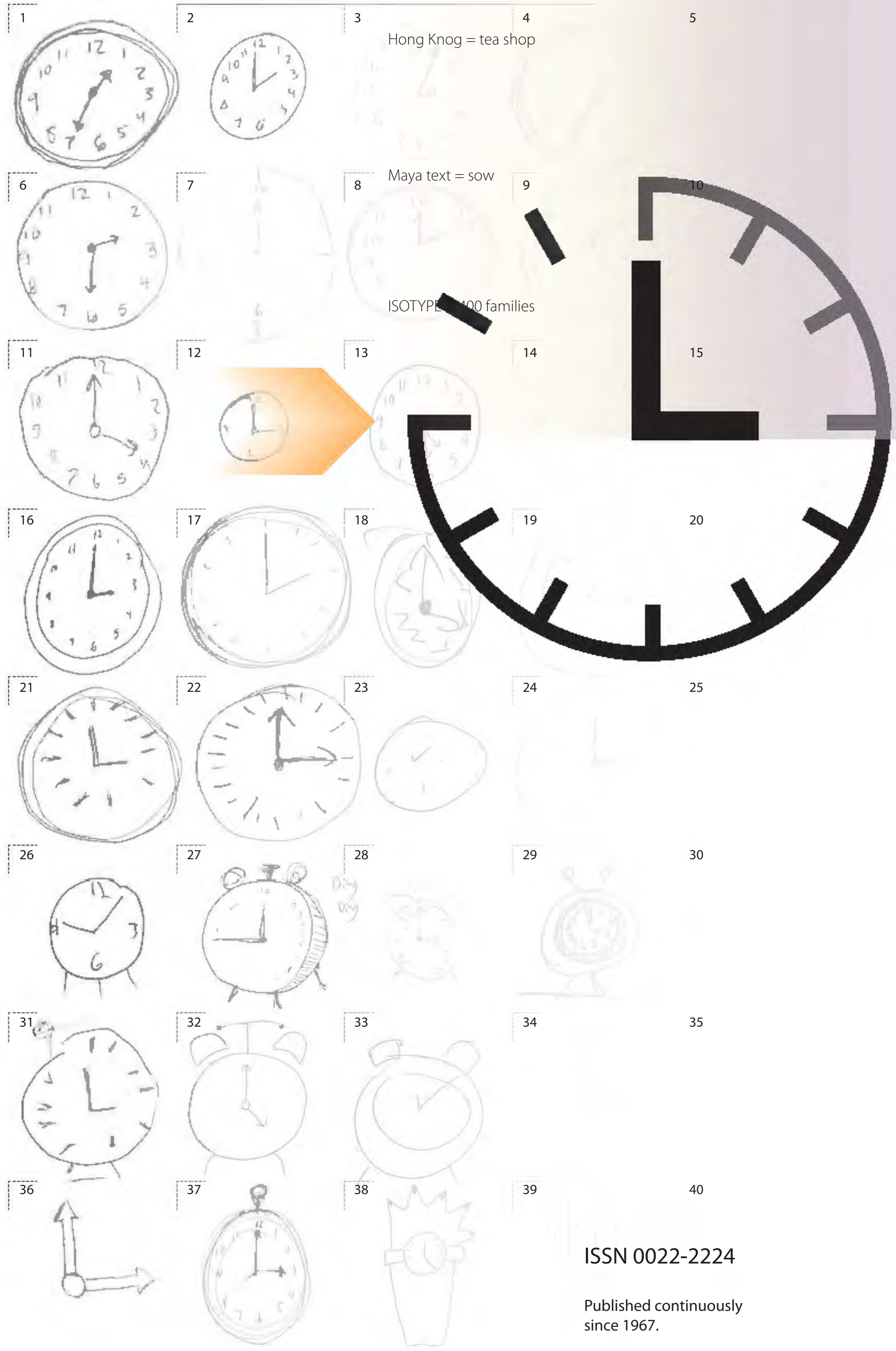


ISSN 0022-2224

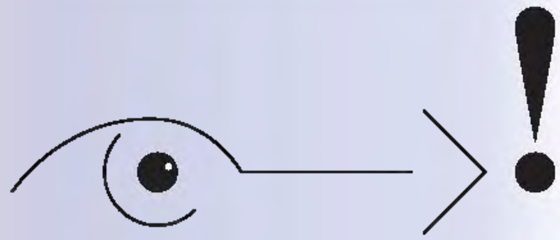
Published continuously since 1967.

Visible Language

51.2

the journal of visual communication research

august 2017



51.2

Visible Language

the journal of
visual communication
research

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Before there was reading there was seeing. *Visible Language* has been concerned with ideas that help define the unique role and properties of visual communication. A basic premise of the journal has been that created visual form is an autonomous system of expression that must be defined and explored on its own terms. Today more than ever people navigate the world and probe life's meaning through visual language. This journal is devoted to enhancing people's experience through the advancement of research and practice of visual communication.

