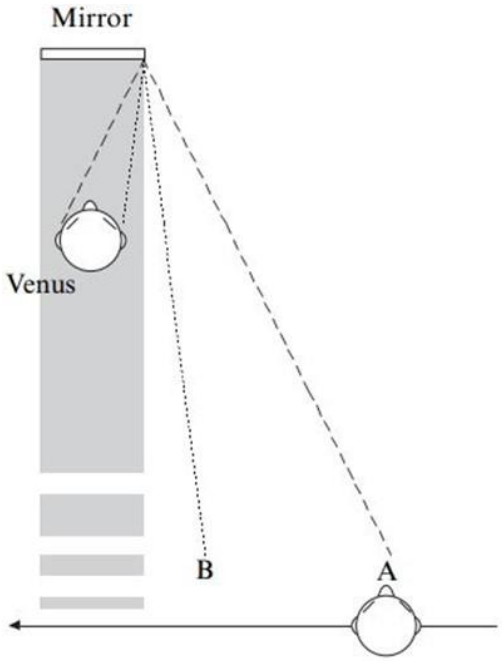

Fig 6. The diagram represents Venus in front of a mirror. Venus can see the reflection of her own face in the centre of the mirror. Venus's head orientation is irrelevant as long as she can turn her eyes to look at the mirror. Outside the grey area, Venus could not see herself at all. Imagine observers moving from right to left. At position A they will start seeing Venus's left ear, but only at position B will they see the right ear and therefore the full face (albeit not yet centred in the mirror). The reader can extrapolate the lines for different positions of the observer. The size of the mirror is also an important factor, as smaller mirrors constrain the alignment more than larger ones. [Adapted from Bertamini et al., 2003].

Two important information should be mentioned about the Venus Effect:

1. The VE is about how observers describe the scene, not the painting itself. The VE is not implying that there is anything wrong with the image.
2. The intent of the artist is to produce an image that tells a certain story, exploiting (consciously or not) how observers will interpret the scene depicted, they have no obligation to reproduce reflections accurately (Bertamini & Parks, 2005).
3. VE originates from a fundamental error of prediction on what a person can see in a mirror from a given viewpoint.

From these assumptions the central point is although the representation of the mirror is informative, it seems that humans do not find this information salient, but rather they seem to be tolerant to large variability of distortions in mirror images - be it in real life, visual art, or photography (Croucher et al., 2002; Bertamini et al., 2003; Bertamini et al., 2010). In the pictorial context, it is possible that VE arises in people's minds when looking at a precise mirror-and-person dynamic scene, rather than a subject itself (e.g., Venus). Although in the original study, the layout of Venus with a mirror was the first generating a VE (that's why "Venus Effect"), we believe that many other similar layouts can be found in pictorial art as possible examples of VE.

CHAPTER 2:

2.1. An Inventory for the Venus Effect: The Catalogue of Artworks with Mirrors (CAM)

Looking back in history, countless are the examples of paintings with mirrors. Artists drew inspiration from various contexts: mythology, poetry, and even biblical narratives. The biblical (apocryphal) episode of *Susanna and the Elders* and the narrative of *Bathsbea at her Bath* both became artistic motifs represented by major artists over centuries. In the first, Susanna is a young and beautiful woman, who is caught and seduced by two elders while having a bath alone in her garden. Because she resists to their threats and raises her voice against them, she is taken to court accused of adultery. In the trial she is defended by Daniel, who cross-examines the two elders ad eventually proves her innocent.

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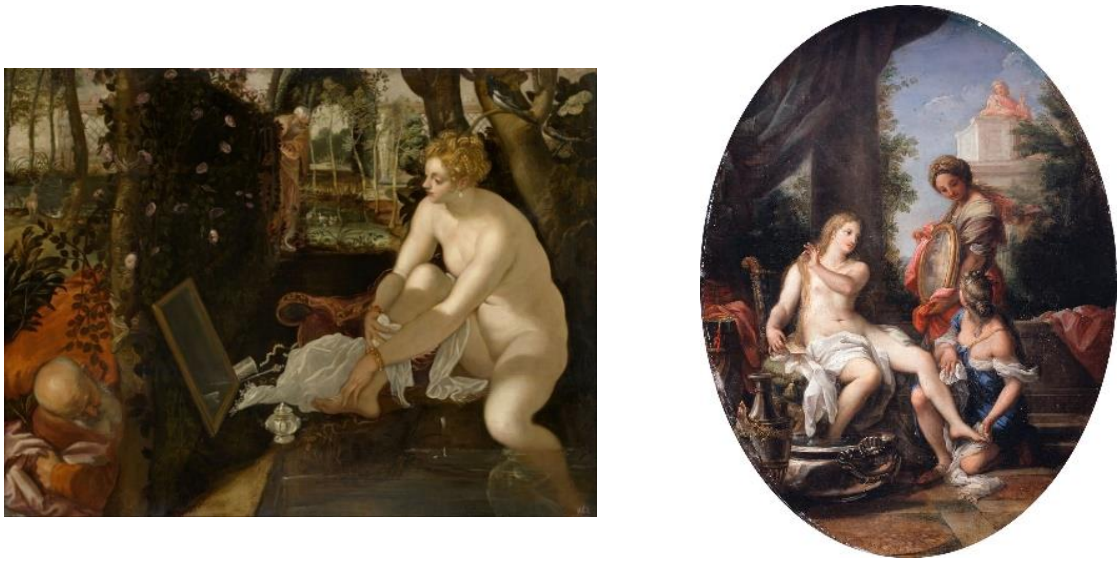
After justice is proclaimed, Daniel begins his path to become a prophet – one of the most legendary ones. The dramatic story was immensely popular among artists, who often portrayed the moment in which Susanna was caught spied in her garden. Of particular interest, is the version of Susanna and the Elders by Jacopo Tintoretto: in this case the mirror is an essential tool for her morning toilette, together with all sorts of other beautification devices (ointments, necklace etc.) that she is using (Fig 7 A). Similarly, Bathsheba (Samuel 23:34) tells the story of a woman who became pregnant after king David saw her bathing on a rooftop and had her brought to him. Bathsheba later gave birth to Solomon, who would later become king of Israel and a major prophet. Artists recreated the moment of the nude Bathsheba at her toilet tended by servants, while King David gazes at her from the palace balcony. In the version of Giuseppe Bartolomeo Chiari (1654-1727), the mirror is represented again as an essential part of Bathsheba's morning toilette (Fig.7 B).



A B

Fig. 7. Mirror in art and biblical narratives. A) Jacopo Tintoretto. (1518-1594*). Susanna and the Elders*. [oil on canvas]. Kunsthistorisches Museum, Vienna; B) Bathsheba at her Bath; Giuseppe Bartolomeo Chiari. (1654-1727). [oil on canvas]. Metropolitan Museum of Art, New York City (USA).

The depiction of a mirror has been also used for allegorical purpose. Especially in the art of the late Middle Ages and the Renaissance, mirror-gazing often represented religion allegories: the vices of pride and vanity co-existed with the allegories of virtues such as truth and prudence (one of the cardinal

virtues). Starting from the vices, the motif of "Vanitas" (Latin for emptiness) was associated with the mirror as it was a memento mori symbol —a reminder of life's transience, pointing to the futility of earthly gratification and material acquisition. For instance, in an illustration from the Book of Hours (1480) the memento-mori is explicated through a warning as a female skeleton that regards herself in a hand-held mirror. Similarly, in the sin of pride (in Latin *Superbia*) the mirror was a symbol of self-idolatry, in which one rejects God for the sake of one's own image. In the Table of the Seven Deadly Sins (1505-1510), Hieronymus Bosch depicts "Superbia" with a wolf wearing a kerchief in the act of holding up a mirror for a woman, who smiles at herself and adjusts her own kerchief. An open box of jewels sits on the floor, further indicating the woman's pride in her appearance.

