Perceptual Media, Glass and Mirrors[1]

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Now there clearly is something which is transparent, and by 'transparent' I mean what is visible, and yet not visible in itself, but rather owing its visibility to the colour of something else; of this character are air, water, and many solid bodies.

Aristotle, De Anima (On the soul), II, 7, trad. J. A. Smith

Abstract :

In this paper, I argue that perceptual media like air or water are imperceptible, in the sense that they are not directly discriminated by our senses. I show that, despite their lack of phenomenological features, perceptual media crucially affect what we see by selecting what is perceptually available to the perceiver.

In the second part of the paper, I argue that mirrors are visual media like air, water and glass. According to this account, mirrors are transparent and invisible and cannot therefore have a distinctive look or appearance. In the last part of the paper, I extend the general account of perceptual media to the sense organs themselves by showing that perceptual media not only include external entities causally involved in the perceptual process but also comprise the perceptual system itself.

In this paper I argue that perceptual media generate causal perspectives. The spatial position of the observer determines what the observer perceives. in the same way,

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perception varies according to the medium in which it takes place. The perceptual medium is a crucial element of perception, and its omission renders philosophical accounts vulnerable to paradoxes and mistakes.

Perceptual media have been largely neglected by philosophers, most likely because media are not perceived in the same way the objects of perception are. We see the tree in front of us and hear the bird hidden in its leaves, but we do not see or hear the air in which those perceptions take place.

Although media are not perceived, they fundamentally shape the way we perceive. The essential role of media in perception can be noticed when we change from one medium to another. In diving, for example, our vision is dramatically modified, and although we do not *sensu stricto* see the water surrounding us, we notice that seeing underwater affects the way we see things.

In this paper, I will argue that visual media are invisible. This claim appears to be quite trivial once the distinction between media and objects of perception is drawn. If the medium is defined as what causally mediates the relation between the object of perception and the perceiver, it cannot be perceived; if it were perceived, it would be considered an object of perception and not a medium. But such an argument is in fact too thin. It could be objected that the distinction between medium and object of perception is not exclusive and that something can be both a medium and an object of perception. In fact, that is what the perception of coloured transparent objects seems to show: although we can perceive their colour, their transparency mediates the perception of the objects we perceive through them. Contrary to what is suggested by this account of transparent objects, I will show that visual media are essentially invisible and that we perceive only the objects they mediate.

I claimed above that perception is shaped by the medium: vision underwater differs from vision in open air. But if the medium is invisible, how can it affect what we see? I will argue that each perceptual medium or combination of media corresponds to a particular causal perspective. What we see through different media differs, because we see different things. When we look into a microscope, we do not see the properties of the lenses used to magnify the objects. What we see with a microscope is a part of reality that is not visible to the naked eye.

Although mirrors are not physically transparent, the experience of seeing something in a mirror has many similarities with perception through transparent objects. In the last part of the paper, I will explain those phenomenological similarities by extending the proposed account of perceptual media to mirrors. I will show in particular that mirrors, like the other visual media, are, in a sense to be explained, invisible.

1. Perceptual Media as Causal Intermediaries and Filters

Following Brentano, most philosophers agree that perception is intentional[2]. According to Brentano, every mental state, such as loving, hating, desiring, believing, judging, hoping, and perceiving, is characterized by its intentionality, the fact that these mental states are directed toward things different from themselves. Thus, when I see a table, my perception of the table has two components: the act of seeing and its intentional object, the table.

However, many philosophers consider perception to be more complex. Although it may seem that we directly perceive the table in front of us, it has been argued that a

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[2] I will use the term "intentional" only to indicate that perception is directed or points towards something else. I will not use it to defend a more Brentano-like theory of perception which holds that intentional objects are inexistent, i.e. existent in the mental act itself (cf Barry Smith 1994:41)

scrupulous analysis shows that ordinary objects, like tables, are only indirectly perceived. In fact, indirect realists claim that when looking at an everyday object, we do not see that object directly, but rather a perceptual intermediary. Depending on the particular version of indirect realism defended, perceptual intermediaries have been identified with various entities: ideas, sense data, contents, appearances, etc.

Whatever version of indirect realism is defended, perceptual intermediaries are supposed to explain the phenomenology of perceptual experiences. It is argued in particular that if veridical and non-veridical experiences can be phenomenally alike, it is because the way things look is determined primarily by some perceptual intermediaries and not by the ordinary objects in the external world that we naturally take ourselves to be aware of.

Whereas perceptual intermediaries, like sense data or sensations, have been extensively discussed in philosophy and science, there is another kind of perceptual intermediaries which are almost entirely ignored by philosophers: the perceptual media.[3] The aim of this paper is to partially fill this gap.

Unlike typical perceptual intermediaries like sense data or sensations, perceptual media cannot directly enter into the phenomenal content of our experiences. Quite the contrary. Whereas perceptual intermediaries are supposed to specify the way one's experience is, perceptual media have been postulated to explain how there can be causal intermediation in perception *without* perceptual awareness. Consider the air in which most of our perceptual experiences take place. Most of the time, air is colourless, odourless, tasteless, and inaudible. And the reason it is this way is not merely trivial.

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[3] Some notable exceptions are Heider (1959), Gibson (1986), Casati et Dokic (1994), Casati (2000), Massin & Monnoyer (2003).

From a purely physical point of view, air is far from causally inert. As we know from our experiences with planes, air exerts pressure. But it also interacts with light and propagates sound waves. Despite its major causal role in our environment, we tend to ignore its presence and almost never perceive its characteristics. How is this possible and why?

Reflecting on the fundamental inability of the causal theory of perception to explain why we see an object in our proximity rather than the sun, which is at the causal origin of our visual perception, Fritz Heider (1959)[4] made a major contribution to explain the essential role played by media in perception. Heider's work maintains that perceptual media are causal intermediaries: their perceptual role is to convey perceptual information from the perceived object to the perceiver. It is crucial that media, as intermediaries, do not interfere with the information they convey. Otherwise the information would not be about the perceived object but also partially about the medium itself. As stressed by Heider, "the configuration of light rays which meets my eyes, is coordinated to the object, the stone, in a special way. Even a small change of the surface of the stone changes the stimulus configuration. It is not coordinated to any specific properties of the mediator."