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.

Published continuously since 1967, *Visible Language* maintains its policy of having no formal editorial affiliation with any professional organization — this requires the continuing, active cooperation of key investigators and practitioners in all of the disciplines that impinge on the journal's mission as stated above.

website:
http://visiblelanguagejournal.com

send address changes to:
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College of Design, Architecture, Art, and Planning
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PO Box 210016
Cincinnati, OH 45221-0016

Published tri-annually in April, August, and December

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Visible Language

the journal of
visual communication
research

special issue:

Symbols _ Icons _ Pictograms

August 2017

Advisory Board

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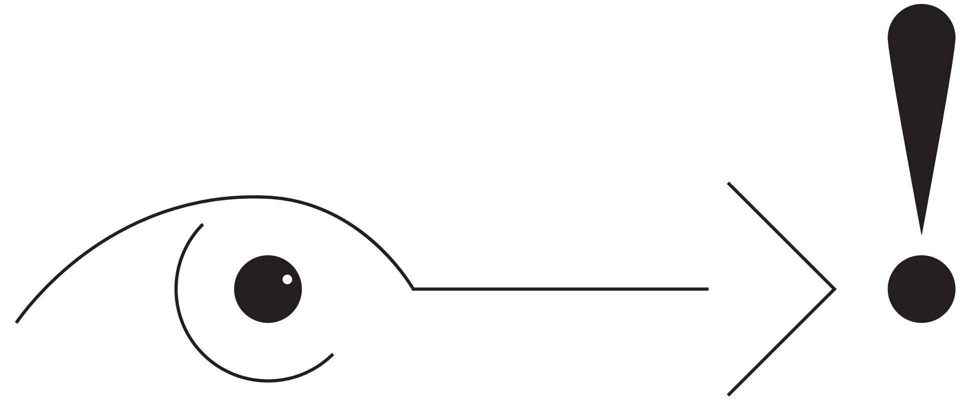
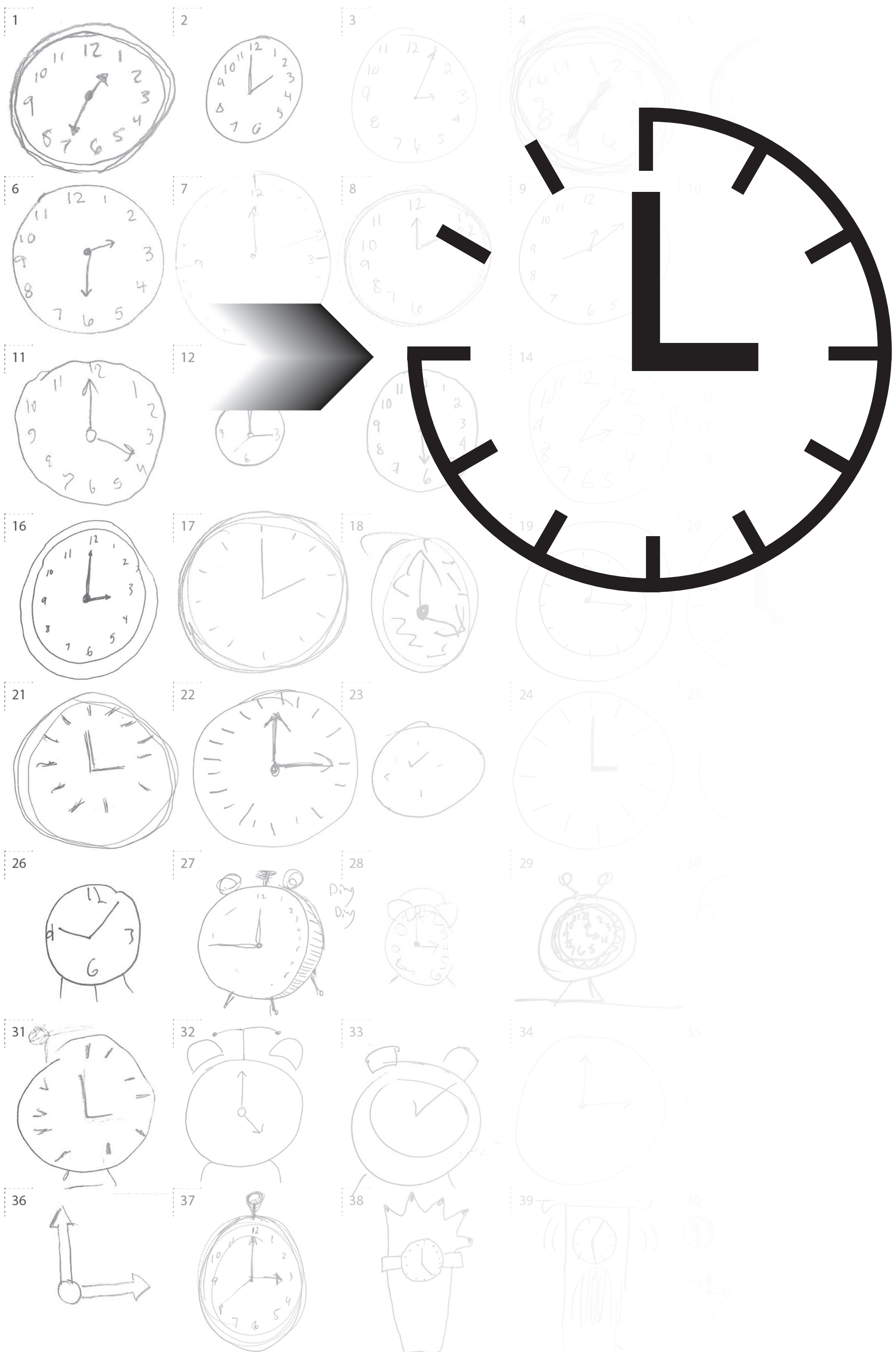


