



The Future of Visual Perception

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Abstract. We sketch some Psychological and Anthropological notions on visual perception, ranging from automatic mechanisms, to learning and context. Moreover, cultural knowledge supports context-specific understanding. New technical developments trigger changes in how and what people may perceive as well as what they let others perceive. This requires reconsidering privacy. And interactive VR worlds still await facilities for multi-person interaction.

1 Introduction

Daily use of information and communication technology (ICT) by non-experts in computer science is quickly spreading in our world. Literally billions of people [5, 7] communicate, work, travel, drive cars and use household appliances, use facilities for health care and learning, participate in culture and social life, and make use of their civil rights, by looking at, and interacting with, screens of any size. Rendering information and affordances for interaction on screens requires understanding of how people look, understand, and be guided in their interaction, by what is displayed.

This paper is an analysis of how people perceive visual images, how perceptions is influenced by context and by learning, and how people's understanding of what is being rendered has been changing over the centuries and is rapidly changing in the current era of revolutionary ICT innovations and applications. We will illustrate that cultures with different values or different views on aesthetics require different ways of representation.

In the current turmoil of human mobility and geographical cultures interconnecting, of social media being deployed as soon as replaced by new hypes, cultures develop and change rapidly. Designers of hardware, software, and applications for users need to be aware of these mechanisms and developments in order to optimally serve the users.

In 2 we will give some highlights regarding what occurs before stimuli of the senses results in perception. In 3 we show how basic processes as well as learning affect attention to sensory input and the resulting meaning. Cultural influences to this process are illustrated in 4, and in 5 we show how new techniques change perception and interaction with visual rendering.

2 Before Perception

Prior to any perception, humans receive input through the senses, of which sight is only one (among the others most scholars count at least: hearing, taste, smell, and a complex of sub-senses like touch, thermoception, nociception, kinaesthesia, proprioception, and equilibrioception). Senses are the physical processes of stimuli (light, sound, etc.). For the sense of sight, the stimulus is light, received by several types of photoreceptors in the retina [6]. The image received differs between the two eyes, hence the signals transferred to the brain allow for 3D vision. The image remains available in the receiving organ for a short period (less than 1000 milliseconds). This time cannot be prolonged by rehearsal, since attention does not affect the physical process. All sensors only act if the stimulus is above a certain lower limit (the absolute threshold) and with increasing intensity the receptor reacts stronger until an upper limit is reached. Above this limit stimulation will result in a possibility of damaging the sensor and an experience of pain (this is why people quickly learn not to look directly to the sun). In order for two stimuli to trigger a distinguishable reception, the difference needs to be beyond the “just noticeable difference” threshold [11]. If a sensor is exposed to a certain stimulus for a long time, it adapts and gets less sensitive. On the other hand, if the stimulus changes suddenly the sensor reacts quickly.

A place where theory about senses has been put into practice is the hospital. The colours in the operating room (OR) are usually greenish. The reason for this is the so called afterimage effect of the eye. When the eye has been exposed to a lot of red colours (like blood), it will start to adapt to the colour red (get less sensitive to it). If you look in a white area directly after being exposed to intense red colours, your image will be greenish. This is because your eye still is less sensitive to red, so the image lacks red colours to compensate the green. Doctors won't notice this greenish afterimage, because OR's are coloured green. The afterimage then simply blends with the environment, and is less annoying.

3 Perception, Learning and Context

Perception is the result of attention, and only what is processed by the senses can subsequently be perceived. Schacter et al [13] define perception as “the organization, identification, and interpretation of sensory information in order to represent and understand the environment”. Gestalt psychology is a theory about fundamental laws of human perception, explaining the human ability

automatically structure stimuli into meaningful perception [15]. Some important Gestalt laws in the domain of vision are:

- Closure - we tend to see complete figures, even if some parts are missing. Like the square on the right: it is merely four circles with a gap in them, but we perceive it as square (see Figure 1a);
- Similarity - when we see similar objects (colour, texture, shape, size, orientation) we tend to group these objects together. So in the image on the right we tend to see diagonal stripes (see Figure 1b);
- Continuation - if two lines cross each other, we automatically assume that each line follows its initial path, because that would be a logical continuation of the lines (see Figure 1c).
- Proximity - depending on the proximity of objects that are ordered in rows and columns, we will either perceive them as a whole, as a bunch of rows, or as a bunch of columns. Figure 1d is perceived as a whole; Figure 1e as 'rows', and Figure 1f as 'columns'.