A

B

Fig. 8 A) Matteo da Milano (attributed). (1480-1520). *Detail of an initial in the Office for the Dead, from the Hours of Dionora of Urbino.* [manuscript]. British Library, London; B) Hieronymus Bosch. (1453-1516). *Pride, detail from The Seven Deadly Sins and the Four Last Things.* [Oil on poplar panel]. Museo del Prado, Madrid, Spain.

Moving onto the virtues, in art Prudence was personified as a woman looking into a mirror whilst holding onto a snake. Here the mirror symbolized self-knowledge, which is essential to follow in the path for becoming wise. Like Prudence, the figure of Truth is similarly shown holding a mirror, the reflection of which is not meant to lie. The figure of Truth is often depicted alongside that of Time, based on the idea that truth will be revealed over time, supported by the ancient saying 'Veritas filia temporis' — 'Truth is the daughter of Time'.

A B

Fig. 9. A) Piero del Pollaiuolo. (1443-1496). *Prudence*. [oil and temper on panel]. Uffizi Gallery, Florence, Italy; B) Annibale Carracci. (1560-1609). *An Allegory of Truth and Time.* [oil on canvas]. Royal Collection, London.

These are just few of the examples showing the symbolical roles assumed by mirrors throughout various artistic periods. But many more could be reported, and all would have in common an interplay between a person and a mirror - albeit with difference in details in perspectives configurations. We started wondering whether they could elicit a VE, as it was already found in response to "Venus at her toilette" layouts. However, no study in literature has provided a list of clear conditions necessary for paintings to elicit a VE. We proposed to fill this gap by creating an open-access catalogue of artworks

images portraying a potential VE on the bases of three criteria:

1) The image of the artwork portrays a subject and a mirror
2) The scene involves an interplay between the subject and a mirror
3) The mirror does not necessarily include a reflection

The images of the paintings were found online on blogs and museum websites using key words "paintings", "artworks", "mirrors". A total of 330 image files was collected and reported in a Microsoft Excel file catalogue we named "Catalogue of Artworks and Mirror", or CAM. In the CAM each artwork image was categorized according to descriptive labels: year of creation, title of the artwork, name of the artist (date of birth and death), location (i.e., museum, city, and state), artistic school or period, and internet source. In addition, each artwork was reconducted to a class of a categorial system describing the strength of potential VE, appositely created for this study.

Image	Category	Year	Title	Artist	Location	Art period	Source
	A1	200	Toilet of Aphrodite	UNKNOWN	Museum of Suweida, Philippopolis (Siria)	Christian Iconography	
	A1	300	Toilet of Venus	UNKNOWN	The National Museum of Bardo, Tunisi (Tunisia)	Christian Art	
	A1	1403	De mulieribus claris Marcia	Master of the Coronation of the Virgin	Bibliothèque nationale de France, Paris (France)	Miniature	
	A1	1470	Artist in her Atelier	UNKNOWN	The New York Public Library Digital Collection, Library Division: "Spencer Collection", Collection "DES CLERES ET NOBLES FEMMES Collection, MS. 33, f. 37v, French", New York City, USA	Miniature	

Fig. 10 CAM: Catalogue of Artworks and Mirrors. Each column represented a label: Category (of VE) - Year - Title-Artist – Location - Art Period - Source.

1.1. *The categories of the CAM*

The CAM includes a large collection of artworks appositely selected for their content, i.e., representations of interplay between humans and mirrors. When looking not at their configurations, the

layouts of these representations varied a lot. Some of the parameters that changed more consistently were: the orientation of the subject towards the mirror; the size of the mirrors depicted; the gaze of the subject on the mirror; the visibility of a reflection in the mirror; the inclinations of mirrors. Because we hypothesized some combinations of parameters to be more immediate than others in eliciting a VE, we created a categorial system which differentiated for different grades of "VE strength". Each painting was assigned to one of three macro categories: A) Strong VE; B) Ambiguous VE; C) Absent VE.

A Strong VE: the person is oriented towards the mirror, and the mirror reflects the image

A1. Clear Venus Effect = the viewer sees the face of the subject figure in the mirror, and they are not directly behind her, therefore what the subject sees in the reflection cannot be the same as what the viewer sees (Fig 11).

Fig.11 A1 Strong Venus Effect: the person is oriented towards the mirror and there's a reflection of the face in the mirror. From left: "La Dame à la Licorne", Jean d'Ypres, 1480 c.; "Venus with a Mirror", Paolo Veronese, 1585 "Toilet of Venus", Simon Vouet; 1644-48.

A2. Framing Venus Effect = again, the observer sees the subject's face reflection in the mirror, but this is optimally distorted to be centred for a vantage viewpoint. The centred reflection is possible to see only for the observer, but not for the protagonist of the painting (Fig.12). Often, in response to this category, the reflection is depicted giving the impression that the subject sees the observer from the

mirror. This was strategy was often reported by artists across various art periods.

Fig. 12 A2 Framed Venus Effect: The person is oriented towards the mirror, the reflection in the mirror is centred. From left: “Couple with a Mirror”, Hans von Aachen, 1596; “The Toilet of Venus”, Peter Paul Rubens, 1614. "I See You!", Frederick Morgan, 1847

B. Complex Layout VE: variations in subject’s orientation and mirror’s inclination

B1. No Orientation Towards Mirror: in the interplay between the subject in the mirror, the subject is not oriented to the mirror. However, the mirror includes a reflection of the person’s face. If the image in the mirror is centred for us, it can’t be centred for the subject. There is no VE in the sense that we do not expect observers to conclude that the person is looking at her/his reflection. Rather, people may think that the subject could self-reflect by turning around.

Fig.13 B1 No Orientation Towards Mirror. The person is not oriented towards the mirror, but her reflection is visible in it. From left: “Allegorie des Gesichtes”, Frans Floris I, 1530; “Woman in front of a Mirror”, Gerard ter Borch, 1652; “Girl at a Mirror”, Paul Moreelse, 1632.

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B2. Narrow Line Sight: in this case observer and subject seem to share a similar or the same perspective line of sight. This is often the case when the distance between the subject and the mirror – is small. In this sense the observer is behind the subject with respect to the mirror. Alternatively, the mirror dimensions are big, and this makes the cone of visibility wide (Fig.14).

Fig.14 B2 Narrow Line: there is a similar line of sight between subject and the observer; alternatively, the dimension of the mirror is bigger. From left: "Mrs Russell and Child", George Romney 1786; "A Nude Woman Doing Her Hair before a Mirror", Christoppher Wilhelm Eckersberg, 1841, "Girl at a Mirror", Norman Rockwell, 1954.

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C Implicit VE: the interplay is not always present, and the reflections in the mirror are not very clear

C1 Partial VE: there is a mirror in the painting and a reflection is visible, but no face reflection is depicted in it (and hence, possibly less informative). Although the person is looking at the mirror, it is impossible to say anything certain about VE without a 3D reconstruction (Fig.15).