I noted in the previous issue, *Visible Language* 51.1, that people have communicated with visual symbols / icons / pictograms for thousands of years. To punctuate that point - four articles in these issues are on ancient Mesoamerican hieroglyphic communication systems: two in 51.1 “Tz’ihb ‘write/paint’: Multimodality in Maya glyphic texts” by Agnieszka Hamann, and “Signs of resistance: Iconography and semasiography in Otomi architectural decoration and manuscripts of the early colonial period” by David Charles Wright-Carr, and two in 51.2 “Metonymic and metaphoric series in the *Codex Borgia*, Plates 33-34” by Angélica Baena Ramírez, and “The Written Adornment: the many relations of text and image in Classic Maya visual culture” by Daniel Salazar Lama and Rogelio Valencia Rivera.

These papers were first given as presentations at the conference *Sign and Symbol in Egypt and Mesoamerica: Exploring the Interrelationships of Writing and Iconography* held June 30 -July 07, 2016 at the University of Warsaw, Warsaw, Poland. The aim of the conference was to address a question that has received little attention: how graphic communication systems - traditionally known as notation/numeration, iconography, and writing - relate to, interact with, and exert influence on each other. The focus was on the civilizations of Egypt and Mesoamerica that provide abundant evidence for the interplay of systems in books and on monuments. The conference also sought contributions relating to cultures and systems beyond the bounds of the focal area, such as Mesopotamia, Anatolia, India, and China.

We appreciate the help of Katarzyna Mikulska, Daniel Tacacs, Gordon Whittaker, and conference organizers in bringing these papers to our attention and helping the authors prepare them for publication.

Mike Zender



DrawIt:

a user-drawn design research method for symbol design

Mike Zender

Symbols are essential to communication design. Unfortunately, designers often draw unclear symbols because they fail to anticipate how people will respond. This paper describes a research method to help designers draw better symbols by having users inform symbol drawing decisions. It is based on popular games like Pictionary and findings from vision science on "mental images" and psychology on "basic level" mental categories. It has been developed over five years in multiple studies and demonstrated to help design symbols with clear comprehension.

keywords

design research methods
icons, pictograms, symbols
user-drawing
user-centered

How do designers know the best way to draw a symbol for an icon? In my experience they mostly guess. Designers may look inside themselves and think of how they picture the item they are drawing and then create an image from memory, or they may take a further step and do some research and look at images in their files or found online. Designers then draw a simplified representation that captures the essence of the object or concept as they see it. These non-user-centered approaches have been taught for decades and are the ones still in use by professionals at the highest levels of practice today. It's not an unreasonable process seeing that designers are people whose minds presumably work much the same as the eyes and minds of proposed users. Presumably.

The problem is that immediately after designers start to draw a symbol, they lose the perspective of a novice user who will see the symbol or icon for the first time. It is just not possible for designers to erase the knowledge and experience gained while designing and exclude this knowledge from their minds to imagine a naive user's mind. Nor is it possible for a single designer to look at their icon through the eyes of all the many and varied races, genders, ages, and cultures who will consume a designed icon once it is in use. In striving for innovation, designers are tempted to push beyond conventional images that come to mind as they search for a creative solution and this search for novelty further complicates designers' speculations about user comprehension. Designers just can't replicate in their minds users' experience. The user-centered design movement is founded on this truth and has amply demonstrated that designers' interaction with users both stimulates designers' thinking and improves end-design effectiveness.

Designers' online image research does not obviate the need for user input. Images found online are by nature a mixture of things not created by the target population of users but by advertisers to persuade or by photographers to glorify or various people for myriad reasons. Moreover, the images returned in a search have been tagged by professionals whose job it is to assign images to categories meaning that the images returned are what a third party, not a user, has defined as representing the terms of the search. An online search shows what Google thinks, not what a user thinks. Designers who try to improve their guess of how to draw by searching online are as likely to be misguided as guided.