Although it is correct to say with Heider that the medium does not impose its own structure on the information it conveys[5], there is nevertheless a clear sense in which the medium directly affects what is perceived. In order to grasp the role of media

[5] To avoid any confusion, I would like to stress that to say that a perceptual medium does not interfere with the information it conveys does not mean it is causally idle. Quite the contrary. The perceptual medium is an essential part of the causal process involved in perception. As a causal intermediary, its role is to causally transmit perceptual information, like shapes, colours, sounds,... Each medium has its own causal characteristics which determine what kind of information it can transmit. But, as I will try to show, there is no good or bad perceptual medium, but only different media transmitting different kinds of perceptual information.

in perception, one should first realize that the causal texture of our environment is enormously complex. We see coloured surfaces, we hear sounds and smell odours, but a large number of causal processes that take place right before us are not directly accessible by our senses. For example, we don't perceive radioactivity, geological changes, or most electromagnetic processes. The reasons for our relative blindness to the complexity of the causal texture of reality are multifaceted, but Heider’s notion of perceptual media is an invaluable resource for explaining how perception extracts information from this inextricable web of causal relations.

Although we rarely feel its presence, air is the most vital element of our environment. With very few exceptions, since our birth and until our death, we are permanently surrounded by air. It is therefore unsurprising that most of our senses rely on air to acquire information about the world. From a physical point of view, the way air contributes to the transmission of information varies greatly with the causal interactions involved. To travel from their source to the ears of the listener, sounds must travel through a material medium like air or water. Sound propagation is in effect a repetitive disturbance of a medium's particles. Once the first particle of the medium is set in motion by the disturbance of a vibrating object (the source of the sound), the sound wave is propagated through the air by means of a chain of particle-to-particle interactions.

Light transmission through air, on the other hand, does not rely on the air particles. Quite the contrary. Unlike sound, light doesn't need material particles to travel. In fact, it is only in a vacuum that light reaches its maximum speed. Air is a gas and, as with all gases, its particles are very far apart from each other. As a result, light can pass through it without hitting too many particles. Therefore, air functions as a medium for light and sound transmission for different and even opposite reasons. Air can serve as a medium for sound because its particles can interact with each other and transmit the initial disturbance through the medium, whereas it can serve as a medium for light because the scarcity of its particles allows light to pass through almost unchanged.

The kind of causal process involved in a medium is therefore directly correlated to the kind of information it conveys. Consider water. Like air, water is a medium for sound and light, but it is also a good electricity conductor.[6] It is therefore unsurprising that electroreception is largely found in aquatic animals. In fact, it appears that the capacity to detect electrical signals in the environment arose early in evolutionary history, but was then lost in those vertebrates that crawled onto land, because air, a poor medium for electricity, replaced water as their natural habitat. Perceptual media enable the transmission of information, but they also select what kind of information is available to the perceiver. The main thesis of this paper is that the perceptual variations induced by perceiving through different media are always correlated to a change of the kind of information available to the perceiver. If the snow appears yellow when I'm wearing ski goggles, or if lukewarm water seems hot when my hands are cold, it is not because the medium interferes in some way with the information it conveys, but because the type of information accessible through those different media is not the same.

In the same way as the position occupied by the observer determines a spatial perspective, the medium in which perception takes place determines a causal

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[6] More accurately, only water that has minerals, dirt, or any other particles in it is a good conductor. Pure water devoid of minerals is unable to conduct electricity.

perspective. Visual experiences essentially involve visual standpoints which determine the visual appearances of objects: a coin appears circular or "elliptical"[7] depending on its orientation to the observer. We can similarly say that perceptual experiences involve causal standpoints which determine what kind of information is available to the observer : snow appears white or "yellow"[8] according to whether the observer is wearing sunglasses or not. As will be explained in 3.1, colour filters like sunglasses determine which colours are perceptually available to the observer by selecting which wavelengths can enter the eye of the observer.

Like spatial perspectives, there are no right or wrong causal perspectives. But all perceptions are essentially perspectival in the sense that they present their objects from a particular point of view. The fact, for instance, that we may notice a huge difference between a drop of blood seen through a microscope and the same drop of blood seen with a naked eye does not indicate that one of these appearances is misleading. The same drop of blood looks different through the microscope and with the naked eye because, the kind of information accessible through these different media is different. Like spatial perspectives, causal perspectives are objective and mind-independent. They correspond to the fact that perceptions always take place in a particular medium (or a particular combination of media). A particular spatial point of view determines a

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[7] While it is common practice to say that a coin can appear elliptical from a particular point of view, it is misleading. Whatever its orientation, a non-illusory appearance of a coin is not elliptical but circular. By changing the orientation of the coin, we change the relative distance between the different parts of the coin and the observer. It is those objective differences of distance which account for the differences of appearances exhibited by the coin, not a difference in its shape.

[8] Like with the use of word "elliptical" when describing a change of orientation, the use of common colour terms to describe a change of perceptual medium is misleading. By wearing sunglasses, the appearance of the snow change, but it is not like the snow appears suddenly to be yellow like a ripe banana. The change of causal perspective involved by the change of perceptual medium cannot be captured by the common colour terms because their uses are anchored in the way we refer to colours in "white" light without filters.

particular spatial field which delimitates what is perceptually accessible for the observer at that particular location. Likewise, we can say that by transmitting particular causal processes but not others, perceptual media determine causal perceptual fields which delimit what is causally accessible for the observer.

2. Transparency, translucency, opacity and blurriness

I have claimed that visual media like air, water and glass are transparent and invisible. Although most people would agree that the transparency of a flat pane of glass makes it invisible, few people would generalize this claim and maintain that *all* transparent objects are invisible.