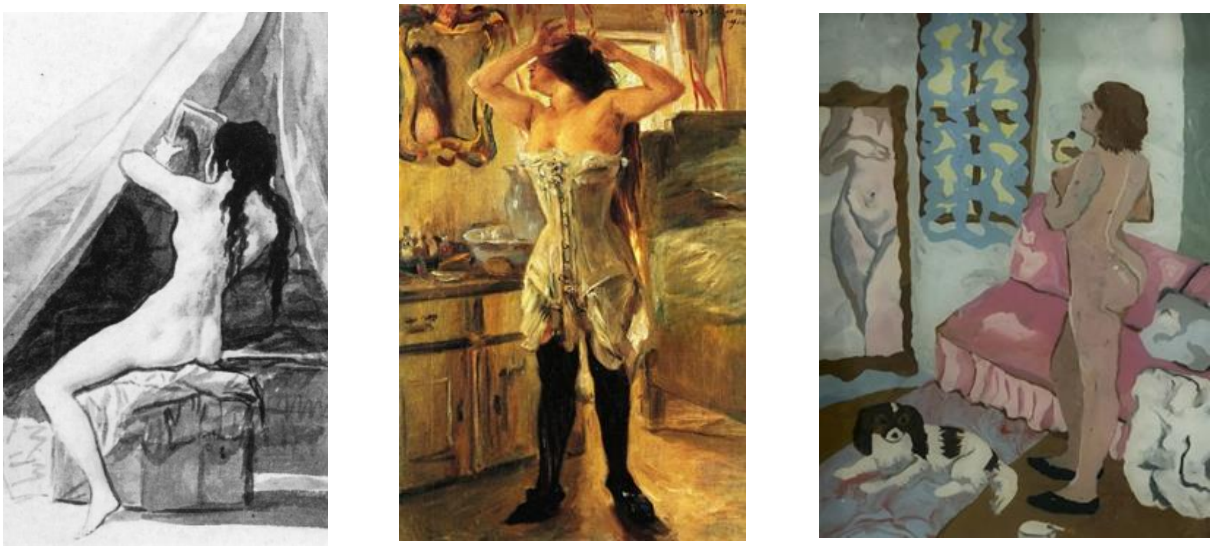

Fig.15 C1 Partial VE: a part of the body is displayed in the mirror but not the face is visible; the person is oriented towards the mirror. From left: “Nude Woman Holding a Mirror”, Francisco Goya, 1796; "In a Corset", Lovis Corinth, 1901; “In a Mirror”, Mia Darling, 2019.

C2 Sideways Mirror: the mirror is presented sideways. The person is looking at the mirror. Impossible to say anything certain about VE without a 3D reconstruction (Fig.16).

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Fig.16 C2 Sideways Mirror: the mirror is presented sideways; no reflection is visible. From left: “Die Toilette der Venus, Simon Vouet”, 1625-27; “Margaret before the Mirror”, Manuel Domínguez Sánchez, 1866; The Mirror”, William Closson, 1889.

C3 No VE: although there is a mirror depicted, no face is visible in it. The person is not looking at the mirror. The reflection is just part of the environment (Fig.17).

Fig.17 C3 No VE: the figure is not in a specific interplay with the mirror. From left: “Lady at the Virginals with a Gentleman” or 'The Music Lesson', Johannes Vermeer, 1662;“The Awakening Conscience”, William Holman Hunt, 1853, “Destiny”, John William Waterhouse, 1900.

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To make sure each category of the VE did not overlap with the other ones, we decided to test different versions of the VE on a cross-cultural sample of participants.

The categorization of each painting portraying a potential VE has been carried out by multiple judges to increase the inter-rate reliability.

CHAPTER 3:

Experiment 1: The defining criteria of a potential Venus Effect

3.1. Introduction

There is some ambiguity in the categories created for the paintings of the CAM. In some cases, artists did not portray a reflection where it was expected; in others they portrayed the reflection of the protagonist perfectly at the centre of the mirror, creating a deceiving effect: a centred reflection can be seen only if two people share the same line of sight making it impossible for us spectators to see it.

These examples signed the starting point for the implementation of Experiment 1. We decided to re-visit the theoretical framework of VE by testing our categorial system of "VE strength" through presentations of images extracted from the CAM. The aim was to explore whether paintings from the CAM could elicit a VE in participants' responses, and possibly with what level of variability and immediacy ("strength"). In case participants reported descriptions of VE with a variability of strength we were interested in seeing to what extent this would correspond to our categories.

We explored how VE is perceived by people by directly asking them to report their impressions in text boxes. On the bases of the answers reported, we analysed and classified the descriptions reported. We implemented the Experiment online, making it the first case reported in literature of the VE adapted in online tasks. Also new to literature is the fact that we tested the VE on a large sample of cross-cultural participants. In fact, this experiment was conducted in collaboration with the University of Balearic Islands and was carried out in two versions: Italian and Spanish. The creation of two parallel versions of the experiment allowed us to deepen our understanding of the perception of the VE not only by considering each participant's own perception, but also by comparing possible emerging cultural differences.

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3.2 Method

3.2.1. Participants

Ninety-nine participants took part in the online experiment. This study included two groups: forty-eight Italian participants (mean age: 26,44 ± 6,53) and fifty-one Spanish participants (mean age: 25,87 ± 6,42). Participants were recruited using Prolific. This platform combines good recruitment standards with reasonable cost, along with the possibility to set demographic pre-screening filters like target age-range, level of education, and distribution of sex of the sample (Palan & Schitter, 2018). During the task each participant was assigned an ID code, which was registered and saved by Prolific. In the end, participants sent their submissions and waited for reviews. The participants whose submissions were correctly completed were approved and compensated for 7.43£ per hour on average. The experiment was hosted by Cognition.run, a web server used for running experiments online, and download data collection. Cognition.run allowed us to collect data from participants by sending them a re-directing link to click on, which we included into the experiment.

3.2.2 Stimuli and procedure

Taking the CAM as our reference, we extracted three artwork images that we thought could be representative examples of each of the seven sub-categories of VE, for a total of twenty-one images. The selection of the images was conducted by taking into consideration only figurative art examples to facilitate the recognition and the distinction of the figures depicted; paintings belonging to more abstract or expressionist currents were excluded. There was a problem of balance for the portrayed protagonists of the paintings: female subjects in the act of admiring themselves or in their morning routine were the most common example of humans-and-mirror dynamics representation; inevitably this combination took a major part in the selection. Nevertheless, even if in small number, images portraying other types of subjects (e.g., males, children) were included too.

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Tab. 1: The selection of the paintings from the CAM for Experiment 1. Three paintings were extracted from each category and presented in a random order.

Category		Paintings		
A	**A1**	*Venus with a Mirror*, Paolo Veronese, 1585	*Venus at Her Toilet*, Jan Van Kessel the Elder, 1626	*Julie Le Brun Looking in a Mirror*, Vigée Le Brun, 1787
	A2	*A Young Woman at Her Toilet*, Gerrit Dou, 1667	*I See You!,* Frederick Morgan, 1847	*Back View of a Young Woman in Her Toilet*, François Barthelemy Marius Abel, 1869
B	**B1**	*Girl at a Mirror*, Paulus Moreelse, 1632	*Woman in front of a Mirror*, Gerard ter Borch, 1652	*Madame Moitessier,* Dominique Ingres, 1856
	B2	*Mrs Russell and Child*, George Romney, 1786-7	*Naniwa Okita Admiring Herself in a Mirror*, Kitagawa Utamaro, 1790-5	*Toilette Paysanne*, Poisson Louverture, 1947
C	**C1**	*In a Corset*, Lovis Corinth, 1901	*Eugénie Nue se Coiffant devant le Miroir*, François Gall, 1912	*In a Mirror*, Mia Darling, 2019
	C2	*Venus Adorned by Graces*, Annibale Carracci, 1590-5	*Margaret before the Mirror,* Manuel Domínguez Sánchez, 1866	*The Mirror*, William Closson, 1889 c.
	C3	*Ritratto di Anna Eleonora San Vitale,* Girolamo Mazzoli Bedoli, 1562	*Woman Massaging her Foot*, Utagawa Kunisada, 1820	*The Awakening Conscience,* William Holman Hunt, 1853

The experiment was coded using jsPsych, an open-source framework used for creating and running behavioural experiments in a web browser developed by de Leeuw (2015). The platform has been growing popularity due to its easy-to-use interface for writing experiments that is much simpler than writing the entire experiment from scratch. In fact, jsPsych not only contains code to perform common behavioural experiments tasks (e.g., displaying a stimulus, getting a response, measuring response times), but also formalizes a structure for describing experiments by writing only a few lines of code. Before starting with the experiment, participants accepted informed consent and provided essential biographical data (i.e., sex, age, educational level). In addition, instructions on the structure of the experiment informed participants to expect seeing images of paintings and be asked questions about them. To prevent possible pressures in the experimental performance, we stated

that the experiment was not going to focus on intelligence or skills but rather on the collection of genuine first-impression opinions. It is important to underlie the fact that participants read a version of the experiment appositely translated in Italian or Spanish, according to their nationality. For convention, in this thesis we will report an English translation of the original text we wrote. Translations in each language will be included in addition in the text.