Introduction

In the context of designers guessing how to draw symbols from imagination or misguided research, a novel user-centered method has been developed at the University of Cincinnati (UC) to help designers draw better symbols by getting user input. While drawing has been used in the past to gain insight in fields as diverse as social science and information design (Lutz, 2015, p. 1384), this method has been developed specifically to inform the communication design process. It originated at the intersection of a party game, vision science, and psychology.

Background

Many people have played the game Pictionary and its various iterations where a person receives a concept or object to communicate only by drawing, no words allowed. This fun is founded in the science of mental images. Stephen Kosslyn, William L. Thompson, and Giorgio Ganis' book *The Case for Mental Imagery* defines mental images as stored representations of objects in our brains. To be more precise, "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" (Kosslyn, Thompson, & Ganis, 2006, p. 4). Kosslyn et. al. describes how mental images can be recalled and used to think or perform work. You might experience this by visualizing a toothbrush. The essential features of a toothbrush come to mind: a handle with short bristles on one end. Now envision your own toothbrush. To the essential features, you have now added details: color, texture, a button if it is electric, etc. specific to your toothbrush. These specific details are not essential to the mental image of the category "toothbrush," they vary from toothbrush to toothbrush. Kosslyn notes that people appear to store essential features and details in separate regions of the brain. Think of the toothbrush once again. Most people's mental image of a toothbrush is from the side, not the top or either end. Scientists have observed that visual object recognition is viewpoint dependent (Peissig & Tarr, 2004, p. 80). The typical point of view forms a "canonical perspective" related to the object and this plus essential features of the object comprise the mental images that people use to draw objects from memory.

People form mental images as part of the seeing process. Very early in this process, the image from the retina is topographically mapped point-for-point onto the cortex of the brain. Objects close to each other on the retina are also close to each other on the cortical area called V1. There are in fact several topographically organized layers in V1, each layer providing different kinds of processing. Cutting down through layers are columns that distinguish different line orientation, curve, value, and hue (Hubel, 1988). As the seeing process progresses, the cortex integrates these simple elements into columns of neurons that encode more complex visual forms. Groups or populations of these visual features discriminate one object from another. In the toothbrush example above these essential visual features are a straight line (handle) with a perpendicular group of many short lines (bristles) on the end. These stored visual features called activation patterns are distinct for different object categories: cars or faces for example. Vision scientists believe that when we encounter a new object, we immediately and subconsciously compare the unknown object's visual features to a host of activation patterns with similar features searching for a match. When a match is found the object is identified. Current knowledge of this object recognition process was summarized nicely by Peissig and Tarr (Peissig & Tarr, 2004, pp. 91-92). Designers might think of visual activation patterns used in object identification as "brain icons."

Thinking about what we see is also a fundamental human capacity. People naturally sort and categorize the objects they see and the experiences they have into mental taxonomies that have varying levels of inclusiveness or abstraction such as *furniture*, *chair*, *office chair*. A couple of decades before vision scientists detailed the process of mental imaging, researchers in psychology, linguistics, philosophy, and anthropology had used perceptual, behavioral, and communication means to explore how people mentally categorize things and the nature of the categories and subcategories people form. Rosch et. al (1976) described three levels: *superordinate* with six categories (*clothing, fruit, furniture, musical instruments, tools*, and *vehicles*); three *basic level* categories for each *superordinate* category (*table, lamp,* and *chair* for the *furniture* category); and two *subordinates* for each b*asic level* category (*kitchen chair* and *living room chair* for the *chair* category). While researchers had thought categorical groups to be arbitrary and a result of cultural convention they soon discovered "regularities in classification across languages" and that these regularities were "linked ... to structures in the perceived world" (Tversky & Hemenway, 1984, p. 170). In 1984 Barbara Tversky reported in her exploration of categories that *basic level* objects–known to have the most similarity in shape and function, and the most significance for object recognition, communication, and behavior–were characterized by similarity of parts that were both functionally significant and perceptually noticeable: the blade of a saw for example. All saws have blades: table saw, saber saw, coping saw, miter saw. The saw blade is both visually distinct and functionally critical. Hence it is an essential feature of the "saw" category. Though Tversky based her findings on linguistic analysis, she noted that "the basic level is the highest level of abstraction for which a generalized outline can be recognized and the highest level for which an image can be generated. It is the level at which pictures of objects are identified most rapidly" (Tversky & Hemenway, 1984, p. 186).

