Psychology Documentation

- HOME > VISUAL DESIGN

VISUAL DESIGN

Contents [hide]

Introduction

Virtual reality allows emotionally rich interaction between people and the visual elements comprised within virtual environments.

This entry draws on research evidence regarding the visual elements of scenes, objects and the impact they have on our cognition and emotions. A number of core design factors have been identified which shape the emotional impact of a virtual environment.

Vision in virtual reality

Virtual reality provides a sensory experience of computer generated space.

There are two main requirements to creating an effective simulation of vision in virtual reality.

Vision needs head tracking

Head tracking allows a virtual reality simulation to update the user's viewpoint as they move within the virtual environment. Head tracking is essential to provide accurate visual simulation.

Head tracking is also an important factor contributing to the level of immersion in virtual reality. Good head tracking provides a compelling sense of being 'in' the virtual environment.

Visual immersion requires no distractions

To increase immersion, the external visual environment must be blocked out. This avoids sensory conflicts between real world and virtual environment.

Processing visual scenes

A visual scene is made up of objects and surfaces that have been organised in a meaningful way. For example, the setting of a kitchen or a garden has numerous objects and surfaces that contribute to the overall visual information that makes up our understanding of a kitchen or garden path. In this sense, when we think of either of these settings we are thinking of a scene.

An object or a scene?

Visual elements can be either an object or scene. The status of an element may change depending on the context.

For example, a keyboard can be thought of as an object. Yet when we place a keyboard on a desk it becomes part of a continuous surface that makes up the desk. It becomes part of another object.

The keyboard and desk can also be thought of as part of a scene. Together with other objects they make up the scene of an office.

Usually, objects are acted upon, whereas scenes are acted within.

Relying on global layout information

When the objects within a scene are not easy to recognise or understand, we rely on overall scene information to understand what we see. This overall scene information is called global layout information.

This is particularly the case in poor viewing conditions or when viewing a scene at a distance or at a quick glance. In these situations, object identities cannot be derived from local information alone.

The dominance of global information in scene perception can be demonstrated in the way we process images. The left image seems to show a forest scene, with the observer looking up through the trees to see the sky in the background. The right image is the same image, but upside down. Now the forest scene depicts a river receding into the distance.

In this particular illusion, reversing the image changes the assignation of elements as figure (i.e., the object of focus) or ground (i.e., the rest of the perceptual field).

Scene properties – order and complexity

In virtual reality there are an infinite number of realistic and abstract environments we can be exposed to. The type of scene we are placed in will provoke an emotional response due to the context of the environmental setting. In addition to context, the complexity and order of visual scenes are two key elements to consider.

Awe? Fear?

Relaxation? Boredom?

What is visual complexity?

Visual complexity in a virtual reality experience can be understood as the density or richness of visual information processed by the user. Imagine being completely surrounded a mass variety of unfamiliar animated objects and rich details. Such would be a complex virtual environment.

Complexity is determined by three main factors:

Visual richness

The density and variety of objects and information that make up the environment.

This can be exhilarating but also potentially draining if a level of high intensity is maintained throughout an experience.

Familiarity

The extent to which objects and environments are recognisable. Unfamiliar elements are interesting, yet require greater mental processing to comprehend. This adds another level of complexity to an experience.

Information rate

The speed at which information is provided and progression through an experience occurs. Speed is often associated with greater levels of intensity and excitement. However information processing does takes time, particularly in novel, abstract environments.

High complexity

Low complexity

Complexity and preference

Several studies have demonstrated that complexity is an extremely important factor affecting aesthetic judgment (e.g, Jacobsen, 2004; Cox & Cox, 2002). People tend to consider complex stimuli more beautiful than simple stimuli. This extends to a variety of stimuli such as building facades for example where people show a significant preference for more complex schematic drawings (Imamoglu, 2000).

To re-emphasise the importance of context, there are circumstances when increased complexity can cause decreased preference for visual scenes. For example, preference for supermarket scenes decrease significantly as they become more complex (Gilboa and Rafaeli, 2003).