Take for instance an empty glass standing on a bar counter. The glass is colourless and transparent, but it is also visible since it can be pointed at to the server when asking for a refill. [9] Translucent objects, like a window covered with mist or a fine cloth, are also plainly visible and transparent. They are permeable to light, allowing the background to be seen through them, whilst also having a visible shape and colour. Finally, all coloured transparent objects and substances, like tinted Murano glasswares or pints of lager, appear to be both transparent and visible.

Contrary to a more ordinary view, I will argue that these particular cases do not directly threaten the claim that transparency and invisibility are essentially connected. Although these different objects and substances appear to be both visible and transparent, I will show that their apparent visibility corresponds to very different phenomena which needs to be explained by the very nature of the objects and substances they involve.

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[9] I will take vision to involve a conscious acquaintance with sensible qualities, like colours and shapes. On this account, for something to be visible it must exhibit qualities directly discriminated by visual organs and phenomenally accessible to the subject.

Transparent and apparently visible objects and substances belong to three different categories:

1) transparent and coloured objects/substances

2) transparent and colourless objects/substances

3) translucent objects/substances

1) The case of transparent and coloured objects will be examined in the next section where I will argue that transparent objects have no colours and that what appear to be transparent coloured object are in fact filters that modify the way colours are perceived. Although we can locate "coloured" transparent objects by the way they locally affect the way we perceive colours[10], we do not directly see transparent objects in virtue of their own properties.

2) The case of visible colourless transparent objects points to another difficulty involved in our perception of transparent objects. Unlike "coloured" transparent objects which change the way we perceive colours, the presence of colourless objects is not revealed by the chromatic discontinuities they create in our environment but by the way their surface interact with light. Like any glossy object, the boundaries of a transparent object can be perceived through the reflection of light at its edges. Most hard polished surfaces are in effect specular and therefore reflect some light. That is the case of most transparent objects whose reflections are strong at glancing angles but weak at more front on angles. The contours of transparent objects, even if colourless, can therefore be seen due to the reflective properties of their surface. Should this fact constitute a problem for the claim that transparent media, like glass, are invisible? I don't think so

[10] Typically, a white piece of cardboard appears yellow when it is seen through a glass of beer and pink when it is seen through a glass of rosé.

and here is why. First, reflections occur when the light is not completely transmitted by the medium and therefore when the medium is not completely transparent. Transparency and reflection are in effect opposite phenomena. A perfectly transparent medium would not reflect light and would not therefore be visible. Second, the region of the glass we can perceive by perceiving the specular properties of the glass (typically the edges) are not perceived as being transparent. Therefore, transparency and visibility are exclusive even when these properties are attributed to a unique object[11]. An object can then be partially visible and invisible depending on what region of the object is perceived. According to the view of visual media defended above, we can say that an object made of glass is a visual medium when it is transparent and allows other objects to be perceived through it. But when its surface, or part of it, becomes visible, it partially or totally loses its transparency. In that case, the object, or a part of it, cease to be a visual medium and become the direct object of perception.

3) Like many visual properties, transparency (or opacity) is a matter of degree. The gradualness of transparency/opacity makes its phenomenology rather difficult to describe. This difficulty is exhibited by the phenomenon of translucency which characterizes an object that is only partially transparent. Unlike the case of an empty glass which can be seen by the reflections on some particular regions of its surface, a translucent object, like a frosted window or a fine cloth, is seen while remaining uniformly transparent, i.e. we don't see the translucent object in virtue of seeing a

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[11] The fact that reflections are visual obstacles is common knowledge. Fishermen for instance know only too well how the glare coming off the water makes it impossible to see objects below the water surface, therefore greatly affecting their fishing performances.

specific region of its surface[12]. Should we therefore say, contrary to the view defended above, that a translucent object is both transparent and visible? Well, we could say that, provided that we underline the fact that transparency and visibility are opposite properties : the more an object is transparent, the less visible it is, and vice versa. If an object can be both transparent and visible, it is therefore because it is not completely transparent and not completely visible. An interesting property of translucent objects is their blurriness. Unlike the perception through a transparent object (colourless or "coloured"), the perception through a translucent object is blurry. I suggest that the correlation between blurriness and opacity (or better, between blurriness and non-transparency) can be understood by examining the role of visual medium played by transparent materials. As visual media, transparent materials, like glass, are causal intermediaries : they transmit light without changing the configuration of light rays. The case of translucent materials is quite different. Although, they transmit light like other transparent materials, they also scatter the light, hence destroying the configuration of the incoming light and imposing a new arrangement of light rays. Depending of how much light it transmits and how much light it scatters, a translucent material is more or less transparent.

Now it appears that the more a material loses its transparency by the scattering of the light, the more blurred our perception is of the objects seen through this material. I suggest that the correlation between blurriness and opacity is explained if blurriness corresponds to a loss of information as proposed by Tye:

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[12] Of course, a translucent object can be glossy and therefore also exhibit specular reflections. But, unlike completely transparent objects, translucent objects can be seen without seeing reflections of this kind.

> In seeing blurrily, one undergoes sensory representations that fail to specify just where the boundaries and contours lie. Some information that was present with eyes focused is now missing. In particular, the grouped array contains less definite information about surface depth, orientation, contours, etc.
> (Tye, M. (2003), p. 18)

According to Tye, when information about an object is lost in perception, our perception of this object is blurry because it fails to specify the exact location of its boundaries, its depth, its texture, etc. According to the theory of visual media defended here, the loss of transparency exhibited by a translucent object corresponds to a loss of information since, by scattering the light, translucent materials fail to preserve the organisation of the incoming light rays. Rather than transmitting information coming from a remote object, the information transmitted by translucent materials is altered by information coming from the translucent material itself. The absence of determinate boundaries, depth and texture of objects perceived through translucent material can therefore be explained by the fact that translucent materials are poor visual media in comparison to genuine transparent materials. To sum up, a visual medium is transparent and invisible because the information transmitted is not altered by the properties of the medium itself. A translucent material is partially transparent and partially opaque. It transmits the light coming from the objects, but also modifies the properties of the light. Therefore, translucent materials are not genuine visual media like transparent materials, nor pure object of perception, like opaque objects, they belong to an intermediate category where the visible and the invisible merge.