Encouraged by Tversky's comments, we might think of *basic level* features identified by psychologists, linguists, and philosophers as corresponding with the *visual features* stored as activation patterns in vision science. The words psychologists' subjects wrote for the parts of a chair, for example, might have been drawn from each subjects' mental image of a chair. Without setting out to prove a linkage between Tversky's categories and Kosslyn's mental images, both can shed light on our experiences designing symbols. We had observed in the past that it is difficult to visually symbolize high-level conceptual categories and easier to communicate simple objects (Zender, 2006). Tversky's findings that *supraordinate* objects have few features may help explain this. Designers have long described symbol design as a process of simplification. Findings from vision science affirm that the symbol drawing process of progressive simplification is indeed appropriate but suggest that random simplification is not. Rather, a representational symbol such as an icon should be simplified so as to focus on the essential features of the conceptual category and the visual features of the mental activation pattern. As a result, we began to use findings from science to inform our thinking of what a visual symbol is and how it functions. We redefined an icon from being just a simple drawing of an object or concept to being a picture of the essential visual features of an object or concept and the relative absence of particular non-essential details. If this definition is accurate, and if we could identify the visual features people hold in mind, it would remove some of the guesswork from simplification for symbol design.

Preliminary Study

Based on this, in 2010 UC graduate students and faculty adapted Pictionary processes to make people's brain icons visible to help the designers draw better symbols. The method we have come to call DrawIt was first used by graduate students drawing icons for a book to help medical students memorize the side effects and interactions of thousands of commonly used pharmaceuticals. The book's premise was that pictures aid recall–the "picture superiority effect" (Paivio & Csapo, 1973). Student designers informally asked a handful of medical student participants to draw what came to mind when presented with a concept for an icon: blood for example: "Draw what comes to mind when you think of blood." Designers collected the drawings, compared the similarities, and then used these basic features as the starting point to draw their icons. The medical students approved the icons and the resulting book, *Pharmacology You See* created by Dr. Browne and written by students in the Physician Scientist Training Program (PSTP) at the University of Cincinnati, was published in 2011 by McGraw-Hill Medical.

Just after finishing the icons for *Pharmacology You See* the author got the opportunity to test DrawIt's applicability across cultures on a trip to India in Spring 2011. In the context of conducting design workshops for aspiring young communication designers, I asked each student in a class of about 30 students in New Dehli and a separate class of about 70 in Chennai to draw what came to mind for the object "chair." After a minute or so participants were then asked to form into groups of 3 or 4, to share their "chair" drawings with each other, and to come up with a consensus "chair" drawing for their group. After a few minutes, I randomly selected 4 group leaders to come to the front of the room to each draw their group's consensus "chair" on one side of two freestanding white boards. As the two drawings facing the class took shape, everyone was surprised by the "chairs" similarities. When the white boards were rotated to reveal the other two drawings people laughed and clapped as they saw that all four drawings were virtually identical. Not only did the chair drawings have the same essential features: a seat, a back, and four legs, but they were drawn from the same point of view: a 3/4 view from above. We were looking at people's brain icons. What the class did not know was that four legs, a seat, and a back were the same verbal attributes listed by Barbara Tversky as the most important for a chair in her 1984 article 27 years earlier. It was luck or intuition or tacit knowledge that led to me selecting a "chair" to draw in India in 2011. I had not read Tversky's article then. But the correspondence between verbal list and drawn features is notable. I have had groups draw a "chair" many times and at various locations around the world all with the same result: four legs, a seat, and back. Brain icons for "chair" are a mental reality shared by people around the world that can be uncovered through DrawIt. But what about other objects in other places to improve a design outcome?

I got a second international opportunity to try DrawIt in a more practical sense in Tanzania in summer 2011. I was designing icons for a rural medical clinic. Some icons were performing very poorly, such as icons for "surgery" and "children's ward." Our attempt to find a successful icon approach using a "Comprehension Estimation" survey that showed people several candidate icons was not providing the answer. Comprehension scores from villagers were still unacceptably low. So we began asking them to simply draw what came to their mind for "surgery" and "children's ward." The insights gained were immediate. None of the designer-drawn icons featured a knife, but user-drawing (*figure 1*) showed the essential objects for "surgery" were a person with a prominent knife. Designers had not thought of including a mother in the children's ward icon, yet users showed (*figure 2*) the essentials for "children's ward" were a mother and baby and a room full of beds. We had not considered that in a rural Tanzanian context the lack of transportation caused most mothers to stay overnight in the room with their children. A children's ward included mothers! Figure 3 shows the final "children's ward" icon.

These early experiences encouraged us that a user-drawn activity could provide reliable insight for designers drawing symbols.