Complexity, preference and the familiarity effect

Another very interesting finding with regards to complexity and preference is the existence of a familiarity effect. People familiarised with simple stimuli later tend to prefer more complex stimuli, whereas those familiarised with complex stimuli tend later to prefer simpler stimuli (Tonio & Leder 2009).

This is an important point to consider when engaging user interest and maximising enjoyment. High and low complexity should be well balanced throughout the duration of an experience.

Complexity and arousal

As the complexity of imagery increases, there is a general increase in the arousal levels of observers. This applies to nature scenes, paintings and music (Marin and Leder, 2013), as well as urban environments (Ulrich 1983 and Nasar 2000).

In circumstances where the aim is to stimulate the user, increased complexity within the environment should encourage an active response.

What is order?

Order refers to the arrangement and behaviour of elements within an environment. If we were to bring order to a busy, highly complex environment it would still be complex, yet it would feel less intense, confusing or chaotic.

Within a virtual reality experience, order is determined by three main factors.

Organisation

The extent to which visual elements are arranged randomly or if they fit within a clear structure.

Coherence

Whether the components of an environment look and behave with an internal logic. Blue bananas which defy the laws of gravity would lack coherence.

Clarity

How easy it is to comprehend the visual elements of the environment. Some objects may be difficult to see or the purpose/awareness of an available tool may not be clear.

Order, preference and arousal

Well-ordered scenes provide a more simplified experience, drawing less on our cognitive resources and as such tend to be rated as more pleasant (Nasar, 1997).

Disordered environments require greater mental effort, through processes of meaning assignment, stimulus interpretation and cognitive evaluation. Greater stimulus input is associated with a higher arousal response (Gilboa and Rafaeli, 2003). However, continuous over exertion will lead to mental fatigue.

Balancing order and complexity

When designing a visual environment that could be considered too extreme (e.g. highly complex or disordered) we can manipulate complexity or order accordingly.

High complexity-low order

Highly complex environments provide us with vast amounts of information and stimulation. In such cases order is needed for us to be able to cognitively and emotionally deal with these situations. Research in this area supports the notion that by introducing order to complex environments this leads to significant rises in interest and enjoyment levels Berlyne, 2007).

Low complexity-high order

Conversely, in this environment there will be very little to stimulate the user visually. This will ensure arousal levels remain low. However, discounting audio or interactive stimulation, users may become disengaged and bored with the experience. In which case order and complexity can be manipulated over time either towards or away from a low complexity-high order environment.

Different order and complexity combinations in a garden scene.

Scene properties – perceptual shapes

All scenes, whether physical or virtual are made up of perceptual shapes. We can see them by extracting the contours (shape outlines) from an image or scene.

The relationship between perceptual shape features and the emotional effect of imagery has been well-documented. The two most prominent features are angular metrics and line orientation.

Angular metrics

This refers to the amount and range of different angles within an image.

As discussed in the shape and emotion section, angles are associated with an arousal response due to their threatening connotations.

In the context of perceptual shapes, an increased range of angles contributes to the complexity of an image (Arnheim, 1974). As such this contributes to the complexity of visual environments and is linked to a significant increase in arousal.

Example images high Vs low angle count (Lu et al., 2012).

Line orientation

The orientation of lines within the perceptual shapes of imagery have a consistent effect on the emotional impact of visual scenes (Arnheim, 2004). For instance, vertical and horizontal lines are usually preferred over diagonal lines (e.g. Latto, Bryan & Kelly, 2000).

Horizontal lines

Associated with calmness, peacefulness and relaxation because they are associated with a static horizon. In a sense they can be perceived as inactive or at rest.

Vertical lines

Indicative of strength as they communicate vitality and eternity.

Diagonal lines

Communicate instability. Compared to vertical and horizontal lines they are more dramatic and less predictable.

Varied directions

Often interpreted as chaotic or confusing. They take on the dynamic and high energy characteristics of diagonal lines.

Curved lines

Can either be calm or dynamic depending on how much they curve. Less active gentle curves correspond to feelings of calm. Large sweeping curves animated at high speeds will have the opposite effect.

