

BREAKING THE RULES OF VISUAL PERCEPTION

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1. INTRODUCTION

We are living in a world with abundance of choices. To purchase a product, consumers can have lots of choices across brands and models, and many efficient digital tools (e.g., Edmunds.com and Bizrate.com) to compare products side by side. Form is still one of the most important considerations for purchase decision-making. People don't typically think about how they perceive or identify an object, they just do it intuitively. As designers it is important for us to understand how consumers view and identify products. Designers need to have an understanding of how their design decisions affect the perception of the consumer and polish the design to meet their expectations. In identifying a design consumers rely upon three major factors to understand the product's form: the profile or silhouette of the product, the details of a product, and the topography of the surfaces. Once it is understood how people perceive the form of an object, the designer can take advantage of this and "break the rules of perception" to make a product look thinner or thicker, more professional or casual, more delicate or strong, to fit different consumer groups. This paper is an exploration of how the designer can take advantage of how people perceive objects, change the silhouette, details and surfaces to impact the perception of the design. Limited by the length of this paper, we will focus on discussing the cognitive theories of silhouettes identification and adopting them into our design considerations.

2. UNDERSTAND AND TAKE ADVANTAGE OF HOW PEOPLE PERCEIVE OBJECTS

An observer understands 3-D objects through deciphering the profile, details and surface topography. To do this the observer must deal with varying lighting, viewpoints, other variables, and incomplete visual information to recognize an object from the thousands of classifications of objects known to the observer. A designer can emphasize or deemphasize certain features of a design through changing the colors, details, textures, and edge details to create a desired effect in how the object is perceived. For example, a designer can obscure certain edges and emphasize others to change how the observer perceives the form, proportions, details, and surfaces of an object. This is nothing new: designers have used perceptual awareness for thousands of years to get the desired effect in the eyes of the observer. Nowadays, cognitive scientists have built up the understanding of how human perceive and recognize an object (DiCarlo, Zoccolan, and Rust 2012; Todd 2004; Bruce, Green, and Georgeson 2003). Based on this knowledge, the designer can add or remove portions of the object to affect the perceived form of the object freely and with confidence. This may be as simple as emphasizing vertical edges to make an object appear taller, or using chamfers to change the perceived outer profile of an object. Even using

shallow reliefs to visually break up a surface into smaller perceived parts. This paper starts from our findings in the literature to build up a cognitive foundation.

2.1 HOW DO PEOPLE RECOGNIZE OBJECTS

When you are reading this paper in a cafe, it is effortless for you to recognize the words here, pick up the coffee cup besides you, and be aware of people in and out the store. This “apparent ease of our visual recognition abilities belies the computational magnitude of this feat: we effortlessly detect and classify objects from among tens of thousands of possibilities” (Biederman 1987) and we do so within a fraction of a second (Potter 1976; Thorpe, Fize, and Marlot 1996), regardless of the potential big changes in appearance that each object produces on our eyes (Logothetis and Sheinberg 1996). “From an evolutionary perspective, our recognition abilities are not surprising— our daily activities (e.g., finding food, social interaction, selecting tools, reading, etc.), and thus our survival, depend on our accurate and rapid extraction of object identity from the patterns of photons on our retinæ.”(DiCarlo, Zoccolan, and Rust 2012). To understand how people recognize 3D objects, it is necessary to understand that what they see of 3D objects varies, depending upon lighting, viewpoint, orientation of the object, and movement. Additionally, the perspective is an essential variable here, depending on how close the object is to the viewer. The brain must adjust and account for these variations and let the observer categorize or recognize the object. It is important that designers understand how people recognize and categorize objects, so that they can effectively design objects and adjust their features to achieve the desired visual effects.

