THE MOST IMPORTANT DESIGN BOOKS MOST DESIGNERS HAVE NEVER READ:*

The Case for Mental Imagery

by

Stephen M. Kosslyn, William L. Thompson, and Giorgio Ganis

Mike Zender

date: 2035 CE
location: a design office

The designer looked at the screen and watched the child's memory of being sick. "I'm sorry to ask you this, but think of diarrhea again please," she said. The toilet shimmered into view briefly followed by transparent wavy lines. The designer noted the lines, then replayed the other children's memory and noted that 67% of them included shimmering, wavy lines to represent smell. "Thank you, that's all I needed. You've really helped me design this icon," she said.

Paul Rand once said that communication design is about "saying the commonplace in an uncommonplace way." (Rand, 1970, p. 36) This suggests that effective communication is essentially enhancing the familiar. For visual communication design, this means creating unique images that will connect in predictable ways with the images people already hold in their minds. From this perspective, the whole user-centered design movement is a cultivation of means for designers knowing, not just assuming, the mental images people have. Stephen Kosslyn, William L. Thompson, and Giorgio Ganis' book *The Case for Mental Imagery* (Kosslyn, Thompson, & Ganis, 2006, p. 4) gives designers an accurate glimpse into how mental images work.

MENTAL IMAGES

The plausibility of the fictional design office above hinges on the answer to a debate that has raged for at least decades, perhaps centuries: do we see mental images or not? According to Kosslyn, Thompson , and Ganis, "A mental image occurs when a representation of the type created during the initial stages of perception is present but the stimulus is not actually being perceived." Mental imagery is seeing what is not there, not an illusion or a mirage, but seeing in our mind something familiar and then perhaps using that mental image to think with or solve a problem. We might experience this by answering this question: how many windows face the street in your house or apartment? Given this task most people gaze blankly for a second

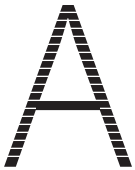
or two as they push into memory an image of their house and then briefly count the windows in the image. Kosslyn et. al. cite similar questions such as "Do you know which is darker green, a frozen pea or a pine tree? Or the hand in which the Statue of Liberty holds the torch" as examples where people use mental imagery.

Belief that this phenomena exists are not new. The authors briefly note that thinkers from the classic Greeks to Einstein claimed to use mental images "in memory, problem solving, creativity, emotion, and language comprehension." However, introspective experiences are notoriously difficult to study, easy to refute, and thus ripe territory for endless debate. Kosslyn, Thompson, and Ganis use Chapters 2 and 3 to detail the debate, Chapter 4 to marshal empirical findings from a broad range of cognitive psychologists and neuroscientists in order to settle the debate, and Chapter 5 to articulate a well-founded theory of mental imagery.

The theory articulated in the book is based on the process of visual perception which it describes. The eye is just the start of a process that occupies much of the brain. In fact, approximately 50% of the cerebral cortex is devoted to visual processing. The brain is not like a general-purpose computer with generic processing capacity to which are downloaded different problems for analysis. Rather, the brain is like a special purpose device with different neurons in different regions hard-wired to accomplish specific tasks. Vision is one of the brain's largest tasks. In visual perception a huge volume of sensations are processed and reduced to simpler more organized forms. It's as if individual camera pixels are processed for simple features then structured into units that correspond to distinct objects and key properties that define and distinguish those objects from each other. Kosslyn and his colleagues propose that we can reverse this process and push the abstracted memory of a visual object backward onto the brain's early visual processing areas and there mentally re-construct a representation of something. Representation is a key idea here. The authors point out that stored depictive representations are not like photographic pictures. They are simplified forms that can be re-presented and then examined and to which detail can be added. It may help communication designers to think of these abstracted representations as "brain icons" because they, like drawn icons, are simplified and focus on key features of an object or idea rather than inessential details. We can use these mental images to reason about problems, like whether a jar could squeeze into a crowded pantry shelf, or to communicate with people by creating images that connect with their visual imagery. It is important to note that understood this way, there is a deep and complex relationship between seeing and thinking that deserves attention.

COMPETING THEORIES

Kosslyn et. al. identify the core of the debate as two competing conceptions of the format we use to store internal visual representations: depictive



Depictive format above

FIGURE 1

FIGURE 2

Propositional format below

"two diagonal lines that meet at the top, joined halfway down by a short horizontal segment."