The approach of transparency defended here conflicts with most theories of perceptual transparency which characterize transparency as the simultaneous perception of overlapping surfaces at different depths. This is, for instance, Fabio Metelli's definition: “[o]ne perceives transparency when one sees not only surfaces behind a transparent medium but also the transparent medium or object itself.”[13] Then, according to Metelli, perceptual transparency must be strictly distinguished from physical transparency which does not involve how we perceive one object through another but rather refers "to the fact that light can pass through a thing or a medium".[14] Rather than splitting the notion of transparency into a perceptual and a physical notion of transparency, I defend the view that it is fundamental for our understanding of visual transparency to maintain the unity of this notion. According to the goal of this paper, a comprehensive explanation of perceptual transparency must therefore account for the cases where the visual medium, although invisible, contribute to the way things appear.[15]

3. Glass: One Material, Various Media

Glass is an incredibly versatile material that has made possible many transformative technological developments. The material was first used to make containers for carrying and preserving food and beverages and as bottles for cosmetics and dyes, and its applications have grown with the successive discoveries and improvements in its fabrication. Today, glass can be found almost everywhere: from the huge panes of glass

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[13] F. Metelli, 1974, p. 91.

[14] Ibid.

[15] It is not surprising that perception specialists have put aside the cases where perception through perfectly transparent media are involved. In effect, unlike partially transparent objects and coloured transparent objects which have a clear impact in our visual experiences, the role of genuine transparent objects is not so noticeable and therefore largely ignored by the layman and most vision specialists.

that characterize modern buildings to light bulbs, computers, medical devices, etc. The extraordinary versatility of glass lies in the fact that it was for a long time the only solid and shapeable material that could be used to transmit light.[16] Whereas sounds are easily transmitted in solids, visible light rays are only absorbed or reflected by most solid materials.

Since the first glass material purposefully manufactured in Egypt and Mesopotamia over five thousand years ago, this highly adaptable material has been continually tailored to new functions and applications. Today, the use of glass is so common that we hardly notice its presence and the perceptual adjustments it involves. To get a better understanding of the different roles glass can play in visual experiences, I will consider three of its many applications. Exploring these different uses of glass will help us understand the role of media in perception. I will show in particular that glass can change our perception of reality by selecting what portion of reality we are able to perceive. But I will also argue that despite the dramatic perceptual changes induced by the use of glass in perception, glass as a medium always remains transparent and invisible for the perceiver.

3.1 Glass as Colour Filter

Some objects made of glass seem to be both coloured and transparent. Take for example a yellow-tinted drinking glass or a glass filled with beer. If we discard all reflections and impurities that could lessen its transparency, a yellow-tinted glass appears to be both transparent and yellowish. But is that really so? Suppose the glass is located in

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[16] With the discovery and the rapid advances made in polymer science in the twentieth century, many transparent polymers with many different properties have been developed.

front of a black wall. What colour does it appear to have? Does it still look yellow? If it does not create any discontinuity in the visual field of the observer, the transparent body appears colourless and becomes invisible provided the specular reflections of its surface and edges can be suppressed. To illustrate this point, suppose for the sake of simplicity that we take a grey-tinted piece of glass and place it on a piece of white cardboard. The greyish piece of glass can be seen as long as its light transmission properties change our colour perception of the background. On white cardboard, the filter can be seen because the cardboard seen behind it appears to be grey (see Fig. 1). But if the same grey filter is placed on a piece of black cardboard, it becomes invisible and colourless (see Fig. 2).

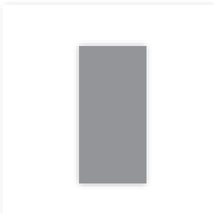

Fig. 1 Grey filter on white cardboard

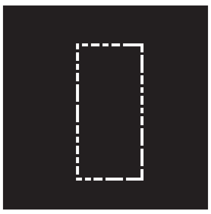

Fig. 1 Grey filter on black cardboard

Because the light transmission properties of the grey filter on black cardboard do not affect the way we see the underlying surface, we cannot see it. Like a perfectly transparent body, such as a pane of glass, the grey filter on black cardboard is both invisible and transparent. More generally, colour ascription to a transparent object depends on the colour of its background. We say that a glass of beer is yellow because that is the way it looks in front of a white piece of cardboard. The way it would appear on a red or blue background would be dramatically different; its appearance would not be described as yellow. To see this, consider again a "reddish" transparent object, like a glass of rosé wine, and a "yellowish" transparent object, like a glass of beer. If a "reddish" glass of wine is placed in front of a yellow background, it no longer looks reddish but orange. And its colour is not different from the colour of a glass of beer in front of a red background. Unlike superficial colours, the colours ascribed to transparent objects seem to depend essentially on the colour of their background.

Now, why should we say that a glass of beer is yellow rather than orange or green? In other words, why should we determine the colour of a transparent object in relation to a white background rather than a yellow or blue one? It seems that there is no principled way to choose one background at the expense of all the others. To claim, for example, that a glass of beer is yellow would imply that a white background causes a veridical perception of the glass's colour, whereas its appearance in front of a blue and a red surface are both illusory. In response to the problem raised by the lack of a principled way to select among the background's colours that are supposed to reveal the true colour of a transparent body, I have argued elsewhere[17] that all transparent objects are colourless. According to this approach, there is no way to select the true colour of a transparent object, because there is no such property. To give some plausibility to this view, it is essential to understand the relation between transparency and light. Contrary to the popular view, I deny that light can be coloured. Light can actualize colour

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[17] Mizrahi (2010).

properties, but it does not colour things. Light of long wavelengths is not red but actualizes, and therefore makes visible, surface colours that are reddish. Light of short wavelengths, in contrast, actualizes bluish surface colours. When using different monochromatic lights, our perception changes, because the colours we are able to perceive are different. More generally, perceived colour variations due to lighting variations correspond to variations of the surface colours we perceive and not to variations of the lights that are used. This account is reinforced by the fact that light is not visible without reflecting surfaces. As rightly pointed out by Hilbert,[18] we never perceive beams of light, but only the reflectance properties of the dust particles they illuminate.