Line type

Aside from the orientation of lines there are further variations in line type to consider.

Length

Scenery with longer perceptual lines are generally more simplistic, compared to complex imagery which is made up of many different line segments.

Thickness

Thin lines convey fragility but also elegance. In contrast thick lines portray dominance and strength.

Perceptual shapes and emotion

Lu et al. (2012) investigated the relationship between the perceptual shapes of different scenes and the corresponding emotional affect caused by each scene. The contours, line segments, continuous lines and curves of 484 images were analysed and compared across 8 different emotion categories.

Low arousal image broken down into contours, line segments, continuous lines and curves

The researchers found perceptual shape features most important to each emotion category. In other words, images which provoke a particular emotional response (e.g. awe) share similarities regarding the perceptual shapes they are made up from.

Awe and excitement

For instance, the orientation of line segments was found to be the significant factor in both awe and excitement inducing images. These images often have a large proportion and combination of vertical and diagonal lines.

Contentment

A small number of lines, low angle count and predominantly horizontal line orientation features were closely associated with contentment imagery.

Fear

With regards to fear imagery, a large variation of line orientations and a high amount of angles were most prominent.

Object properties – shape and texture

Shape and emotion

Emotion attribution

People attribute emotions to geometric shapes even when these shapes have no resemblance to the human body or face. When people describe an object as ‘angry’ or ‘happy’, they are attributing an emotion to the object.

Research has shown that shape contour is an important aspect of emotion attribution Aronoff, Woike & Hyman, 1992; Aronoff, 2006). Results found that angular shape contours gave impressions that are negative, arousing and powerful. Rounded shape contours were perceived as positive and less arousing. Diagonal lines were shown to evoke impressions of negative emotion while curved lines evoked positive emotion attribution

Induced emotion

There is evidence that variations in shape can trigger emotional reactions in the observer.

Whilst comparing the effects of angular shapes to curved shapes, Bar and Neta (2006; 2007) found that angular objects were liked the least and were more likely to cause an arousal response. This was the same for real objects and geometric patterns.

Examples of curved and angular object comparisons (Bar and Neta, 2006; 2007)

Angles metaphorically express threat because sharp and jagged objects are often dangerous. Even though not an ‘actual’ threat, the arousal response associated with angular objects is thought to be related to a threat perception.

In further support, V-shapes and triangles received significantly more negative responses when downward-pointing than any other orientation (Larson et al., 2007; 2008). The authors speculate that when positioned downwards these shapes elicit a threat response.

Shape size and emotion

The surface area of simple geometric patterns is associated with impressions of power. An increase in shape size correlates with an increase in how powerful something is perceived (Aronoff, 2006).

The height of a shape relative to the viewer is positively correlated with perceived dominance (Schubert, 2005).

With regards to preference, Silvera, Josephs and Giesler (2002) found that participants consistently chose the bigger of two shapes as their favourite.

Shape preference

Angles or curves?

In their 2006 study, Bar and Neta found that curved objects were liked significantly more than their angular alternatives. When preferences didn't follow this general finding it was because an object had a strong association that superseded contour preference. For example, snakes are curved objects that people may dislike and chocolate bars are sharp objects people may like.

Angles, curves or straight lines?

In a more recent study, Bertamini et al. (2016) set out to assess whether angular shapes are liked less simply because they are normally made up of more straight lines.

Is it the angles or the straight lines that we dislike?

Preferences for angular, curved and straight lines were compared with varying colours and both circle and square apertures.

Curved lines were consistently liked the most, followed by straight and then angled lines.

Stimulus set used by Bertamini et al. (2016)

3D objects – simple or complex?

Phillips, Norman and Beers (2010) compared preferences for abstract 3D objects at different complexity levels.

The most complex objects (see objects 9&10) were consistently rated as the most visually pleasing. Surprisingly, after the most complex objects, the simplest 3D forms were then liked the most.

The middle ground appears to be the least favourable aesthetic for 3D objects when compared with the extremes of high or low complexity.