In Experiment 1 participants were presented twenty-one images of artworks extracted from the CAM, one at a time. Each presentation was divided in two phases. In the first phase a painting appeared followed by two open questions: the first question (Q0) was to simply describe the scene, whereas the second question (Q1) more specifically asked what the main character in the picture was doing. In neither case there was a mention of the mirror.

1) *What is happening in the scene?*
2) *What is the main character in the scene doing?*

[Italian version: 1) “Cosa sta succedendo nella scena?”; 2) “Cosa sta facendo la figura protagonsita?”; Spanish version: 1) “¿Qué está ocurriendo en la escena?” 2) “¿Qué está ocurriendo en la escena?”].

Participants could answer using open-text boxes positioned underneath the questions. There was no

time restriction. By clicking on “Continue” participants passed to the second phase of the trial. Here, they saw again the image of the last trial but this time it was accompanied by the answer they had previously given to Q1 (i.e., “What is the mean character in the scene doing?”) and a question asking to rate their confidence about it. Precisely, participants were asked how much sure they were of the answer they reported. They could drag a cursor on an analogical slider ranging from “Not Sure” to “Sure” to answer: the more the cursor was put on one of the two extremities of the slider, the higher or lower their level of confidence. Only after they positioned the cursor, they could click “CONTINUE” and proceed with another trial.

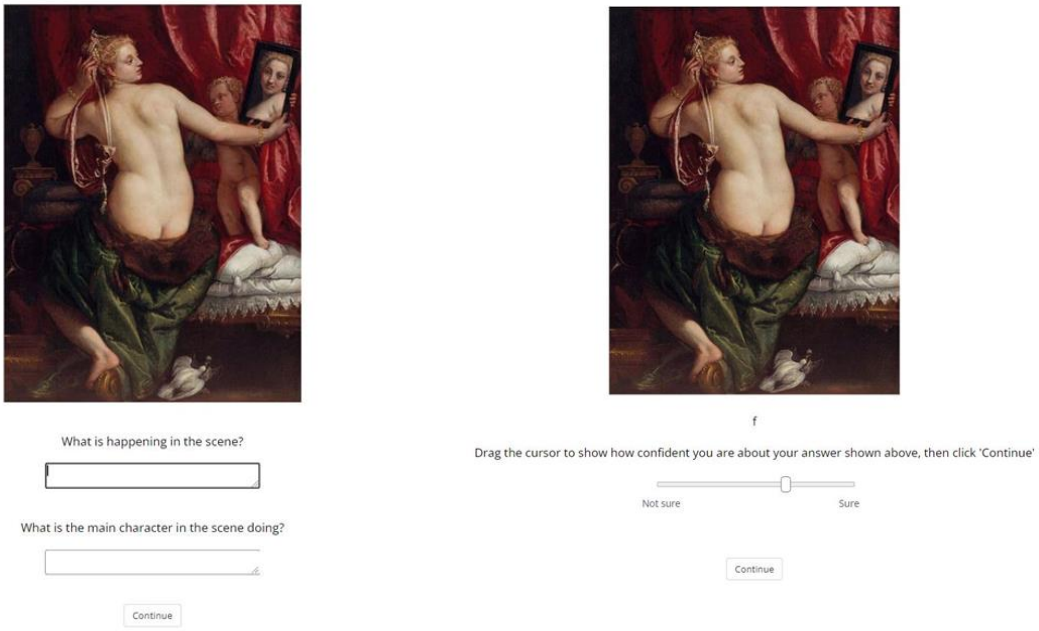

Fig 18. An example of a trial of Experiment 1 and its two phases. First participants saw the image with two questions below it, and then the same image was represented with a request on the confidence about a previous answer.

Both questions of the first phase were designed to elicit descriptions related to the VE. In Q0 participants were asked to report their impressions of what was happening in the scene. Instead, Q1 was more explicit as it aimed at bringing participants’ focus on the protagonist. We hypothesized that if Q0 was sufficient in eliciting a VE effect, then the reference-artwork had reasons to be considered as a strong, evocative example of a VE. Differently, if VE was reported in Q1 but not in Q0, then the

reference-artwork was to be considered a weaker, less evocative example of a VE. The experimental design of Experiment 1 consisted of one total block composed of twenty-one trials presented in succession. Here, by trial we intended the singular presentation of a painting and its two phases, i.e., the display of Q0 and Q1, and the following request of confidence rating. The order of the presentation of the images was randomized to prevent ordering effects.

The data from Experiment 1 were collected on Prolific, and then downloaded and analysed. The open answers were categorized by three judges independently following a precise scoring system. The scoring system provided a classification of 0, or 1, or 2 depending on how much the answers were considered close to a VE description:

2: when the participants described a subject in an act of self-reflection in a mirror to Q0 or to Q0 and Q1

1: when a similar description was reported only in response to Q1

0: when participants did not mention that the subject was self-reflecting

The ratings to the answers were carried independently increase the degree to of inter-rate reliability. The inter-rate reliability among the three judges was consistent both for the Italian and Spanish version.

Table 2: percentages of the agreements between judges in Experiment 1.

Inter-rate agreement	**Italian**	**Spanish**
Judge 1 vs Judge 2	87,13%	92,1%
Judge 1 vs Judge 3	81,89%	88,35%
Judge 2 vs Judge 3	86,56%	93,1%

The process of revision of each answer led to a very careful process of analysis and classification of the words chosen by participants that referred to a VE in the paintings. On the bases of the frequency of some descriptive expression recurring in the answers, some inclusion and exclusion criteria were

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adopted and taken as a common reference for the judges to assign scores. Expressions used by participants too vague, ambiguous, or general, were excluded; instead, words or phrases that were clear and concise in their meaning were included.

Table 3: Examples of expressions commonly reported when describing a VE potential painting.

Language	**Phrasal expressions used by participants**	
SPANISH	INCLUDED	EXCLUDED
	Mirar/se	Arreglar/se (peinarsee, maquillarse) en el espejo
	Ver/se	Estare frente o delante de un espejo
	Observar/se	Señalar su reflejo en el espejo
	Examinar/se	Posar frente a un espejo
	Viendo su reflejo	Jugar en el espejo
	Reflejar/se en el espejo	Sostener un espejo
	Contemplar/se en el espejo	Reflejar (without mentioning the person)
	Apreciar/se en el espejo	Apreciar/se (without mentioning the mirror)
	Admirar/se en el espejo	Admirar/se (without mentioning the mirror)
	Contemplar/se (without the mirror)	Contemplar/se (without the mirror)
ITALIAN	Si specchia	Guarda lo specchio
	Si riflette allo specchio	Posa per il pittore
	Ammira il suo riflesso	Gioca davanti ad uno specchio
	Si ammira allo specchio	Lo specchio riflette
	Si guarda allo specchio	Regge lo specchio
		E' davanti allo specchio
		Si prepara allo specchio

The VE is more similar to a process in which the protagonist actively decides to be looking at their self-reflection. For this reason, we classified as valid those answers containing phrasal periods and verbal tenses used in active forms that described self-reflection as an active, aware process coming from the subject (e.g., "The person is looking at her image in the mirror"). They were classified as "2" (=strong VE description) or "1" (=weak VE description). Instead, answers reporting passive forms were excluded, as they described self- reflection as a passive process coming from the mirror (e.g., "The mirror is reflecting the face of the protagonist figure"). They were classified as "0" (=absence of VE description). It is worth mentioning that, in some answers participants went beyond the description of self-reflection and described a more complex dynamic in which the protagonist figure seemed to be in the act of looking at an imaginary observer or the painter from the reflection in the mirror (e.g., "Una bambina si specchia in modo tale da guardare il pittore attraverso lo specchio" or "una niña sujeta un espejo y mira a través de él"). This description gave us a further insight of the nuance of how dynamics involving mirror and reflection could be perceived by people.