Now, why are these remarks about variation in lighting conditions helpful for our understanding of the relation between colour and transparency? As I propose to show, transparent objects and light sources are closely related.

Change in colour perception can be caused by changing the lighting conditions. A yellow banana in daylight can appear red or blue when illuminated with an artificial light. But changing the properties of the light source is not the only way to select and obtain lighting colour variations. The use of transparent objects, for example, can produce similar colour variations in different ways. First, a transparent body can be used like a filter to modify the properties of the illuminant by selectively absorbing some of its wavelengths. By changing the properties of the illuminants, transparent bodies can therefore change the colours we perceive. But transparent bodies can also be located between an observer and a coloured surface. In this case, transparent bodies do not directly filter the light emitted by the source, but they partially absorb the light reflected

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[18] Hilbert (1987), p. 162.

by the coloured surfaces. If a white surface, for example, reflecting equally all the wavelengths, is viewed through a filter, only the wavelengths that are not absorbed by the filter will reach the eyes of the observer and be perceived. In both cases, the surface colour perceived by the observer is the same. Whether it is located at the light source or between a reflective surface and the observer, the transmitting properties of the filter selects in the same way which reflectance properties are perceived by the observer.[19]

By filtering the light, transparent materials, like glass, determine which colours are perceptually available for a given observer. Understood in this way, transparent bodies are not intrinsically coloured, but only select the colours we can see through them. By selecting which colours are perceptually available, transparent materials do not add colours to or subtract them from the world. They only change accessibility of colours to particular observers.

There are, in fact, many situations in which filters are used to reveal physical properties that are not available to the "naked" eye. Consider the role of filters in forensic practices. Evidence at a crime scene, such as fingerprints and body fluids, is often hidden, but can be revealed and made plainly visible with the use of a particular

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[19] The selective role of transparent bodies resonates with the pluralist view on colours defended by Allen (2009), Kalderon (2007), and Mizrahi (2006). Colour pluralism is the view that objects simultaneously instantiate many different colours. According to this view, the preexisting and mind-independent colours of a given surface are not all accessible to a given observer at a given time. Their perceptual availability varies according to internal and external conditions. Different visual systems, for instance, can be sensitive to different colours of the same object, and some of its colours could be perfectly undetectable by any existing living organism. Colours' availability to observers depends in large part on the observational conditions in general and on the light source properties in particular. Transparent objects are particularly interesting in this context, because they can modify those conditions and change our perceptual access to colours.

light source and special glasses. The glasses used in such situations are filters able to block a special band of wavelengths. When wearing such glasses, the perception of the forensic investigator is limited to a very small part of the visible spectrum. The chromatic discontinuities corresponding to fingerprints or particular smears are not brought into being by the forensic glasses. They pre-existed the investigation at the crime scene. Colour perceptions through transparent materials are therefore neither illusory nor erroneous. They are, on the contrary, admitted as evidence in court.

When glass is said to be coloured, it is not in virtue of its own colours, but only because glass can modify which colours are perceived. Contrary to what is often assumed, glass as a visual medium is always transparent and invisible. It is only because glass can cause some discontinuity in the visual field that its presence is revealed.[20] Like other media, glass doesn't have intrinsic perceptible qualities. Its role in perception is to select and transmit information to the visual system.

3.2 Glass as Polarization Filter

Another case in which glass can be used to enhance perception is polarization. Polarization refers to the direction of vibration of electromagnetic waves. A light wave vibrating in more than one plane is referred to as unpolarized light. Polarized light, conversely, is composed of waves vibrating in a single plane. Unlike animals with

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[20] However, most ordinary transparent objects are not perfectly transparent. First, materials often contain impurities that make them partially opaque. Second, due to their shape and their surfaces, most transparent objects locally reflect some light; this is the case, for example, with the edges of a pane of glass. Notice that what is perceived in these cases is always the surface of the object, not its volume.

polarization vision, humans are almost insensitive to polarized light. In fact, despite its invisibility to the human eye, light polarization gives rise to an impressive number of diverse phenomena that are an invaluable source of information for many species. Animals with polarization vision include some birds, insects, and marine animals. They use this capacity to navigate, detect water, identify objects, and probably also to communicate.

The lack of polarization vision in humans can be compensated for in some circumstances with the use of polarized filters. By absorbing the highly polarized light reflected from water, it is possible, for instance, to suppress the water's glare and to perceive objects below its surface. In the same way, reflections from windows can be reduced, making perception through them possible. But in some cases, the use of polarized filters not only enhances perception in particular contexts, but also reveals details of reality entirely concealed to the naked eye. Take for example the patterns on cars' windshields that can be seen with polarized glasses. These patterns are not optical effects or illusions, but correspond to the particular structure of tempered glass. It is also possible to used polarized filters as a navigation compass by exploiting the polarization of the skylight for orientation. This method of navigation was supposedly discovered more than one thousand years ago by the Vikings, who used a natural crystal, referred to as "sunstone", as a polarizer. Whether or not the Vikings' remarkable sailing achievements were conducted with the aid of a polarization compass, we know for sure that the polarization of the skylight is used as a compass by many animals.

As with coloured glass, polarized filters determine which physical properties are perceptually available to the observer by filtering the light. Although invisible *per se*, polarized filters can be detected by the physical properties they transmit, offering in this way a particular causal perspective on the world.

3.3 Glass as Magnifier

A similar analysis can be applied to non-flat lenses in the sense that their presence is only attested by virtue of the perceptive properties of the objects seen through the lenses. Consider a perfectly transparent lens facing the observer. If the lens is flat, it is invisible. But if the lens is curved or distorted, its own presence emerges in the observer's visual field (see Fig. 3).