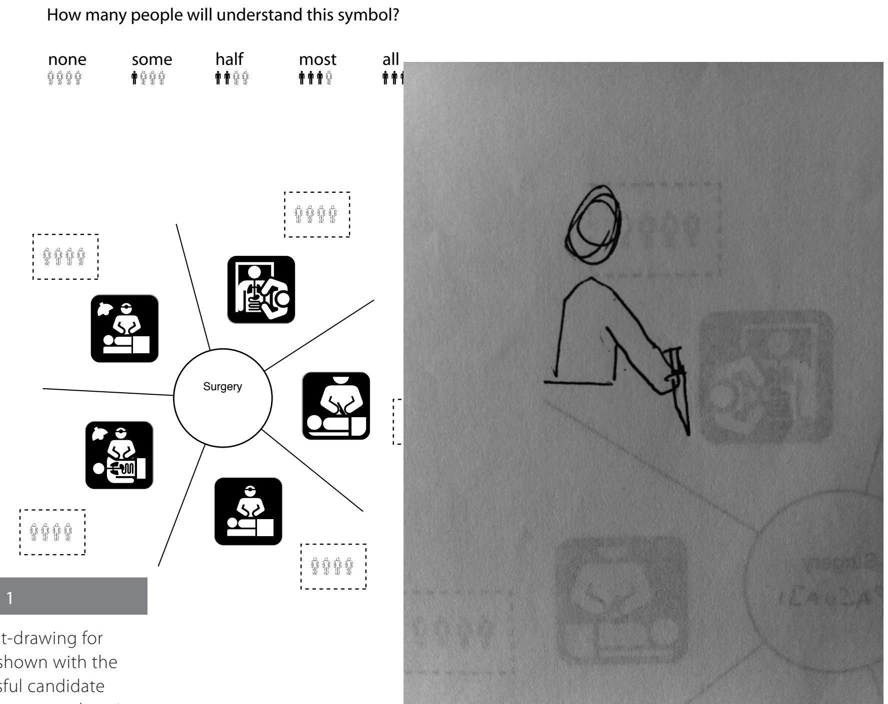


Figure 1

Participant-drawing for "surgery" shown with the unsuccessful candidate icons in the comprehension estimation survey.

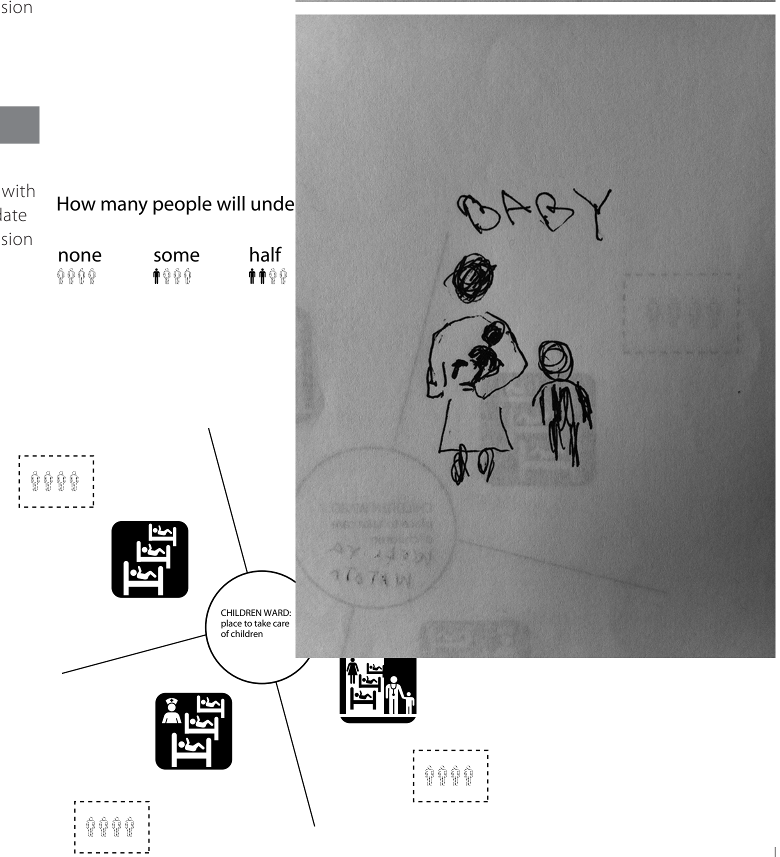


Figure 2

Participant-drawing for "children's ward" shown with the unsuccessful candidate icons in the comprehension estimation survey.

Figure 3

The final icon for "children's ward."

DrawIt: User-centered method to inform symbol drawing

Since these early explorations, the DrawIt method has become more formalized through use in dozens of studies over five years. It has become a qualitative, open-ended, mixed methods approach characterized by user-drawing.