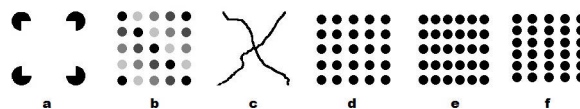


Figure 1. Illustration of Gestalt laws Closure (a), Similarity (b), Continuation (c), and Proximity.

In general this type of phenomena supports interpretation. On the other hand there are visual illusions [2] that might sometimes disturb perception: the horizontal lines at the left and the circle at the right of figure 2 cannot be perceived as they are in fact drawn.

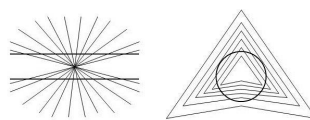


Figure 2. Some visual illusions.

The above mentioned types of phenomena will be found for people from many cultures, independent of education or explicit learning. On the other hand, perception of renderings that are not perfectly clear or precise is often supported only for people who have relevant basic knowledge (e.g., language, Figure 3-left).



Figure 3. Ambiguous text (left); Effect of colour contrast (middle); Spoiling capitals (right).

When designing for a screen, obvious knowledge of human perception should be applied, including the effects of contrast on colour (Figure 3-middle), and the meaningless use of capitals on readability, as illustrated in Figure 3-right.

And be aware, readers from screens follow the “normal” reading behaviour of their language culture: in the Western world from left to right, top to bottom, but often scan only the left few words or symbols and never see lower right info.

4 Cultural Knowledge Makes Us Understand

If we understand the logo in figure 4, this is because we are able to read the characters (“solidarnosc”) and associate this with the English “solidarity”, have seen enough pictures of political demonstrations to interpret the typography, and remember (or have read about) the Polish shipyard strike in 1980 and the following political change in 1989.



Figure 4. Logo of Solidarnosc, the Polish revolt 1980-1989.

4.1 Perspective

In Western society, for about 500 years (until Cubism challenged the relevance of it), perspective drawing has been the standard base of rendering visual reality on a 2D surface. Alberti and Brunelleschi are generally considered the original developers of the technique, around 1430.



Figure 5. New perspective, Florence 1430 (left); and isometric rendering, London 1616 (right).

Figure 5-left shows a painting by Masaccio in the Brancacci Chapel, Florence, ca. 1430 [14]. The new way of rendering was immediately

considered to provide more realistic representations. However, even when the technique was known and taught, there could be conditions when a deviation towards isometric representation of reality made much more sense if details really mattered for the viewer, see Figure 5-right [9], where even today specialists in architecture can derive details and measures of St. Pauls in 1616 that would not be found even in a photograph.

In the Western world Chinese visual art could be misunderstood as being primitive on perspective. However, the techniques and rules are well documented and taught, and have been preferred by the culture for many centuries [10]. In addition, when we consider the Chinese genre of scroll painting, this way of rendering makes in fact much more sense for whoever is viewing (while walking along) a horizontal scroll, see Figure 6.

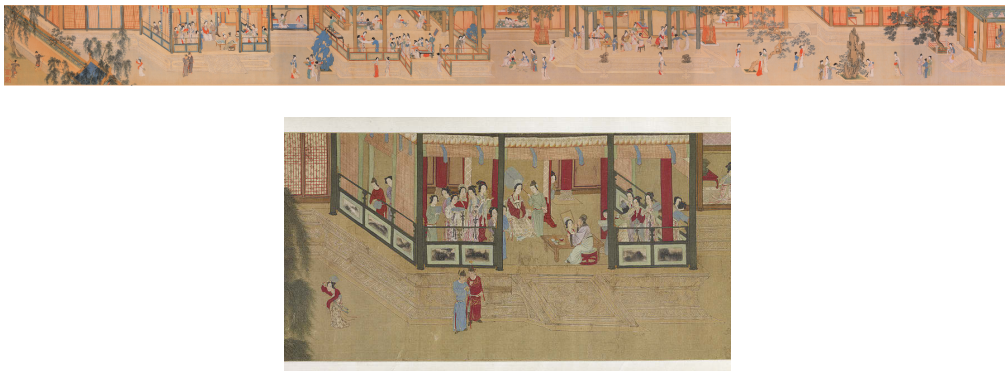


Figure 6. Spring Morning in the Han Palace – part of the scroll, and a fragment showing the Chinese perspective [12].

4.2 Humans and Gods

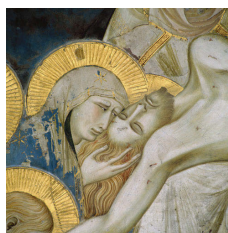


Figure 7. Pietro Lorenzetti, *Compianto* (detail), [1].

