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Translating 2D Geometric Illusions for 3D Contexts

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ABSTRACT

This paper describes the creation and evaluation of four novel, interactive objects that have been used to evaluate the effectiveness of 2D optical illusions within 3D objects. Illusions are recognised as a key means to understand how one processes visual input and perceives the world around them. A huge number of 2D illusions have been generated from the 18th century onwards, and a significant body of work exists that explores their characteristics, classifications, and operations. This paper identifies and selects four established 2D geometric illusions and explores their viability as 3D objects. A controlled experiment was conducted to ascertain whether they retained their perceptive illusory strength. A sample population of 30 participants was used and their interaction with purpose-built models was measured. Means are discussed whereby the illusions can be utilised in product design to either emphasise or counteract optical effects in geometric form.

KEYWORDS

Aesthetics, Geometric, Illusion, Optical Effects, Perception, Product Design

INTRODUCTION

Our ability to interpret the world around us through the sense of vision is something we take for granted: our sensory perceptions are treated as facts that are "obviously correct" (Wade & Finger, 2001; Wade & Swanston, 2013), and we assume that others' perceptions are identical to our own. Through the course of our evolution, we developed an appropriate ability to perceive and recognise shapes, patterns, and colour in our environment to identify food, predators, weather, and other factors essential to survival. In the present day, our use of vision may be less existentially pressing, but we nevertheless utilise it constantly to assess our situation and to make decisions on how to react accordingly. Given its role in our interpretation of the world around us, the association of vision with knowledge is reflected in the terminology we use: *I see* is to know, *far-sightedness* equates to anticipation, to *see through* something demonstrates perceptive ability, and so on.

From a neuroscientific perspective, visual perception is described as the "mental representation of the original stimulus" (Gazzaniga et al., 2014), and the processing undertaken by the brain is still far beyond the reach of our most advanced computational systems. However, our perception is not always an accurate interpretation of what we see. Our interpretations can be significantly influenced by a range of factors such as mismatches in expectation, sensory imbalances, and the viewing context. When the perceived object differs from that of the original stimuli, this is said to be a visual or optical illusion.

This has implications for design, particularly in product form and aesthetics. The plethora of 2D optical illusions that have been documented show how particular combinations of line, shade, and colour can have a tremendous effect on the viewer's understanding of what they are viewing.

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Misinterpretations of shape, dimensions, and movement are effects that a designer may wish to avoid in the generation of a form. There are particular properties that could imbue a design with a particular emphasis. However, given that the majority of work in optical illusions has been focussed on 2D formats, this work seeks to explore these can be translated for 3D contexts. By identifying which types of illusions are applicable and important, we can consider guidelines, frameworks, and tools that can support designers in the refinement of their product forms.

To achieve this, the paper is split into a number of sections. Firstly, the nature and types of common illusions are discussed, along with an examination of the challenges of translating these to 3D. Secondly, the experimental methodology is outlined. This describes the derivation of four prototype illusions and a controlled experiment to determine their effectiveness is outlined. The data derived from the experimental measures are then discussed in terms of perception and applicability to 3D contexts. Finally, we conclude on the implications of this work for designers, and ways in which the findings can be adapted for use in practice.

THE NATURE OF ILLUSION

The discussion of optical illusions—their definitions, causes, and limitations—has been ongoing for almost as long as the study of visual perception. Gombrich postulates that interaction with images elicits a reaction similar to that with the world around us, and are resonant of our reality (Briscoe, 2018). Accessibility and immersion in the presentation of such visuals are essential in order to maximise their effect, allowing users to regard these as something beyond mere representations (Grau, 1999). While these challenges of engagement may be established in the art and design of 2D media, illusions seek not merely to absorb the viewer but to shift their perceptive state. Robert Addams wrote about what is now known as the Waterfall Illusion in 1834 when during a visit to the Fall of Foyers in Scotland, he noticed a motion aftereffect of the cascading water after he had looked away (Addams, 1834). But as far back as the classical period in ancient Greece, Aristotle had noticed similar effects, which prompted studies to determine the nature of such phenomena (Wade & Swanston, 2013). The longevity of the subject is reflected by the abundance of definitions surrounding optical illusions (Luckiesh, 1922). Like the theories of visual perception, there has yet to be a definitive explanation on which psychologists and scientists agree. Gazzangia et al. (2014) state that illusions occur when we form "precepts that do not do not correspond to the true stimuli in the environment." This is similar to Boring's (1942) position, that argues "all perception is 'illusory' in so far as it does not precisely mirror the stimulus" and goes on to suggest that it has no place in psychology (its traditional domain) since no lived experience matches reality. This raises fundamental philosophical questions on the nature of our reality (Bach, 2006). How can we know the original stimulus if we are not able to perceive it correctly in the first instance?

This raises the question: Can we know the original stimulus if we are not able to perceive it correctly in the first instance? Hayward (2008) proposed the assumption has to be made that the original and repeatable perception experienced by the viewer can be regarded as the stimuli. This then can be used as the basis to which any change constitutes an optical illusion (Wade, 2014). It is widely accepted that optical illusions are not "misperceptions" (Wade & Swanston, 2013). Although a change in the perception of our reality—as we think we should perceive it—it is by no mean a mistake. As Ehm and Wackermann (2016) state, illusions are "not deliberate deceptions or random errors of the visual system; they are systematically occurring." Instead, psychologists and scientists are studying the seemingly methodical illusory phenomena to gain a better understanding of their causes and limitations, and to probe for insight as to how visual perception functions as a whole.

Types of Illusion

Historically there have been many ways of grouping and classifying illusions (Gregory, 1968). One of the earliest distinctions drawn in the literature is between illusions of extent and direction (Boring,