Example stimulus set used by Phillips et al. (2010). Objects in order of complexity from 1-10.

Texture, preference and emotion

When texture is added to objects it plays a critical role in the way they are perceived.

Simmons and Russell (2008) investigated the emotional effect of 10 different visual textures on colour preferences.

With no distinguishable texture, more saturated colours are strongly preferred over brownish homogeneous colours. More saturated colours will be rated pleasant, while brownish homogeneous colours will be rated highly unpleasant.

Results showed that when texture is added to unpleasant colours it can significantly change people's preference of that colour. Adding rabbit fur texture to brownish homogeneous colours changed ratings from highly unpleasant to pleasant. The addition of a human skin texture to saturated colours changed ratings to highly unpleasant.

These results suggest that there may be universal patterns of preference for certain texture types and colours.

Visual Design › Awe

Size and Scale – Objects

Exposure to objects and scenery which are abnormally large and expansive is amongst the most common elicitors of awe.

Under the right circumstances, the sheer size and scale of an object is enough to induce feelings of awe and wonder. Imagine growing up in a small country town and then standing at the base of the Burj Khalifa (the world's tallest building at 828m) for the first time. A building or monument could be of such a magnitude that it overthrows our conceptions of normality and what is possible in terms of human accomplishments and architecture, particularly amongst those with minimal exposure to big city skyscrapers. This realisation can trigger a need for accommodation as we are forced to update our mental schemas.

Burj Khalifa, Dubai

Different perceptual cues can be employed to convey physical size. It could be how big something looks compared to the size of the user, or compared to other components of the environment. Alternatively, size could be demonstrated through loud all-encompassing sounds or through the ground shaking in the presence of an enormous object in motion.

Viewpoint

The importance of size and user viewpoint was demonstrated by Joye & Dewitte (2016) who compared participant ratings of awe when viewing different sized buildings from different locations. The higher and closer the buildings appeared to be, the more participants reported to have experienced feelings of awe and smallness. The results demonstrate the importance of both size and user positioning when conveying vastness.

Images of small and large buildings from close and far away viewpoints (Joye & Dewitte, 2016)

Buildings viewed from close up

Buildings viewed from far away

In VR we have much greater freedom to manipulate size, scale and the viewpoint given to users from which we can exaggerate vastness and the sense of smallness felt by the user.

The role of context

The relationship between physical vastness and awe is reliant on the context and meaning portrayed. Larger objects or landscapes will only produce an awe effect if their size demonstrates something which challenges normality and our current mental schemas.

Piff et al. (2015) compared participant reports looking up at two objects similar in height: (1) a range of trees identified as the tallest strand of hardwood trees in north America and (2) one of the campus buildings similar to the other buildings on campus where the participants studied. Unsurprisingly the participants gave much higher ratings of awe when looking up at the trees. The authors suggest that the trees are abnormally tall which violates people’s expectations, compared to the campus building which was no different to the other buildings on campus they have become accustomed to.