In the European Middle Ages rendering pictures of humans included representing their social or religious role or state, by showing indicating attributes, dress, etc., see Lorenzetti's *Compianto* in Basilica Inferiore, Assisi (about 1320, Figure 7) where all saints are characterised by a Halo and the Virgin Mary is further specifically indicated by the colour of her dress.

4.3 Aesthetics

One important aspect of the cultural background of perception indicated above is aesthetic preferences. To a certain extent these just result in positive or negative feelings towards the rendering, which might or might not strongly affect the meaning of the perception [3, 4]. Early Egyptian drawings and paintings show remarkable standard ways of representing humans and gods (and combinations of these) [8]: female Pharaohs feature a beard, faces are shown strictly in profile, even if the crowning set of bull horns (indicating Apis) is always drawn from the front. It seems that in this case appropriateness of representation also supported easy recognition of the intended meaning (human or animal face, deity).

5 Modern Techniques Trigger Novel Perceptions

Presentation techniques evolve fast. We find developments in rendering that support 3D perception; perception of history; unobtrusively collecting knowledge of invisible characteristics; and perception of personal and private knowledge about strangers.

5.1 3D Perception – to be Continued

The 19th Century showed the development of panoramic (still) paintings that provided immersive experience of being in a 3D world. One century later panoramic movie projection upgraded this to a dynamic experience. Early 3D vision required special viewers, like in Figure 8, or polarized presentation with matching goggles. Currently, 3D vision can be provided in several ways, e.g., with goggles, with the help of polarised glasses, or by holograms. Newer technology allows “normal” vision where the presenting screen carefully aims different images at both separate eyes. Developments are still going on to get rid of those prostheses that detach the viewer from the real visual world around.



Figure 8. 20th Century 3D picture requiring red-green glasses (left) and a separation viewer (middle) for two separated 2D images (right).

5.2 Looking into Past and Future

Who is interest in the past of an object or in scenes related to cultural or natural history will increasingly find possibilities to watch renderings of what might have been a state at a specified number of years ago, by looking at a specific App on a smartphone or an interactive screen based museum device. Advanced applications allow the viewer to specify the time and aim the phone or screen at a scenery or artefact, seeing the presumed past state in its (current) context. IKEA applies Metaio, an App to view how new pieces of furniture would fit in people's living rooms. For private use Google's Cardboard box allows VR presentations to run on a smartphone.

5.3 Looking What's Inside

The British Museum provides a non-destructive opportunity for visitors to find out what is inside the mummy, allowing to virtually unwrap the artefact through layers of X-ray and CT representations. Medical professionals use these techniques for diagnostic, radiation, and surgical purposes, and these applications are used by non-professionals as well: Apps allow future parents to watch their unborn child on their smartphone, and many of these videos are shared on YouTube, even if the interpretation is not straightforward without careful explanations of an expert.

5.4 Looking to Create New Knowledge for the Benefit of Others

Supermarkets are currently experimenting with eye-tracking glasses fitted with a camera (e.g., to be obtained from Amazon), to study looking behaviour of customers. So far the customers supposedly are aware of the destination and use of the knowledge they provide, but privacy laws lack behind the new possibilities.

5.5 Looking may Turn into Spying on Privacy

Google glass, now (temporarily?) withdrawn from the consumer market, came with experimental Apps that allowed, for example, identification of faces based on facial characteristics stored in the cloud. The wearer of the Glass could be informed of the identity and other information of the, until then unknown, stranger. And we all know how hard it is to get personal information removed from data sets collected and stored in the cloud. Here, again, laws lack behind possibilities. But experience on new applications (e.g.,

of social media) show users quickly get used to the fact that their information moves around beyond control, and stop bothering about this till serious damage actually occurs to their privacy.

6 Designing for Future Perception: the Good, the Bad, and the Ugly

Designers should be aware of effects and mechanisms indicated above. In a world where people interact, perceive, and communicate with multiple screens and mobile devices, visual renderings should fit psychological processes as well as varied and rapidly changing cultures and context of use.

The good news is that new applications emerge rapidly, VR and Augmented Reality can be offered on location and to go on an increasingly diverse type of platforms.

The bad news concerns the indicated aspects of privacy that still needs to be considered and will require reconsidering national as well as international legal measures and a new professional orientation on ethics of design and application of novel technology.

Ugly is still the lack of technical facilities for sharing a VR world. Even the lightest of VR glasses like Oculus Rift still detaches the viewer completely from the social surroundings, and collaboration in VR in fact would require the use of multiple CAVEs. Technology experts should find their challenge here.

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