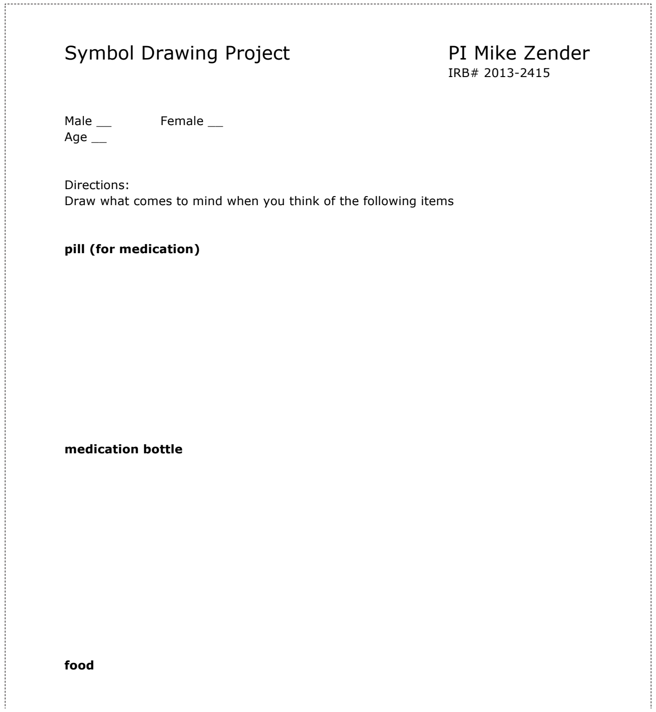
The DrawIt process starts by deconstructing the symbol concept also called the referent, to identify all the symbols that might be part of that referent. One referent concept might include several individual symbols. Blood draw, for example, requires a symbol of a syringe, blood, an arm, and a medical practitioner. Various methods can be used to identify the necessary symbols including Freelisting and Pilesorting described by Strauss and Zender. (Strauss and Zender, 2017) Alternatively, participants might be asked to draw a complex concept such as "blood draw" as a means of both determining what symbols to include and how to best draw each symbol.

After determining which symbols are needed, a survey instrument such as Figure 4 is prepared that includes the context, a request to draw the required objects or concepts, and a blank space for participants to draw their responses. The survey should include a brief description of the context of the symbol to elicit an accurate response. We might ask "Imagine that you are in a hospital, please draw what comes to mind when you think of *blood draw.*" or "Imagine that you are in a hospital, please draw what comes to mind when you think of a *syringe.*" Failure to specify context can produce confusing results.

The DrawIt survey instrument is then given to a randomly selected sample of approximately 20–40 people who represent the target population. The survey may collect apt demographic data, but in our DrawIts we

Figure 4

Sample DrawIt survey.



Symbol Drawing Project

PI Mike Zender
IRB# 2013-2415

Male __ Female __
Age __

Directions:
Draw what comes to mind when you think of the following items

pill (for medication)

medication bottle

food

collect no identifiable personal information. DrawIt can be administered either to individuals or groups. In our experience participants in group settings are often too absorbed in drawing their own response to think of cheating by copying their neighbor's drawing. The research administrator explains the study and obtains each individual's consent to participate, then gives each participant the paper instrument, some drawing tools (such as colored pencils, pens, or markers), and asks the participant(s) to draw quickly what first comes to mind for each concept. The administrator is permitted to verbally interact with the participant(s), though not to draw for them or explain the concept to them. If a participant asks "what is a blood draw?" the administrator tells them to do the best they can or if nothing comes to mind to simply skip that object/concept.

The completed surveys represent the brain icons of the participants, and by inference, the target population. These brain icons are analyzed using a general inductive approach. This inductive analysis is performed by three independent research administrators to find common ways (there may be multiple ways) of representing each symbol, including common and divergent points of view (perspective). If topic or study complexity dictates it, a code book can be developed in which drawn responses can be categorized such as is done in Constructing Grounded Theory. Survey analysts do their work independently then compare their results. Any areas of disagreement are resolved or let stand by consensus. One student's analysis of DrawIt data for "syringe" is shown in Figure 5.