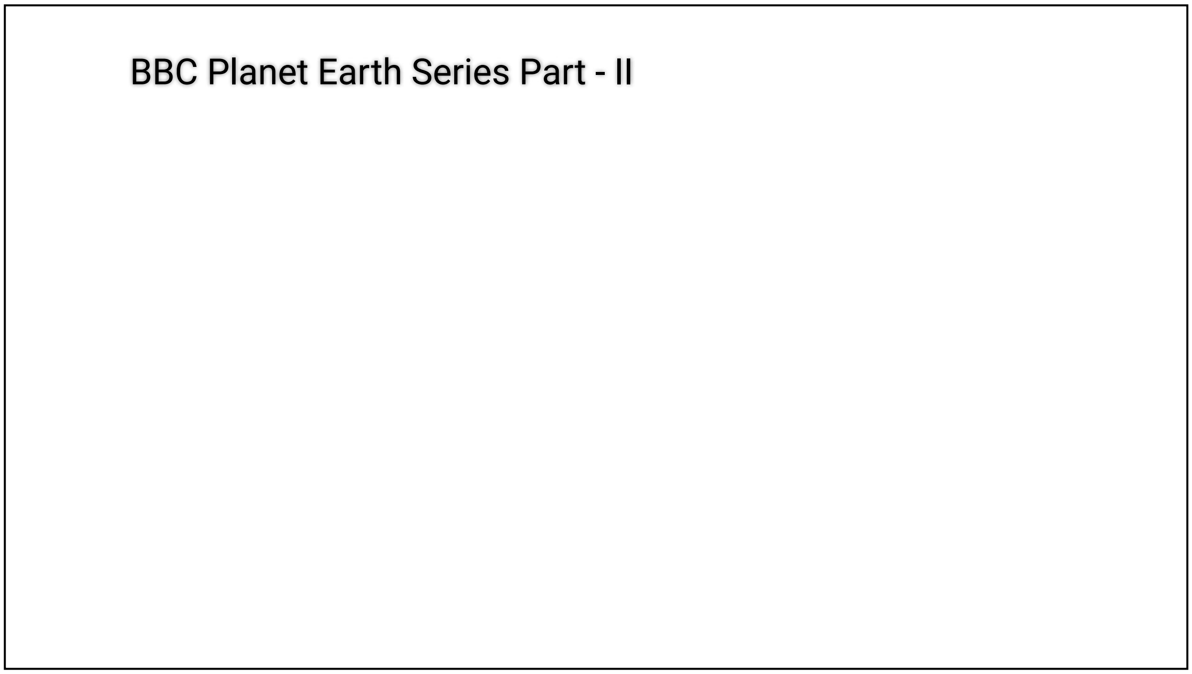
The leaning tower of Pisa is a great example of the role of context. It is by no means the tallest building in the world. However, when considering its size and its gravity defying lean, it challenges our conceptions of architecture and physics. It provides an overwhelming sense of amazement that it still stands, mixed with elements of fear when imagining it toppling over, particularly when you see people enjoying the scenes from above.

The leaning tower of Pisa

Size and Scale – Landscapes

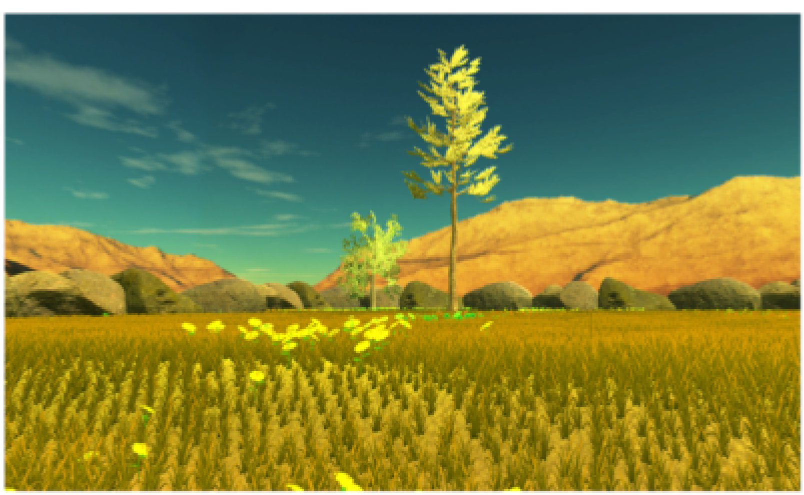
The awe response to size and scale also corresponds with landscapes which portray wide open vistas. In psychological studies, pictures and video clips of vast natural scenes and phenomena are often used to provoke feelings of awe.

One such video, used by Gordon et al. (2017) showed scenes from the BBC's Planet Earth series in which the camera sweeps over the Earth's vast landscapes with magnificent scenes of the natural world, accompanied by uplifting music.



BBC's Planet Earth

Part of the design approach used by Chirico, Ferrise, Cordella and Gaggioli (2018) was to create a neutral (non-awe-inducing) VR environment and compare it with other awe inducing environments. One of the key steps in this design process was to restrict the sense of vastness portrayed in the environment. They integrated a wall of boulders which obstructed the much larger view of the surrounding woodland. Alongside other factors the restricted vastness was effective when minimising awe. This demonstrates the importance of a clear line of sight for the viewer when trying to convey the vastness of a landscape, either through the removal of obstacles or providing a higher viewpoint.