2.2 RECOGNIZE OBJECTS WITH SILHOUETTES

The shape of the silhouette is very important to the identification of an object. In perceiving objects the eyes are firstly drawn to the edges. Edges are the sudden changes in the surface that can either be the outer profile of the object, or the juncture of two surfaces within the object. The shapes of the edges of the object give clues to the relationships of various components of the object. The observer must decipher if these edges are the outer perimeter of the object (the extents of the object) or interior to the object. For example, the occlusion contour is such an especially important feature since it separates an object from its background” (Koenderink 1984). Indeed, an occlusion contour presented in isolation (e.g. a silhouette) can often provide sufficient information to recognize an object, and to reliably segment it into distinct parts” (Todd 2004). Therefore an important characteristic used to identify an object is the outer profile or silhouette.

2.3 RECOGNIZE OBJECTS WITH DETAILS

The details of an object help the observer to distinguish one design from another even more precisely. Details are detected only to the degree that they are essential for determining contents. Interpretation of details is essential for resolving ambiguities stemming from rotation, projection, and interposition (Navon 1977). Details include the shapes of distinct parts, segments, as well as added or subtracted portions such as holes or appendages. When identifying the details, the observer again relies upon edges to visually separate the details. These can be described as three kinds of edges; contiguous edges, non-contiguous edges, and part-lines, which will be described in more detail in a later paper.

2.4 RECOGNIZE OBJECTS WITH SURFACES

In addition to the silhouettes and details, the surfaces of an object also help in the identification of the form of the object. The surfaces' topography can be understood in a number of ways. The light bouncing off the surface creates shading, which give indications if the surface is flat, concave, or convex. The topography of a surface is can also be clarified in the reflections of the environment. Psychologists have found that the understanding of the surface form can be done quickly and accurately. However, it is difficult to accurately judge the magnitude of the depth of a curved surface, thus the surface depth is often misjudged. (Todd 2004) states that "when observers make judgments about objects depicted in shaded images, they are quite accurate at estimating those aspects of structure that are uniquely specified by the available information – in other words, those that are invariant over affine stretching or shearing transformations in depth". Designers who are aware of this tendency to misjudge depth of curved surfaces can make use of this principle in their designs.

2.5 EXAMPLE OF THE PARTHENON



Figure 1. The front view of the Parthenon

Designers started to use some of the tricks of visual perception in design thousands of years ago. For example, the architect of the Parthenon (completed in 438 BC, Figure 1) used a number of techniques to create visual effects.

- The silhouette of the columns has been tapered from wider at the base to narrower at the top. This creates two effects. First, it creates a feeling of stability by firmly grounding the column, making them appear strong and stable. Secondly, the tapered silhouettes accentuate the height of the columns, especially when viewed up close when the tapering exaggerates the perspective, making the columns appear even taller than they are.
- The architect has used details to reduce the mass of the columns and lintel. The columns have vertically fluted edges, which make them appear thinner and taller. Similarly, the horizontal details on the lintel make it appear thinner and less massive, thereby defying gravity. The horizontal details include an eve or overhang, a horizontal band that visually

divides the lintel into two sections, and a textural detail above the band with none below further accentuating the split in the lintel.

- The surface of the columns includes concave flutes that accentuate the shading between the edges of the flutes.

3. DESIGNING WITH SILHOUETTES

The silhouette of an object is the outer perimeter of that object. This outer perimeter can be perceived after an observer determines what is the object and what is not the object. The eye is drawn to edges often seen as places of high contrast. More specifically the corners of the edges have high importance and are critical to the identification of the object. In separating an object from its background there is sometimes missing information, due to confusion with the background or obstruction from other objects in the foreground. Gregory (1972) found that having only corners of shapes present allowed the observer to fill in the rest of the shape that was missing and perceive the shape. The Gestalt law of closure states that individuals perceive objects such as shapes, letters, pictures, etc., as being whole when they are not complete. Specifically, when parts of a whole picture or an outline are missing, our perception fills in the visual gap (Bruce, Green, and Georgeson 2003). Likewise for 3D shapes the corners of the edges are critical to understanding the form of the object (Malik 1987).