3.4. Results and Data Analysis

Experiment 1 followed a 2x7 levels mixed design. The independent factor "country" had two levels: Italian vs Spanish. The dependent variable "categories of VE" had seven levels: A1, A2, B1, B2, C1, C2, C3. We analysed the experiment using a 3x2 mixed ANOVA (Table 1).

Table 4. ANOVA of the variables in Experiment 1

Effect	DFn	DFd	SSn	SSd	F	p	ges
(Intercept)	1	95	3262198.74	434763.8	712.82	< .001*	0.74
Country	1	95	9520.29	434763.8	2.08	0,15	0.09
Venus Effect	6	570	1037513.90	712617.7	138.31	<.001 *	0.47
Country:VE	6	570	13063.42	712617.7	1.74	0.11	0.01

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The ANOVA analysis showed no significant effect of the factor “country” (F(1,95) = 2.080274, p =0.15), which means that Spanish and Italian participants performed similarly. Differently, the factor “Venus Effect” showed a significant effect (F(6,570) = 138.31; p< 0.001). Therefore, we can assume that there is a main difference between all the categories of VE. The interaction between the two variables “Country” and “Venus Effect” was not significant (F(6,570)= 138.312351; p=0.11). The data are reported also in a graphical plot showed in Fig.19.

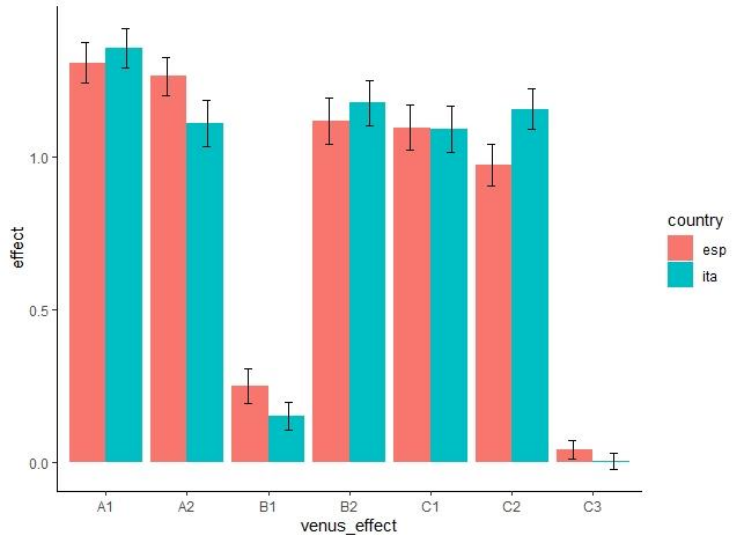

Fig.19 *Histogram of the results in Experiment 1. On the x axis: each VE category tested. On the y axis: measure of the VE weighed by the confidence participants reported for each painting. The bars are specific for group of participants (red=Spanish, blue=Italian).*

Overall, a significant measure of the VE was found in all the categories tested except for C3 (t(96)= 1.35, p-value > 0.05). Although present, the VE in response to B1 was less significative compared to the other categories (t (96) = 5.4688, p-value = 3.59e-07).

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Table 5. T-test results observed for each category of the VE weighted by confidence ratings.

	VE	N	Mean (SD)	t	p
1	A1	291	106 ± 44	27.85	<0.001
2.	A2	290	97 ± 50	20.06	<0.001
3.	B1	290	15 ± 28	5.468	<0.001**
4.	B2	291	93 ± 44	21.72	<0.001
5.	C1	290	85 ± 49	19.41	<0.001
6.	C2	291	88 ± 49	18.90	<0.001
7.	C3	290	1.7 ± 12	1.347	0.2

*Note: Data from Spanish and Italian participants are merged. **=less strong VE.*

Additional analyses were conducted on the comparison of some categories of our interest:

Test comparison A1-C1 Paired sample t test

We were interested in this comparison for evaluating the effect of what is visible in the mirror, given subjects oriented towards a mirror. Whereas in A1 we see the portrait of the reflected face displayed in the mirror, in C1 we don't because the mirror portrays some vague parts of the body. A paired- t test comparing the confidence ratings of A1 and C1 revealed a statistically significant difference ($t(96)=4$, $p<0.001$). The effect was a result of images in category A1 receiving a higher rating score (M(SD)= 106± 44) compared to images belonging to category C1 (M(SD)= 85 ± 49). This means that, participants are less accurate at infer that a subject is looking at their reflection in the mirror when their face is not portrayed in the mirror. The description of the action of someone looking in the mirror becomes less probable.

Test comparison A1-A2 Paired sample t test

As expected, the mean difference between the confidence scores of A1 (M(SD) 106 ± 44) and A2 (M(SD) 97 ± 50) did not result statistically significant ($t(96)= 2$, $p=0.08$). This suggests that the portrait of the reflected face in the mirror, whether framed or not, does not generate differences in the strength of a potential VE.

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3.5 Experiments 1' discussion and possible limits

The results of Experiment 1 confirmed that VE in visual art is not so immediate and univocal to perceive. People's descriptions of VE varied: VE was stronger for some paintings than others. This was in line with our hypothesis, which proposed that VE shall not be considered as a univocal phenomenon, but as distributed in different categories of strength. The effect would not emerge just from an interplay between a mirror and a person, but rather from an interaction of different layout parameters (including the interplay mirror-person). We expected participants to report an immediate VE description (i.e., in Q0) in response to paintings we categorized as strong (i.e., category A). We expected participants to report weak or confused descriptions of VE in relation to paintings we categorized as ambiguous (i.e., category B). Lastly, we expected participants not to report a VE in paintings we classified as non-descriptive of a VE (i.e., category C).

A possible reason behind a weak effect of the VE in response to category B1 may rely on the fact that the paintings in this category portrayed people not oriented towards the mirror but in a somewhat interaction with it; basically, although the figures did not look directly at it, the mirror was put in a position so that it could reflect them. The weak VE effect observed in B1 may be indicative of the relevance of the factor of orientation of a person towards a mirror when interpreting reflections.

CHAPTER 4
Experiment 2: Individual differences involved in the Venus Effect

4.1. Introduction

In the revision of the open answers of Experiment 1, incongruencies between our categories and participants' responses were found. Although most participants correctly performed as we predicted, a minority did not: in a few cases participants failed to report a VE at all. What factors could possibly count as responsible of such differences? Experiment 2 was carried out to explore possible factors modulating the interpretation of a Venus Effect in different contexts. Our hypotheses mainly concerned the ability of visual perspective taking (VPT), and the mental representation of the space.

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In the first part of the study, by presenting three artworks, we collected participants' responses. In the second we tested participants' personality traits through the Autism Quotient Questionnaire (AQ). Finally, in the third part we assessed participants' mental spatial representation by administering the ROMP (Room Observer and Mirror Perspective Test), a cognitive spatial task. Participants selected (circled on paper) which objects behind the observer in the room were visible, reflected from the mirror and from a given position (viewpoint).