(Kosslyn et al., 2006, p. 12)

or propositional. The depictive approach suggests that our brain encodes images in a visual format using points, similar to the way a computer screen uses pixels. The blocks forming the triangle in Figure 1 illustrate a depictive format. The propositional approach suggests that we format images using abstract concepts like words in language or computer software. The words "two diagonal lines that meet at the top, joined halfway down by a short horizontal segment." in Figure 2 illustrate a propositional format for the same image.

The format used may seem like an academic debate, but it matters because the format of representation makes possible, or at least preferences, different kinds of thinking and from this the creation of different knowledge.

To settle the debate the authors call upon findings that add significant detail to the outline of the perceptual process noted above. Very early in this process the image from our retina is topographically mapped point-for-point on our brain. Objects close to each other on our retina are also close to each other on the cortical area called V1. There are, in fact, several topographically organized layers in V1 with each layer providing different kinds of processing. Cutting down through layers are columns that distinguish different line orientation, curve, value, and hue. These topographic layers are part of what Kosslyn labels the "visual buffer." The "visual buffer" then "reports" the results to other areas of the brain where patterns and shapes are assembled, where objects are formed and subsequently identified. Kosslyn asserts that through these successive stages a "population code" is assigned containing in abstracted form the key visual features that define an object. Kosslyn posits a "hybrid representation" that combines information for each point about its role in the depiction of the object, as well as additional abstracted information. "In spite of their coding nondepictive information, these hybrid representations cannot be reduced to propositional representations. Crucially, they use space (literally, on the cortex) to represent space in the world. The fact that each point codes additional information does not obviate its role in depicting the shape."

The highlight of Kosslyn's argument is that these encoded representations can be recalled and when they are, an image is reconstructed from memory using the same topographic neural space in the "visual buffer" that was used to "see" the initial image from the eye. In Kosslyn's words, the "stored shape representation is primed so strongly that activation is propagated backwards, including a representation of a part or characteristic in the visual buffer (which corresponds to the depictive image itself)." Kosslyn theorizes that we literally re-construct the object from memory and create a representation of it. These are mental images.

VALIDATION

When Kosslyn and his colleagues wrote this book some years ago the viability of their theory was still open to debate. But much has happen since then to support its basic premises.

In 1988 Tootell et. al. provided a foundation for how we see when they showed a topographically represented visual image mapped on the surface of a primate brain. Over the years various scientists have developed techniques that enable them to dye a primate brain and see there on the cortex - in real time - the images from the eye. A 2012 NIH presentation by Dr. Eyal Seidemann is one example of video showing this. ("Decision Related Activity and Top-down Attentional Modulations in Primate VI" http://videocast.nih.gov/summary.asp?Live=11769&bhcp=1) More recently researchers used fMRI to produce an image of a person's recalled memory (mental image) of a simple object. In 2014 Dr's. Cowen, Chun and Kuhl presented findings that through observing brain activity they were able to reconstruct recognizable individual faces from people's mental images of faces they were seeing ("Neural portraits of perception: Reconstructing face images from evoked brain activity" in *Neuroimage).* The title of the March 28, 2014 Fox news article reporting this paper was *"We know what you're thinking: Scientists find a way to read minds."* by Maxim Lott. While the face reconstruction study may be as much about the inventiveness of the computer processes employed as it is about the biological ones, its findings dramatically support the foundation of Kosslyn's hypothesis: mental images are seen reconstructed in the visual buffer. These studies can "see" them.

SO WHAT?

The Case for Mental Imagery may sound interesting to some readers, but to others the question "So what?" may have been lingering for some time now.

So what? How is the information in this book relevant to the designer? One answer is "A theoretical foundation for communication design." Communication design has entertained competing theories to guide practice. Some, such as semiotics, are based in linguistics. Theories of visual perception such as the one articulated by Kosslyn, Thompson, and Ganis may help provide more appropriate visual ground for a theory of visual communication. Knowing how people process, store, and use images is at the heart of visual communication. It's true that communication designers create objects that use both textual and visual forms to communicate and much has been written recently about the role of designer as author and the need for more writing in design education. Without dismissing the positive role designers can play in crafting the written content of the communication they create (designer as author), or diminishing the role writing can play for organizing and expressing thought in design classes (writing in design education), Kosslyn's theory suggests that there is a good reason that college "communication" programs focus on writing while "visual communication" programs focus on image making. Visual images are the essence of visual communication. Communication designers employ forms of communication that largely bypass language. Kosslyn reminds us that people think with images. One benefit of

Kosslyn's theory as it applies to design is that it is founded on hard-wired neurobiological perceptual processes common to all people, suggesting that design principles founded on this approach may be universal, applying to people of every age, language, literacy level, and culture. With limited research resources to invest, design might do well to focus on universal visual processes that can apply to nearly everyone before building upon theories focused on individual differences.