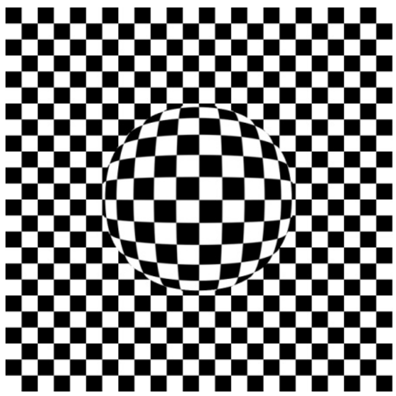

Fig. 3 Convex lens on a chequerboard

The point is that when we perceive a convex lens on a checkerboard, for instance, we do not perceive the geometrical properties of the lens itself but rather the geometrical properties of the checkerboard "distorted" by the optical properties of the lens. Just as the presence of colour filters is revealed through the chromatic discontinuities they create, non-flat lenses are disclosed through the geometrical discontinuities they create in the visual field.

I stressed how the perceptual media of coloured and polarizing glass could change our perception by opening access to new portions of reality. But the most important scientific impact of glass is undoubtedly the emergence of optical instruments.[21]

The invention of the telescope by Dutch opticians and its remarkable improvement by Galileo Galilei literally revolutionized astronomy and science in general. By improving our perception of distant objects, the telescope has provided an inestimable source of new observations that can be directly linked to the scientific revolution of the seventeenth century. Just as the telescope was a critical invention for our understanding of the planetary system, the invention of the microscope was critical to the progress of biology. Since the discovery of micro-oganisms and cells by Hooke and van Leeuwenhoek in the seventeenth century, which mark the start of imaging in biology, imaging technologies have continually evolved and there is today no single field in biology and medicine that does not rely heavily on their use.

By restricting the field of observation to a fraction of reality, the limitations of our senses have been a major obstacle to the development of science. With the invention of optical instruments, many of these limitations have been overcome and major progress has been developed in most scientific domains. By making accessible to observation phenomena too small or too distant for the naked eye to perceive, glass has crucially contributed to the way we look at and understand our world.

[21] In fact, the use of simple optical instruments dates back to ancient times, when lenses were made from quartz. But it was not until the development of the glass industry in the thirteenth century that craftsmen were able to make the first spectacle lenses.

4. Mirrors

Whereas complex instruments, like telescopes and microscopes, are usually trusted by the layperson and scientist to enrich their perception of reality, some simpler optical devices, like mirrors, elicit more questions and suspicions. Although we use mirrors[22] in our daily lives to perform numerous tasks, they are often accused of generating illusions or "virtual" perceptions. The fact, for example, that magicians use mirrors in their tricks to mislead their audience or that our left and right hands are apparently reversed when we look at ourselves in the mirror suggest that what we see in mirrors is merely illusory.

Consider for instance the face you see in the mirror when you brush your teeth. Although you know that the mirror hangs on the bathroom wall, it may seem to you that the face you examine in the morning while brushing your teeth is in front of you, namely "behind" the bathroom wall. But there is nobody behind the wall, even if it may seem that a doppelganger is staring at you. To capture the fact that we can mistakenly perceive objects as standing "behind" the mirror, MacCumhaill (2011) ascribes to mirrors a "see-through" look. She explains:

> The claim that empty space seen “in” mirrors looks see-through is motivated by the epistemically innocent case; if one can mis-take the specular case for the non-mediated perceptual case, as one does in cases of innocence, then how space looks “in” mirrors is indistinguishable from how it looks in non-mediated perceptual experience. Assuming, then, that empty space has a phenomenal appearance—a

[22] The word "mirror" is used to refer to a surface that reflects incoming light rays into a single outgoing direction. By extension, the word "mirror" is used to refer to any artefact that encloses such surface. This paper will deal only with the first use of the word "mirror".

> see-through or non-opaque look—it might be wondered how empty specular space can look so indiscriminable.[23]

I agree with MacCumhaill that the possibility of mistakenly perceiving an object as standing behind a mirror must be accounted for by some phenomenological similarities between our perception of mirrors and our perception of empty space. However, I think that MacCumhaill's claim is problematic, because mirrors like empty space don't have any phenomenological properties. If we consider empty space to be what makes perception at a distance possible, we also have to admit that empty space is transparent and therefore invisible. Transparency and visibility are in effect opposite notions. In order to see behind or through something, there must be no visible obstacle. If a body is spatially located between the observer and the background, the background is visible provided only that the intermediate body is not seen. Therefore, if empty space is transparent, it seems dubious that it can have a distinctive appearance or a look as supposed by MacCumhaill.

Rather than postulating some similarities in their phenomenal appearances, I propose to account for the similarities between mirrors and empty space by reference to their similar roles in perception. Empty space, or air, is our standard visual medium. By transmitting light from the perceived object to the perceiver, it mediates visual perception and enables visual perception to take place at a distance. Mirrors have the same intermediary role in perception. Although they often create a discontinuity in the perceiver's visual field[24], they transmit only the visual properties of the object

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[23] Mac Cumhaill (2011), p. 2.

[24] Like with other perceptual media, mirrors create a discontinuity in the visual field *only* when they do not occupy the whole visual field. When using a periscope or inverting goggles

perceived. Mirrors and empty space are therefore similar not because they share some phenomenal features, but because they create an environment where visual perception can take place without obstruction.

The claim that mirrors are perceptual media rather than perceptual objects may encounter some resistance. Is it not obvious after all that we perceive mirrors as we perceive the ordinary objects of our environment? Is our physical interaction with mirrors not a confirmation that we can see mirrors just as we can see chairs or tables? At first sight, mirrors do not seem to differ in any significant way from other pieces of furniture, but a closer inspection reveals how tricky they can be.