Experiment 2 was designed to go beyond the theoretical framework of VE discussed in Experiment 1, and investigated the possible factors involved in the influence and modulation of visual perspective taking (VPT) in VE contexts. The two main hypotheses involved the influence of personality traits on one side, and the influence of cognitive reasonings on the other. The first hypothesis was investigated both explicitly by collecting participants' subjective opinions on VE visual art examples personality questionnaire, and the last section consisted of a cognitive spatial task. We assumed that one can tell what Venus is seeing in the reflection only if the process of visual perspective taking takes place. Consequently, given that Theory of Mind may play an important role when considering a non-egocentric viewpoint, we believed that some forms of perspective taking might impact the correct perception of a visual scene. We explored possible correlations by administering the "Autism Quotient Questionnaire". On the other hand, a second hypothesis concerning misperception might as well depend on how people cognitively represent the space around them. To have allocentric or egocentric conceptions of space may cause different ways to perceive it. Possibly, a wrong cognitive spatial orientation might help understand the bases of VE as visual misperception.

4.3 Method

4.3.1. Participants. One-hundred participants took part in the experiment. The participants were recruited online using Prolific and were divided in two equal groups: fifty of them completed the Italian version of the experiment (mean age: 26,9± 8,37), and other fifty completed the Spanish version (mean age: 27,45 ± 8,76). On average, participants received £8.09/hour compensation for completing the task.

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The two groups were balanced for sex (male, female, not specified), and filtered for previous participation to Experiment 1. Before starting with the experiment participants were assigned a Prolific ID, accepted the informal consent for taking part, and provided basic biographical data (gender; age; level of scholarity).

4.3.2 Stimuli and procedure. The study was divided in three parts, each one designed to test the influence of a different factor: subjective description, personality traits, and cognitive spatial ability.

FIRST PART

The first part repeated the procedure of Experiment 1; again, participants saw artworks from the CAM and by answering to some questions, expressed opinions upon them. Differently from Experiment 1, this time the selection of images relied exclusively on examples of category A for their VE strength (i.e., "Venus with a Mirror" by Paolo Veronese, "Venus at her Toilet" by Jan van Kessel the Elder, and "Julie Le Brun Looking in a Mirror" by Vigée Le Brun) (Fig.20).

Fig.20 Paintings of category A presented in Experiment 2: Venus with a Mirror" by Paolo Veronese, "Venus at her Toilet" by Jan van Kessel the Elder, and "Julie Le Brun Looking in a Mirror"by Vigée Le Brun.

Following the same procedure of Experiment 1, the participants first answered to QO and Q1 and then were asked to provide a measure of confidence on their last answer (i.e., Q1: "what do you think the protagonist figure is doing in the scene?"). They could answer by dragging cursor on a slider ranging from "sure" to "not sure at all". The ratings of confidence were converted in a numeric scale ranging

from 0 to 100. The answers reported by participants were reviewed and classified with the same scoring system adopted in Experiment 1: a scoring of 2 was given when a VE was already described in response to Q0 or to both Q0 and Q1 (strong effect); 1 was assigned every time a description of VE appeared only to Q1 answer (weak effect); 0 was assigned when no VE descriptions were reported.

SECOND PART

The second part consisted in the administration of the Autism Quotient Index Questionnaire (or AQ), a valuable instrument for rapidly quantifying where any adult is situated on the continuum from autism to typical-development (Baron-Cohen et al., 2001). The AQ is designed to be self-administered and for adults (16 years or over) with normal intellectual functioning. It comprises 50 statements assessing 5 different clusters: social skill, attention switching, attention to detail, and communication. For each statement, participants could answer how strongly they would agree or disagree. Items are summed to obtain an overall total score and scores for each of the five subscales. A score above the proposed cut-off of 29 highlights indicate responses that are more consistent with autism traits, and correlation with neurodivergence (Broadbent, et al., 2013). Specifically, higher scores on social skill and imagination subscales would indicate, respectively, social skills deficits and difficulty in abstract thinking, which we think are important in the context of VE Individuals who score high on the AQ may be less able to know what a person sees, but they may also be less likely to make inferences of any type. Because of that they may not be subject to the Venus effect, which by definition is an interpretation of the scene and of what Venus can see.

THIRD PART

Finally, the third part of Experiment 2 consisted of a reasoning spatial task (Room Observer and Mirror Perspective: ROMP). This task explores the ability of visual perspective taking in relation to mirrors' reflections (Bertamini et al., 2010; Soranzo et al., 2018). Here, individuals were asked to decide which objects along a wall of a room are visible to a person facing in the opposite direction, given that a mirror is present on the wall facing the person. The procedure is based on a top-down map of a room and a drawing showing the position of the person and of the mirror. When the position of the

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observer is to the left of the mirror, they could see the objects to the right, and when the observer is to the right, they could see the objects to the left. Fot this experiment, we re-created the ROMP in a digital version using JavaScript and jsPsych (Fig.21).

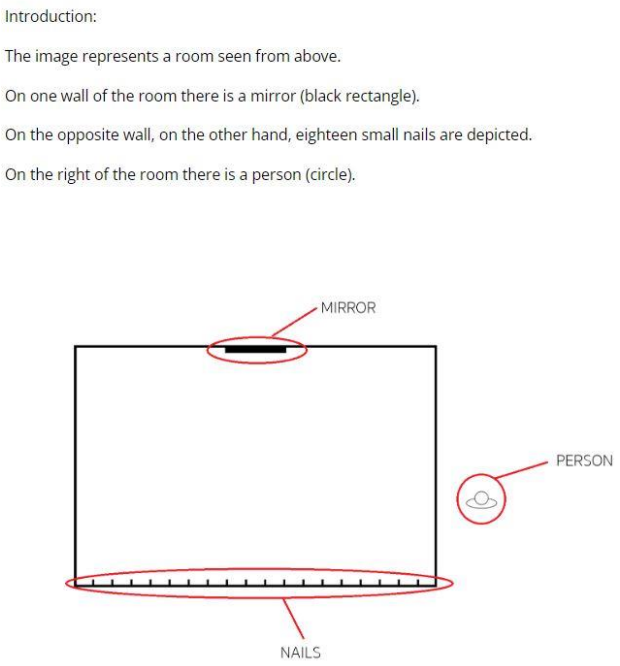

Fig. 21 The Room Observer and Mirror Perspective test (ROMP) task. Participants saw a diagram of a room seen from above with a mirror on the front wall and eighteen little nails on the back wall. Outside the room there is a person oriented towards the front wall. The introduction was followed by the instructions of the task.

The ROMP task was presented in two different layouts, depending on whether the person was portrayed to the right or to the left of the mirror (from observer's perspective). In "ROMP Left" the person was shown to the left side of the screen, and in "ROMP Right" to the right side of the screen. In both conditions, ROMP was followed by the question "Imagine that the person is looking towards the mirror: which nails can the person see reflected?". To answer, participants selected the nails by clicking on them; each time a nail was selected it became red. After the selection participants could either click "CONTINUE" to proceed with the experiment, or "CANCEL SELECTION" to eliminate their last selection and make a new one.

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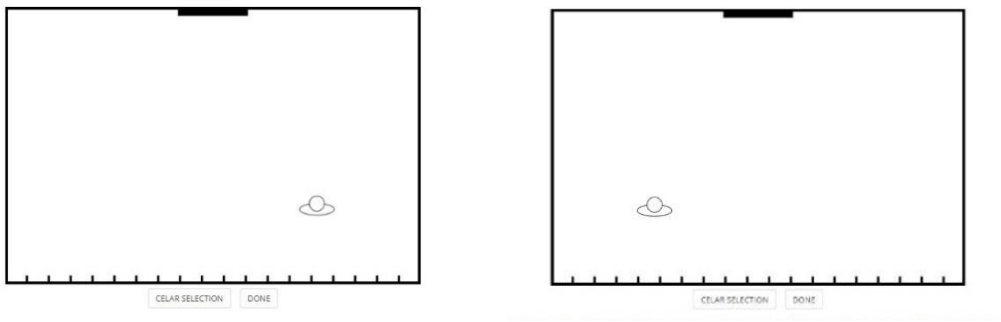

Fig.22 The ROMP task is to select the nails on the wall that are visible from the observer's point of view. We used two different scene layouts, presented one at a time; the observer could appear to the left or to the right side of the mirror. For the observer on the left, the visible nails are 5-9; for the observer on the right the visible nails are -9 -5.