In addition to providing a theoretical foundation for visual communication, "Visual thinking" is another defense of the book's relevance. Kosslyn's theory, based as it is on depictive representations, means that visual designers use a visual language that is inherently more flexible and less inhibited by arbitrary encoding structures than language. Depictive reasoning can be more ambiguous and less structured than propositional reasoning. Images are more direct, less categorical, less overtly defined, and thus better suited for creative thinking and problem solving than language-based propositional representations that seem plodding by comparison. "I see" is a common visual-based metaphor for sudden understanding and an apt metaphor for visually-empowered design thinking.

"User centered" is yet another response. Kosslyn's theory means that communication designers now and in the future can reliably identify the mental images that people have, thus gaining direct insight into how to communicate with them more accurately. Designers who know their subjects' mental images can more reliably produce images that evoke the correct meaning. Knowing people's mental images moves user-centeredness into the user's head, literally. The point of view for designers might be transformative.

"Evidence-based" is another reply. Kosslyn's theory doesn't just apply to the front end of design creation, but also to the back end of design evaluation. Using people's mental images to evaluate communication objects could give not only very accurate measurement of communication but insight to corrective action. A loop of creation and evaluation based on reliable measurement of mental image may provide communication design with some solid principles for practice.

Another Paul Rand quote suggests a final answer when he states, "…the designer must steer clear of visual clichés by some unexpected interpretation of the commonplace." "Innovation" is the final answer. Design has been said to be the process of converting existing states to preferred ones. Designers don't just create what already exists; they create something new. So how can knowing the images people already have in their heads help create something new? To a designer the question is the answer. Knowing what people think enables us to take liberties, to explore novel variations and "unexpected interpretations", to both connect and expand what is in people's minds. Apart from knowing the people's mental images designers innovate in the dark, ignorant of whether their novel approaches support or hinder communication.

Kosslyn, Thompson, and Ganis' theory means several things to communication design. It means that seeing and thinking are complementary, helping to explain the effectiveness of information visualization. It means that visual communication designers who create images are directly connecting to the one of the most significant means people have for processing information, for thinking. It means that emphasis on visual thinking is one key to why design is good at creative problem solving.

If design theories should be founded on research findings in visual perception and cognition, then they will in some measure be founded on work by Kosslyn and his colleagues. It's a book that most designers should read.

Cowen, Chun, & Kuhl. (2014). "Neural portraits of perception: Reconstructing face images from evoked brain activity." Neuroimage

Kosslyn, Stephen M., Thompson, William L., & Ganis, Giorgio. (2006). *The Case for Mental Imagery*. New York, NY: Oxford.

Rand, Paul. (1970). *Thoughts on Design* (Third ed.). New York: Wittenborn Schultz.

Advisory Board

WELCOME

Visible Language wishes to welcome new advisory Board member Keith Crutcher. Keith reflects our interest in connecting to disciplines whose research is well-advanced and whose knowledge is related to visual communication.

Keith Crutcher

Keith A. Crutcher, Ph.D., has over 30 years of experience in biomedical research and technology including prior tenured faculty appointments at the University of Utah (7 years) and the University of Cincinnati (22 years), a founding role in an early stage drug discovery company (ApoLogic, Inc.), and four years serving as a Scientific Review Officer at the Center for Scientific Review at the National Institutes for Health. In the latter role, he managed the peer review of hundreds of grant applications. His academic research program, funded by the NIH, NSF, and other agencies, included studies of brain injury and Alzheimer's disease resulting in over 100 peer-reviewed publications, two issued patents, and numerous presentations. He has also served as an ad hoc reviewer for several federal agencies and private foundations as well as serving on the editorial boards of several journals including *Experimental Neurology*, *Aging Cell*, and *Neurobiology of Aging*, where he participated in the peer review of numerous manuscript submissions. He currently does consulting work for applicants seeking research funding and provides assistance in preparing proposals and navigating the peer review system at various federal agencies.

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If you are involved in creating or understanding visual communication in any field, we invite your participation in *Visible Language*. While our scope is broad, our disciplinary application is primarily design. Because sensory experience is foundational in design, research in design is often research in the experience of visual form: how it is made, why it is beautiful, how it functions to help people form meaning. Research from many disciplines sheds light on this experience: neuroscience, cognition, perception, psychology, education, communication, informatics, computer science, library science, linguistics. We welcome articles from these disciplines and more.

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