3.1 RULES OF PERCEPTION; IDENTIFICATION IS VERY FAST

The process of identifying objects is extremely fast in the central visual field. "Object recognition is defined as the ability to assign labels (e.g., nouns) to particular objects, ranging from precise labels ("identification") to course labels ("categorization") More specifically, psychologists focus on the ability to complete such tasks over a range of identity preserving transformations (e.g., changes in object position, size, pose, and background context), without any object-specific or location-specific pre-cuing. Indeed, primates can accurately report the identity or category of an object in the central visual field remarkably quickly: behavioral reaction times for single- image presentations are as short as ~250 ms in monkeys (Fabre-Thorpe, Richard, and Thorpe 1998) and ~350 ms in humans (Rousselet, Fabre-Thorpe, and Thorpe 2002; Thorpe, Fize, and Marlot 1996), and images can be presented sequentially at rates less than ~100 ms per image (Keysers et al. 2001; Potter 1976).

3.2 RULES OF PERCEPTION; THE EDGES OF AN OBJECT ARE VERY IMPORTANT

Todd suggests that silhouettes (occlusion contours) and edges of highly curvature are qualitative features that remain stable over a variety of viewing angles. "Psychophysical investigations have revealed that observers' judgments about 3D shape are often systematically distorted, but that these distortions are constrained to a limited set of transformations in a manner that is consistent with current computational analyses. These findings suggest that the perceptual representation of 3D shape is likely to be primarily based on qualitative aspects of 3D structure that can be determined reliably from visual information. One possible form of data structure for representing these qualitative properties involves arrangements of salient image features, such as occlusion contours or edges of high curvature, whose topological structures remain relatively stable over viewing directions." (Todd 2004, p.120) Because the highly curved edge features remain relatively stable over viewing directions they are very important to perception and design of 3D forms.

3.3 RULES OF PERCEPTION; THE CURVATURE OF AN EDGE IS VERY IMPORTANT

Todd (2004) tells us that minimum and maximum curvature of an edge can help the viewer orient the surface and identify the 3D shape. “Stability over change can also be important for the perceptual representation of 3D shape. Unlike other aspects of local surface structure (e.g. depth or orientation), curvature is an intrinsically defined attribute that does not require an external frame of reference. Thus, because it provides a high degree of viewpoint-invariance, a curvature- based representation of 3D shape could be especially useful for achieving perceptual constancy(Todd 2004)”. Several sources of evidence (Hoffman and Subramaniam 1995; Siddiqi and Kimia 1995; Singh and Hoffman 1999) suggest that local maxima or minima of curvature provide important landmarks in the perceptual organization of 3D surface structure. For example, when observers are asked to segment an object’s occlusion boundary into perceptually distinct parts, they most often localize the part boundaries at locations of extreme negative curvature.

3.4 HOW DESIGNERS CAN CHANGE THE SILHOUETTE; FILLETS

After reviewing some of the basic principles of how silhouettes impact our perception of an object; we can further investigate how designers have used this knowledge to emphasize certain features and de-emphasize others. The designer can use fillets (rounding of an edge) of an object to change the perception of an object. If a consistent fillet is used around the object it will create ball rounds at the corners. This is what has been called banal design (Hatch 2012). These ball rounds do not change significantly with orientation or viewpoint, therefore they do not help with the orienting the design. However, if the designer uses a larger fillet on one edge and smaller fillets on the adjoining edges then the larger fillet will give hints to the orientation of the perpendicular surface and draw our attention to that surface (Fig 2).