The design of the ROMP involved the manipulation of three different factors. The first factor was **Nationality** type: as already mentioned, there was a group of 50 Italian participants and a group of 50 Spanish participants that completed the ROMP task. Because each participant saw two possible layouts scenes portraying the observer to the left side or to the right side of the mirror, this within-subjects factor was called **Observer Location** type. The order of presentation of left and right locations was kept between-subjects (**Observer Location Order** type factor). Within each group of participants, two subgroups of 25 Italian and 25 Spanish subjects completed first the Right Observer Location and then the Left Observer version of the ROMP, and the remaining 25 Italian and 25 Spanish subjects completed in the reversed order, first the Left Location version and then the Right Location one; this manipulation aimed at counterbalancing possible ordering effect. In total the factors were: Nationality (Spanish or Italian), Observer Location (left and right), and Observer Location Order (first Left – then Right, or first Right then Left).

The position of the nails in the diagram was coded using negative and positive numbers starting from the left, the nails were coded as -9, -8, -7. -6. -5 -4 -3 -2 -1, and then continued to the right side of the wall as 1, 2, 3, 4, 5, 6, 7, 8, 9. The scores of the ROMP were calculated considering the position of the selected nails (position score), and the amount of the nails selected (sum score). The first score, "position score", had to do with two visual perspective sensitivities. The first is sensitivity of viewpoint, occurring when people show the ability to recognize and consider that another observer, standing in a

location, has a different viewpoint. Therefore, because of viewpoint sensitivity we expect participants to select different positions for nails depending on the position of the observer (as an effect of Location). The second is sensitivity to optics, which refers to the ability to recognize that a viewpoint on the left makes objects on the right visible and vice versa. For this score we expected participants to select the nails in positions -9, -8, -7, -6, -5 for the Right Observer Location, and nails in position 5, 6, 7, 8, 9, for the Left Observer Location. As a simple value we summed the valued of the nails selected but setting to zero the values of the nails in the middle. This was done so that the total values would range from a maximum of 35 (9+8+7+6+5) to -35 (-9-8-7-6-5) and it was only possible to obtain the maximum by selecting all the correct nails. More importantly, this summary value measures the direction of the response, the more positive (negative) values correspond to responses on the right side (left side). A value of zero is a symmetrical selection of nails on both sides.

We also computed a different measure for the total number of nails. The values here can go from zero to 18. In this case, the correct amount is five nails in both the Right and the Left Observer Location conditions.

4.4. Results and Data Analysis

Overall, Spanish and Italian participants performed similarly. Because we did not find differences between their data, we merged their results.

FIRST PART

The paintings presented in the first part were selected from category A of CAM to increase the possibility of a VE description. As we expected, the results revealed a strong VE in response to each one of them. The VE was weighed by the rating confidence reported by participants (Fig.23).

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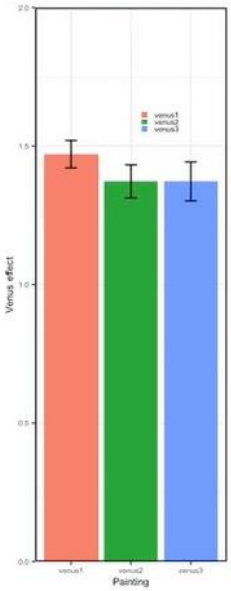

Fig. 23 VE strength presentation of the paintings (colorful bars), and the VE reported by participants weighed by their confidence. The VE resulted strong in each painting.

SECOND PART

The results of the AQ performances did not show an effect of gender. Correlations between the AQ and the other two parts of the test are reported in Fig.26. No significant correlation was found between AQ scores and strength of the VE ($p=0.920$). Though a significant positive correlation was found between AQ and ROMP score, $r(148)=0.170$, $p=0.033$.

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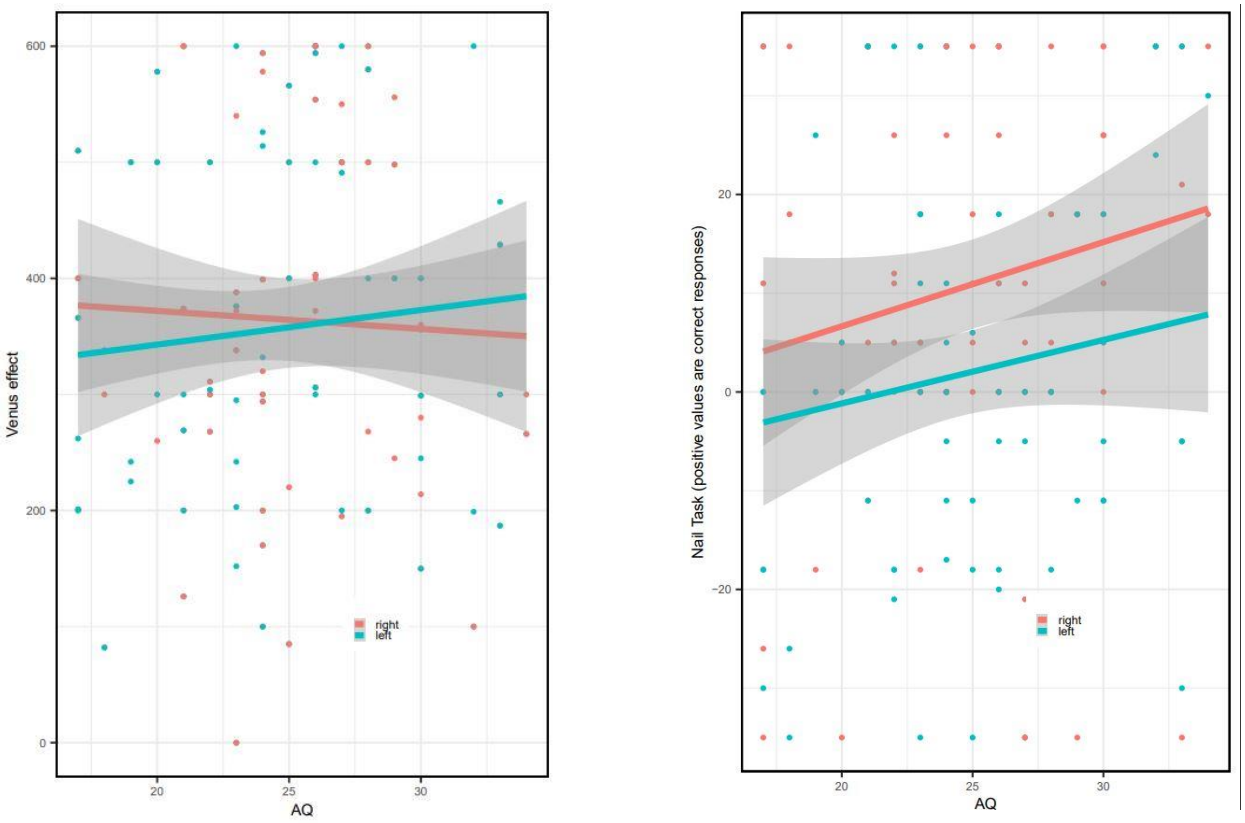

Fig. 26. The first graph on the left describes correlations between AQ and the Venus Effect weighed by confidence. The second graph correlates the performances between AQ and the ROMP task (here indicated as "Nail task"): participants who obtained a high score on the AQ performed better in the ROMP task.