Although our experience with mirrors raises many questions about the nature of what we see in them,[25] the nature of mirrors and its role in perception is rarely discussed. From a physical point of view, mirrors are opaque objects: they reflect incoming light and don't transmit light the way transparent materials do. But from a phenomenological point of view, things are more complex. Mirrors are phenomenologically opaque in relation to objects located behind them. If a mirror hangs on a wall, for example, the observer cannot see the portion of the wall covered by the mirror. But unlike opaque objects, mirrors are colourless. The colours we see in mirrors are the colours of the objects we see in the mirror: the mirror "looks" blue if it reflects the sky or white if it reflects the snow.[26] Therefore, unlike opaque objects, mirrors appear to be transparent in relation to the objects they reflect. Like a pane of glass, a

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embedding mirrors, like in Erismann and Kohler's famous experiment of perceptual adaptation, there are no visual cues that mirrors are involved. The subjects may notice at first that their visual experiences are different, but there are no mirrors among the objects and properties that exhaust the content of their visual experiences.

[25] See Casati (2012) for a presentation of alternative theories about the nature of what is seen in mirrors.

[26] The case of tinted mirrors parallels exactly the case of tinted glass explained in 3.1.

mirror is not a visual barrier to what is perceived through it. In order to not obtrude the perceiver's access to what is perceived in the mirror, the mirror cannot be seen. In fact, from a phenomenological point of view, there are no mirrors, but only objects perceived in mirrors.

The fact that we don't see the mirror, but only what is seen in it, is also supported by the fact that mirrors act more like windows than images. As rightly stressed by Casati, what people see through mirrors and windows changes when people occupy different locations. He explains:

> Windows do not function as images given that what is seen within a window changes according to adjustments of point of view, whereas what is seen by means of an image resists adjustments of point of view. But for this same reason mirrors do not function like images either, given that what is seen within a mirror changes in a way regulated by adjustments to point of view.[27]

From a physical perspective, a window is an aperture in an opaque surface that allows the passage of light. The opening can be filled with glass or transparent plastic, but it is crucial that the material used is transparent in order to allow light to pass through the window. From a phenomenological perspective, a window is a hole in a surface. And as with holes in general, we perceive windows by perceiving "some kind of discontinuity in the surfaces of material objects."[28] Unlike opaque surfaces which present "a barrier beyond which the eye cannot pass"[29], mirrors, like windows, correspond to a particular region of the visual field where visual obstacles have been removed. Rather than exerting a visual resistance like opaque surfaces, mirrors let the vision penetrate beyond

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[27] Casati (2012), p. 197.

[28] Casati and Varzi (1994).

[29] Katz 1935, p. 8

the region they occupy. According to this view, a mirror is a kind of "emptiness", a hole[30] in an impenetrable expanse, a visual opening through which sight can pass.[31,32]

Mirrors as Perspectival Instruments

Although mirrors are not visible *per se*, in the sense that they do not have any visible qualities like colour, shape, or texture, they create visual discontinuities in our visual field. As Casati[33] rightly points out, most of our experiences with mirrors are not "epistemically innocent": we know that we are dealing with mirrors. Like our use of other optical instruments, our use of mirrors enlarges our visual capacities: they extend our visual field to portions of space not immediately accessible with the naked eye. The use, for example, of a rear-view mirror in a car enables the driver to see regions of space behind his car without turning his head. If our experience with mirrors can be uninnocent in Casati's sense, that is because looking into mirrors must differ in some way from looking through glass. But how could that be that possible if mirrors have no visual properties, as I have argued? How could looking in mirrors and looking through glass be different if they do not differ with regard to their phenomenological characteristics?

According to the view defended in this paper, mirrors are perceptual media. Like perceptual media in general, mirrors are not perceived but nonetheless crucially

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[30] Like windows, mirrors are only visual holes. Unlike more common holes, like the hole in a doughnut, mirrors are not tactile holes. We cannot insert a finger in the hole created by a mirror.

[31] This description is best suited when a mirror appears as a hole in a opaque surface.

[32] The fact that mirrors create visual holes in otherwise opaque surface has been used for years by magicians to vanish people and objects. Because mirrors can create visual holes in opaque objects, the trick is simply to create visual holes around objects or people one want to conceal.

[33] Casati (2012), p. 201.

contribute to our perceptual experiences by selecting which portions of reality are perceptually accessible. Consider the periscope, which is a tube containing two parallel mirrors that enable the viewing of objects from a vantage point normally unavailable to the observer. Although perception through a periscope is mediated by mirrors, no mirror is present on the phenomenological level. The phenomenology of the experience of looking through a periscope is captured by the nature of the actual objects and qualities that are seen through the periscope and not by the mirrors that are causally involved in that experience. The experience of looking through a periscope differs from the experience of looking through glass essentially because mirrors affect the spatial properties of our perception. Mirrors affect our visual perception by changing the visual perspective of the observer.

Visual perception is perspectival in the sense that visual experiences incorporate information about distance and orientation from a given point of view. The usual point of view of visual experience is anchored in the eyes of the observer. What is seen by the observer is therefore usually determined by the observer's position and location. The observer can change the perspectival properties of his experience by moving around objects for example, but each new perspective obtained by moving is always anchored in the observer's body.

If mirrors seem magical, it's probably because they seem to cut the indefeasible link between the spatial position of the observer's body and the perspectival properties of his visual experience. When viewing an object through a mirror, it may seem at first that a new perspective is offered that is independent of the observer's location. It may seem like an out-of-body experience, because in contrast to usual visual experiences, the object observed and the eyes of the observer are not on the same straight line. But this first impression is valid only for the epistemically innocent observer who doesn't know he is seeing through a mirror. Although the observer's eyes are not directed to the object seen in the mirror, specular perception is nonetheless perspectival in the sense that what is perceived is determined by the location of the perceiver. Unlike pictorial perception, specular perception varies according to the perceiver's movements. And the geometrical variations observed from different points of view don't differ from those that can be viewed without mirrors. A round plate can appear round or elliptical in a mirror according to the relative distances of the edges to the perceiver's point of view, but it will not appear square. This point is not trivial. It illustrates in effect why seeing through a mirror is not a special type of visual experience, but just a visual experience mediated by a perceptual medium different from air alone.