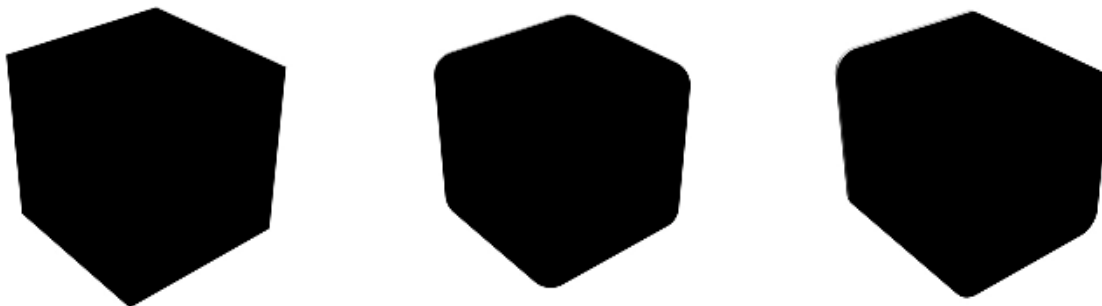


Figure 2 Silhouetted cube no fillets

Silhouetted medium filleted cube

Silhouetted medium fillets on sides

3.5 HOW DESIGNERS CAN CHANGE A SILHOUETTE; CHAMFERS

The designer can use chamfers (angled edges) to change the perception of the object. For example, if a designer uses chamfers on the back edges of a cube. The chamfers will make the sides appear narrower than the front surface, when in actuality the depth of the box has remained basically the same. But by removing a small portion of the edges the perceived depth of the box is significantly reduces (Fig 3 and Fig 4). This is because boxes depth is perceived by viewing the edges as seen in the silhouette.

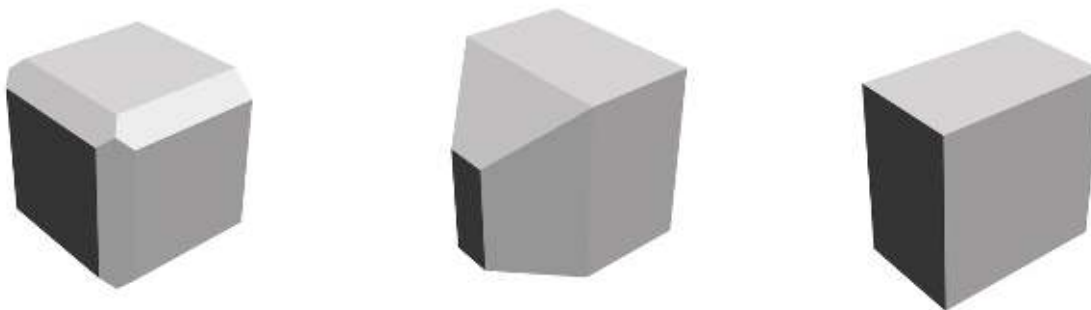


Figure 3 Chamfered cube

Large chamfers left side

Large chamfers rear side

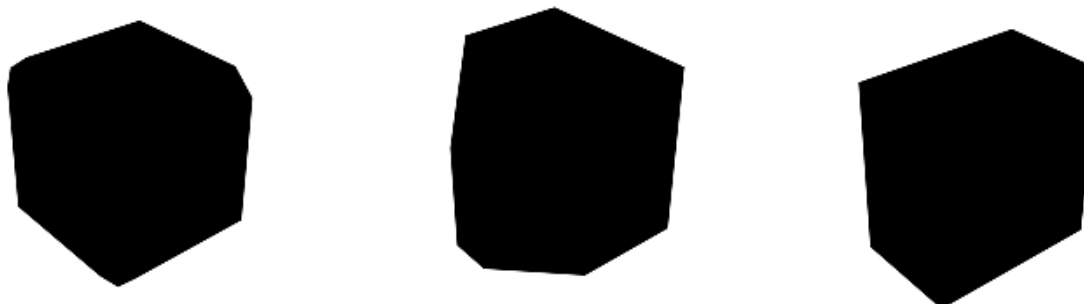


Figure 4 Silhouette chamfered cube

Silhouette large chamfers left side

Silhouette large chamfers rear side

3.6 HOW DESIGNERS CAN CHANGE A SILHOUETTE; NOTCHES

The designer can use notches (negative curvature) to draw attention to a particular portion. The eye will be drawn to notches as important indications of segments of the object. According to Todd (2004), a maximum negative curvature will help the observer segment parts. Therefore a sudden notch in the silhouette will draw the attention of the observer. Selective use of notches in a design can emphasize a certain portion the design. Even a subtle notch in the silhouette and create the impression of two separate surfaces (Fig 5). Alternatively if a notch or transition between parts is smoothed with subtle curvatures it will draw less attention.