THIRD PART

In the ROMP task the fixed factors were the variables Country (Spanish vs Italian), the Observer Location (Left Side vs Right Side), and the order of presentation of the ROMP (first Left Side version then Right-Side version vs first Right-Side version then Left-Side version). The dependent variables were the number of nails selected (Sum Score) and the position of the selected nails (Position Score).

Considering the **Sum Score**, participants correctly selected on average the amount of five nails for both Left-Side and Right-Side version of the experiment. (Fig. 27 A) This graph does not include a measure of the accuracy of the case of the Left Observer Location: participants clicked on the positive numbered

nails, i.e., those showing on the right side of the screen. **Position Score (correct direction)**: the selection of the nails in the correct direction was distributed with more accuracy in the Right Observer Location, i.e., when participants had to select the nails on the left side of the screen (Fig 27 C).

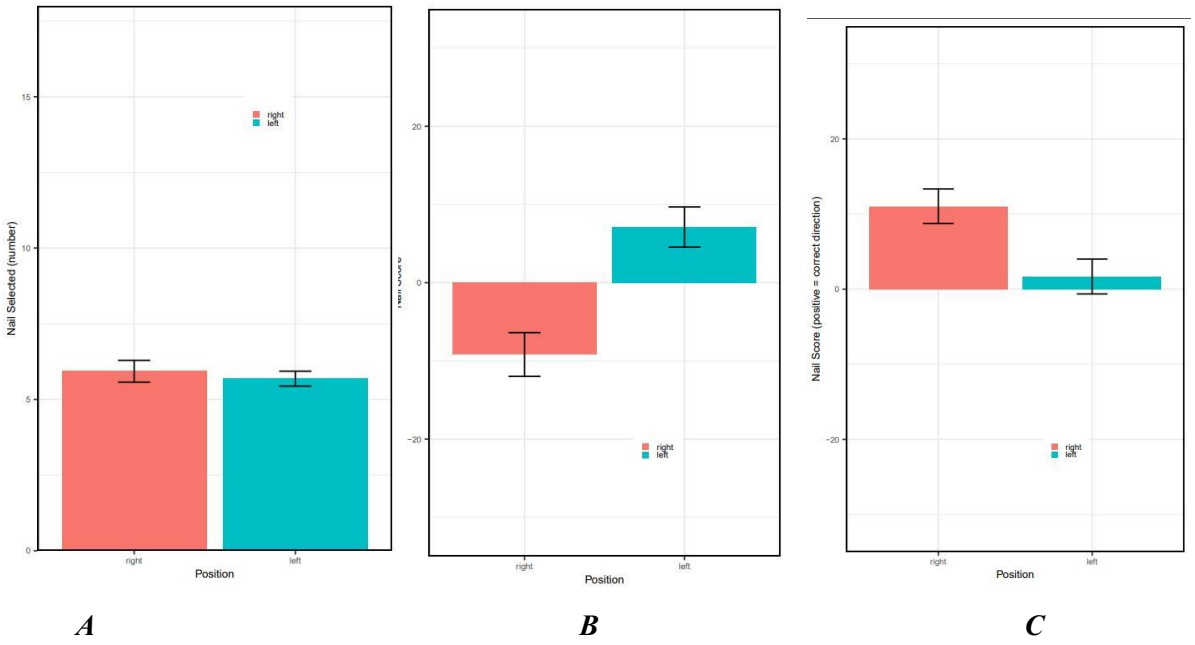

Fig. 27 *Results of the Nail Task. A) The error bars are ±1SE for the mean. A) Sum Score B) Position score C) Position Score considering the correct direction of the nails' position.*

4.5. Experiment 2's discussion and possible limits

Overall, no correlations among factors resulted significative except for the correlation between the VE score assigned to the answers of the participants and their confident ratings. This was expected, because the three paintings presented were extracted from the category A, which was supposed to be the strongest in the generation of a possible VE. Therefore, the high scores assigned to descriptions of the VE resulted coherent with high confidence ratings reported by participants.

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Table: Correlations between the factors examined in Experiment 2.

Variables	M(SD)	1.	2.	3.	4.
1.AQ score		1.000	-	-	-
2.VE		-0.008	1.000	-	-
3.VE Conf.		0.024	**0.9168****	1.000	-
4.ROMP Position Score		**0.170***	-0.1236	-0.1237	1.000

*Note: * p<0.05, ** p<0.001*

4. Conclusion

This thesis is a first exploration of the VE conceived as a multi-facet phenomenon that arises following different grades of strength. Although literature confirmed VE cases in response to real-life set-ups, photographs, and movies, we decided to investigate VE in the pictorial context. We proposed that participants would provide immediate (i.e., strong) descriptions of a VE depending on what type of layout subject-mirror they were seeing in a painting. We proposed a series of categories of paintings portraying subjects-and-mirrors that could be representative of seven different examples of layouts reported in art. We collected more than three-hundreds paintings images in a catalogue, the CAM, all categorized for different combinations of figures interacting with mirrors and reflections. The CAM in this thesis was used as a reliable set of data of potential VE paintings, from which it was possible to extract paintings each classified for a different category of strength. We believe that the CAM may become a reliable open-access catalogue online for future work studies on VE. We tested our categories of the VE in Experiment 1. The aim was to see whether our division in categories for VE strength could find correspondence in participants' descriptions of paintings. We noticed that effectively, the layouts of certain categories of VE did elicit stronger VE descriptions compared to others. This means that participants produced VE reports more immediately in response to some paintings than others. Overall, the difference in categories was not exactly replicated by participants: results confirmed that the effect

is robust and present in the vast majority of the population. Our categories differed classes of strength of VE for parameters such as what was visible in the mirror, the inclination of the mirror, and the orientation of a subject towards a mirror. The only case in which VE was less likely to arise was in response to paintings of category B1, which contained paintings with subject not oriented towards a mirror. This led us to consider the subject's orientation towards a mirror as a parameter that is determinant for perceiving a VE. Besides, another category, C3, did not show a strong VE: this was reasonable, as it was classified as lowest in VE strength. Moreover, C3 did not portray any active interplay between the subject and the mirror, the mirror was just part of the background. Future research may be dedicated to the study of these categories on many independent judges, as to increase the internal and external consistency of each one of them. Some of the differences could be due to a different way of categorizing the paintings, maybe considering different parameters. Our categories division requires confirmation from future work. Moving to Experiment 2, our intent shifted to the exploration of modulating factors involved in participants' perception of VE. To explore individual differences, we used the AQ, and a spatial perspective task that also is known to produce errors (Room Observer and Mirror Perspective test: ROMP). Results showed that no correlations resulted significant. Particularly, high scores on AQ correlates with correct responses on the ROMP task. This was unexpected. Because high scores on the AQ indicate consistent struggle in understand someone else's viewpoint, as well as struggle with assigning a mental state to an inanimate object, we expected worse performances on the ROMP task. However, there is some evidence of a relative advantage that ASD children have in engagement with anthropomorphic stimuli. They tend to anthropomorphize non-human agents more than controls (Atherton & Cross, 2018). This may explain good performances in the ROMP task, as the character used in it ("Observer") was meant to be considered as a person, not an inanimate object. Different versions of ROMP tasks have been already proposed in literature as a tool to study the role of different agents (animate vs inanimate) in the ability of Visual Perspective Task ability (VPT). For this reason, future research could investigate possible correlations between high AQ scores (predictive of ASD traits) and ROMP task versions with inanimate objects (e.g., teddy bear used in Soranzo et al., 2018, camera used in Bertamini et al., 2018) in an adult population.

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