To clarify this point, we must recall Heider's definition of a perceptual medium in terms of externally conditioned entities. To explain how the medium contributes to perception without interfering with the information it conveys, Heider distinguishes between things, which are internally conditioned, and media, which are externally conditioned. The fact that media are externally conditioned corresponds to the fact that their parts are causally independent of each other. Any air molecule can move freely without affecting the way the other air molecules behave. By contrast, all the parts of an internally conditioned object are interdependent. By moving the back of a chair in one direction, for example, we induce a motion of its legs.

The notion of externally conditioned entities explains how media can causally contribute to perception without being part of its phenomenal content. Because the medium's parts are causally independent of each other, the medium as a whole can remain undisturbed by a particular process even while the medium's parts are directly affected by it. As Heider writes:

> The process on the surface of the stone, which reflects the light rays, is a process which is conditioned by the substratum [...] the fact that this particular kind of process occurs, namely, one which contains waves of particular lengths arranged in certain patterns, is determined by properties of the stone. The process in the medium, on the other hand, is conditioned externally. What happens in it is dependent on the form of the impinging process; the special state of the medium is to a high degree irrelevant for the form of the process in it. (p. 4)

According to Heider, the fact that a medium is externally conditioned explains why perceptual media can causally contribute to perception without being part of its phenomenal content. Because the medium's parts are causally independent of each other, the medium as a whole can remain undisturbed by a particular process even while the parts are directly affected. Although Heider doesn't explicitly identify mirrors with visual media, he clearly points to the fact that mirrors are externally determined. He contrasts mirrors with the surfaces of visible objects:

> It is very important that the order of the direction of light rays is changed at the surface of an object. [...] In the case of the mirror, however, they are reflected independently of each other. A mirror changes the direction of light rays; but it changes the direction of all rays in the same way so that the configuration is preserved. At each point there is a multitude of rays of different directions, and the composition is determined externally. With an object which has not the properties of a mirror, however, the kind and direction of incoming light rays are more or less irrelevant.[34]

Unlike the direction and frequency of the light reflected by opaque surfaces, those of the

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[34] Heider, F. (1959), p. 16.

light reflected by mirrors are determined by the properties of the incident light. This physical property of mirrors explains why mirrors preserve the structural organization of the incoming light and therefore why they do not affect the information they convey.

5. Lessons from Mirrors, Glass and Other Perceptual Media

Mirrors, like perceptual media in general, contribute to perception without being part of its phenomenal content, because they preserve and do not interfere with the structural unity of the perceptual objects. By relaying the causal processes that convey information to our senses, perceptual media are an essential component of perception. We tend to neglect and even forget their essential role, because our environment is relatively stable and it is the essence of the perceptual media to be transparent. Sometimes, however, their presence is betrayed. This occurs, for example, when our perception takes place through an unusual medium or when two perceptual media are involved in the same experience. In such cases, we notice some changes in our environment, because the kind of information available through our usual perceptual media is replaced or joined with a different kind of information accessible through a less common medium. But although experiences through an unusual medium can generate some surprise and even confusion, those experiences are not erroneous or illusory. In fact, as the many examples with glass have shown, there is no adequate or inadequate perceptual medium *per se*, but only media tailored to particular perceptions. Consider the case of corrective eyeglasses. The human eye is an incredibly powerful and complex organ, but like every sophisticated instrument it can be defective in many ways. The most common disorders of vision are refractive defects that can be corrected by aids, such as eyeglasses or contact lenses. People with myopia, for example, cannot focus on distant objects. This very common problem is easily corrected with diverging lenses. People with hypermetropia, the opposite defect, have difficulties viewing nearby objects, and they need to use converging lenses to improve their vision. Although converging and diverging lenses have opposite optical properties, it is remarkable that their use as vision aids achieves exactly the same goal: they give "normal" vision to people suffering from vision "abnormalities."

The fact that normal vision can be achieved through the use of different optical instruments calls for two general remarks. First, the use of lenses to correct visual abnormalities clearly demonstrates that lenses are not perceived. When a myopic subject wears his eyeglasses, he does not see the objective properties of his environment combined with the optical properties of his eyeglasses. What he does see are some visual properties that were not visible to him without his eyeglasses. Refractive lenses do not have any intrinsic phenomenological properties; they only change perceptual experiences by changing what portion of reality is accessible to the perceiver.

The fact that there is no phenomenological difference between the visual perception of a subject with 20/20 vision and that of a subject with 10/20 vision wearing adapted refractive lenses calls for a second remark. What this case shows in effect is that perceptual media are not necessarily located between the subject and the perceived objects. As rightly pointed out by Massin (2010), it seems arbitrary to distinguish between the perceptual system and the perceptual media located outside the perceiver's body:

> According to present suggestion, the concept of medium can be extended to some of the perceiver's body parts, in particular to his perceptual system. If air or eyeglasses belong to the medium, why is it not the same for the cornea or the retina? Why not include also the optic nerve, and the primary visual area in the

> causal medium which keeps us and the object apart? Is it not somewhat arbitrary to consider that the causal medium ends as soon as the causal flux enters the body?[35]

Massin's suggestion that perceptual media include not only external entities causally involved in the perceptual process but also comprise the perceptual system itself is powerfully exemplified by the use of refractive lenses for corrective purposes. The fact that a normal visual system is equivalent to an abnormal visual system combined with particular refractive lenses shows that there is no fundamental difference between the role played respectively by the cornea and the corrective glasses.

As argued in this paper, the choice of a perceptual medium affects our perception by selecting what portion of reality is perceived. The choice of a medium is not therefore right or wrong *simpliciter*; it is only appropriate or inappropriate to particular perceptions. The human eye, which incorporates different refractive media (the cornea, the aqueous humor, the lens, the vitreous body), is perfectly suited to see bears and berries, but it fails to distinguish astronomical bodies or very tiny creatures. Evolution makes choices that increase our chances of survival, but it leaves aside other options. By using perceptual media other than the ones nature has selected for us, like refractive lenses or mirrors, we expand our perceptions: we discover new patterns, we change our perspectives, we outreach horizons, we infiltrate seemingly impenetrable barriers. Perceptual media are invisible and transparent but nonetheless indispensable.

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[35] Olivier Massin, (2010) p. 103.

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