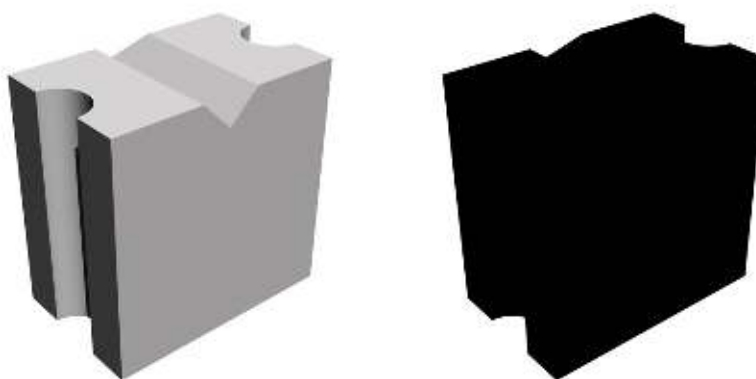


Figure 5 Rectangular form with notches on top and sides

Silhouette of rectangular form with notches on top and sides

3.7 AN EXAMPLE OF HOW DESIGNERS CAN CHANGE A SILHOUETTE

A designer can selectively use chamfers and rounds to get a desired effect. For example in early flat screen TV's there was a desire to make the thinnest screen. Designers would use large chamfers and or

fillets to give the illusion of a thinner screen. Additionally, notches and steps in the design can be added to break surfaces into smaller perceived parts or segments, thereby changing the overall perception of the design. In Figure 6 below, a basic cube is shown in light gray. Inside the cube is a silhouette after it has been changed in a series of three steps. The first silhouette is shown on the left, it shows the box with fillets removed on the sides as well as the top and bottom, but not to the front and back (right and rear left). The fillets unify the connected sides, and set the front and back apart. Additionally the selective use of the fillets give the object an orientation and make it easier for the observer to orient the object in space. The middle silhouette shows the addition of large chamfers on the rear surface of the cube. This creates the impression that the box is significantly shallower than the original box, even though it still has a portion that is the original box length. Finally, the silhouette on the left shows the addition of notches on the top and sides of the box. Even though these notches only change the profile slightly they are rather noticeable and tend to indicate that the box's surfaces are segmented at the sudden changes in the profile.

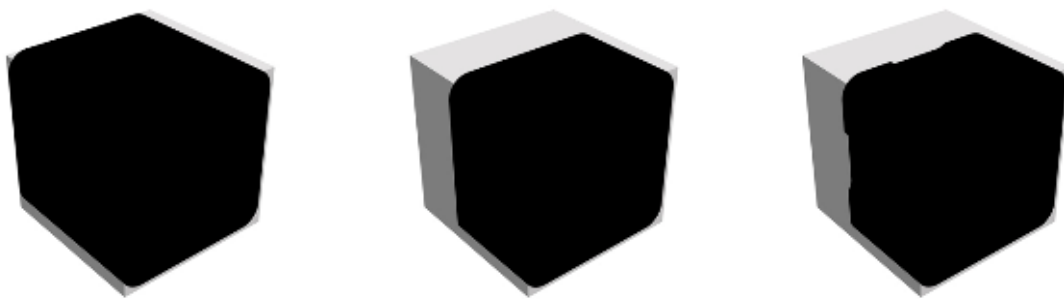


Figure 6 Cube with fillets on left and top sides; large chamfers added on rear; notches added to the top and side

4 CONCLUSION

Designers aware of how objects are observed can use this knowledge to make changes to the design of an object to achieve the desired effect in a product. Psychologists tell us that people identify object extremely quickly, and that silhouettes are particularly important to the identification process. Additionally, sharp curves and corner are critical to the perception of the form of an object. If a designer makes even subtle changes to the edges, corners and curves in an object, they will have a significant impact on the perception of the object. Therefore designers need to pay special attention to, fillets, chamfers and notches and or protrusions that impact the silhouette of the object. These features can be added selectively to impact how the object is perceived and identified.

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