'Neutral' VR environment created by Chirico et al. (2018)

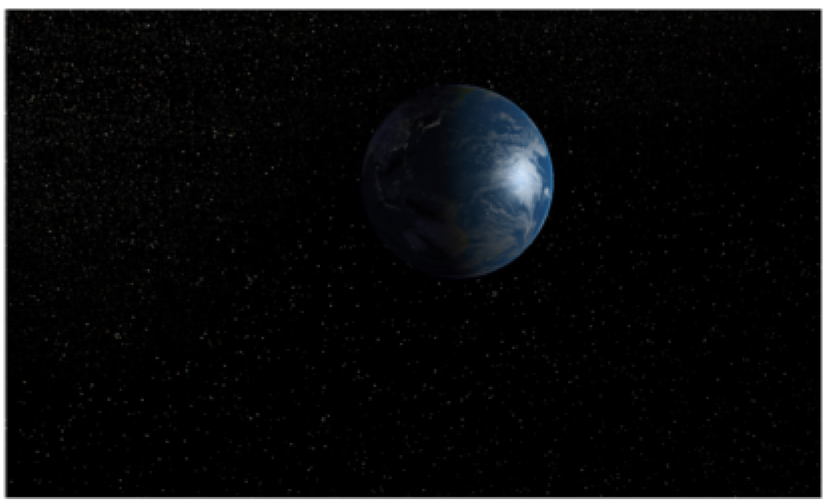
Conceptual Vastness

Through visual scenes we can convey complex information that provokes thought and insights to challenge our current mental schemas. Conceptual vastness refers to the enormity or complexity of a concept that can be drawn from visual information (alongside narrative/audio information etc), as opposed to its sheer physical size.

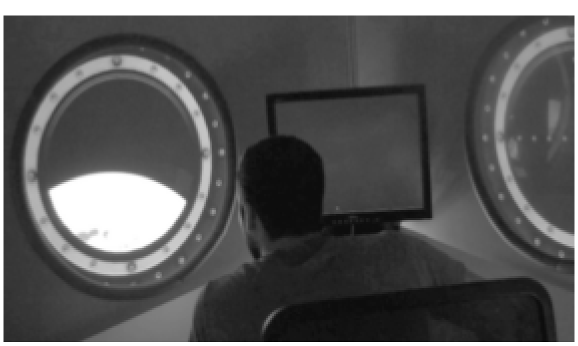
Example 1: The overview effect

The “overview effect” is a form of conceptual vastness considered to be the most prototypical case of awe. It is a term coined by White (1987) following interviews with astronauts as they describe the profound experiences of awe which take place when viewing the earth from space. The view of earth in relation to the vastness of outer space provides a new perspective as we see something much larger than ourselves and indeed everybody we have ever known. This undoubtedly raises questions regarding our significance within the universe.

The overview effect has since been replicated and used to induce awe through a variety of mediums including photos, cinematics, VR and mixed reality installations.



VR experience created by Chirico et al. (2018). Users could navigate towards the earth and observe as different sides become illuminated and obscured due to its natural rotations. No sounds were included to reflect the lack of sound in deep space.



Reinerman-Jones et al. (2013) created a mixed reality installation resembling the international space station. Participants observed simulated views of earth through space shuttle portals. A narrative primed participants to feel rushed before launch, contrasting with the subsequent calmness of observing space.

Example 2: History of the Earth

Participants viewing a life size model of a Tyrannosaurus Rex skeleton reported feeling a sense of awe (Shiota, Keltner & Mossman, 2007). The size alone certainly conveys a magnitude of physical vastness, but perhaps more awe-inducing is that it represents a physical, potentially intimidating glimpse into the time of a different dominant species on Earth. These are concepts far reaching from our daily schemas.

Lifesize Tyrannosaurus Rex skeleton at the American Museum of Natural History

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