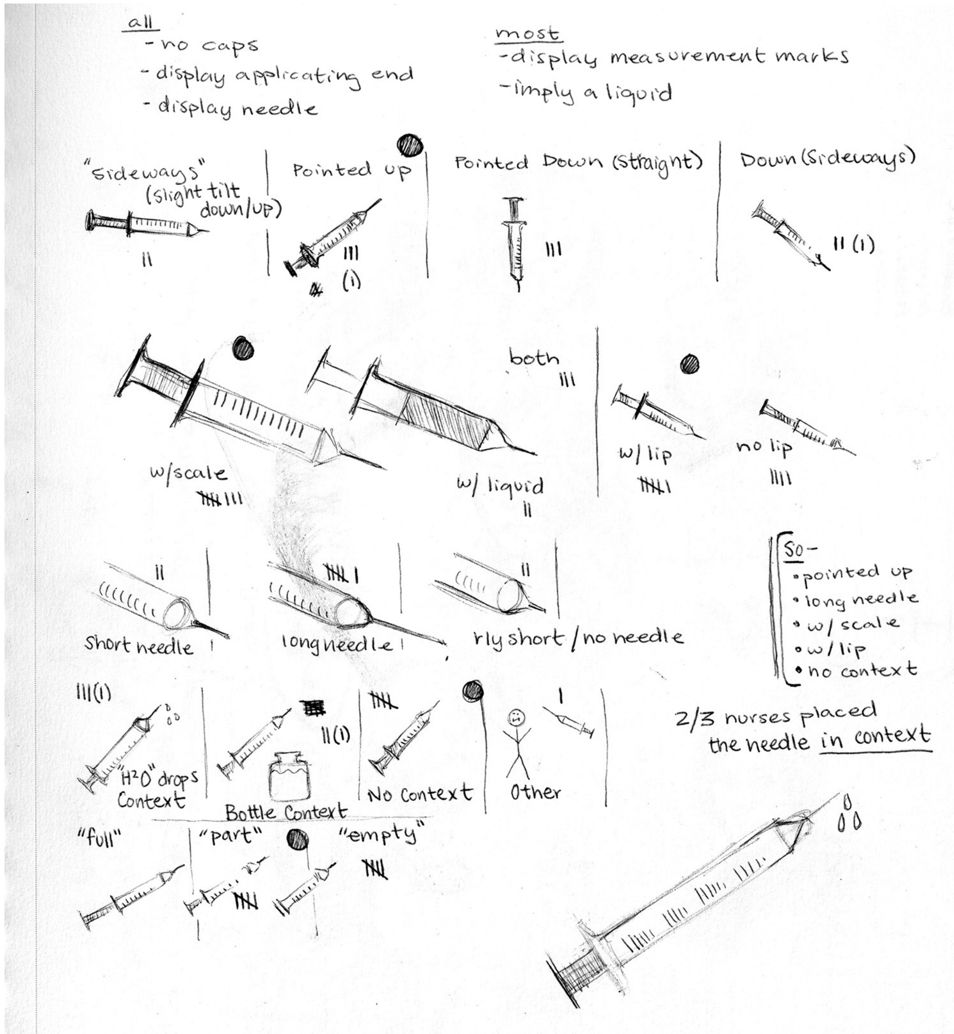


Figure 5

Analysis of DrawIt results for "syringe" by student Madeline Lyon.

These brain icons (common ways of drawing symbols) are then given to the designer who analyzes the results for compatibility (two ways of symbolizing a concept might be combined, others might be mutually exclusive) and characterized. The designer then uses these insights to draw symbol concepts.

The DrawIt process described above is for a University research context under the supervision of an Institutional Review Board and therefore contains all the steps and safeguards it requires. However, you could get the same results having friends draw on napkins at dinner! The gist is to have people from the target audience to quickly draw what comes to their minds when presented with a concept of interest.

Observations

Several informative patterns have emerged from results obtained through DrawIt since 2012. The character of DrawIt results fall into two broad categories: results that are highly unified; results that are significantly diverse.

Unified Results

Define Essential Elements

The first use in India suggested that DrawIt for some objects would yield almost unbelievable unity. This has been borne out as recently as 2017 when 41 Freshmen design students (n=41) in a class of 88 students total were given a DrawIt survey and given 20 seconds to draw the object "Clock." All 41 drew two straight lines connected at one end to represent clock hands; 40 of 41 drew a circle+hands to represent a clock face seen straight-on; 22 of those 41 included numbers around the clock face+hands; 12 of 41 included tick marks in place of numbers around the clock face+hands. The "clock" DrawIt produced data that have 98% agreement that the essential elements of a clock are a clock face+hands viewed straight on and 83% agreement that the clock face+hands has numbers or tick marks. Figure 6 shows the visual similarity of the results. Observe that 5 of the 41 drawings had a clock face+hands with bells on top: a traditional alarm clock. It is noteworthy that 3 of the 5 drawings with bells were also 3 of the 5 drawings that had neither numbers nor tick marks. One must be careful about reading too much into data, but it might be that the participants who drew alarm clocks felt that adding bells was sufficient to communicate their mental image of a clock and that additional information in the form of numbers or tick marks was superfluous. Also noteworthy is that in 23 of 41 drawings the hands point toward 12 and 3 or 12 and 4. This DrawIt was administered in a classroom at approximately 2:30 pm, so it is unclear whether students were subconsciously aware of the time or whether 3 or 4 o'clock are prototypical times that are part of brain icons or whether 3 and 4 o'clock were selected intuitively during drawing because a right angle is easy to draw or because of visual perception's particular sensitivity to horizontal and vertical orientations. Note that this "clock" study did not produce any drawings of digital clocks. Again, speculation should be done cautiously, but it may be that people intuitively sorting through their mental images rejected digital clocks because digital numbers can represent so many different things and, therefore, they did not come to mind. The data decisively shows the brain icon of "clock" is a round clock face+hands+numbers/ticks, suggesting to a symbol designer that drawing a clock should include a circle with hands, optionally with numbers or tick marks, and that drawing a digital clock would be a big mistake.

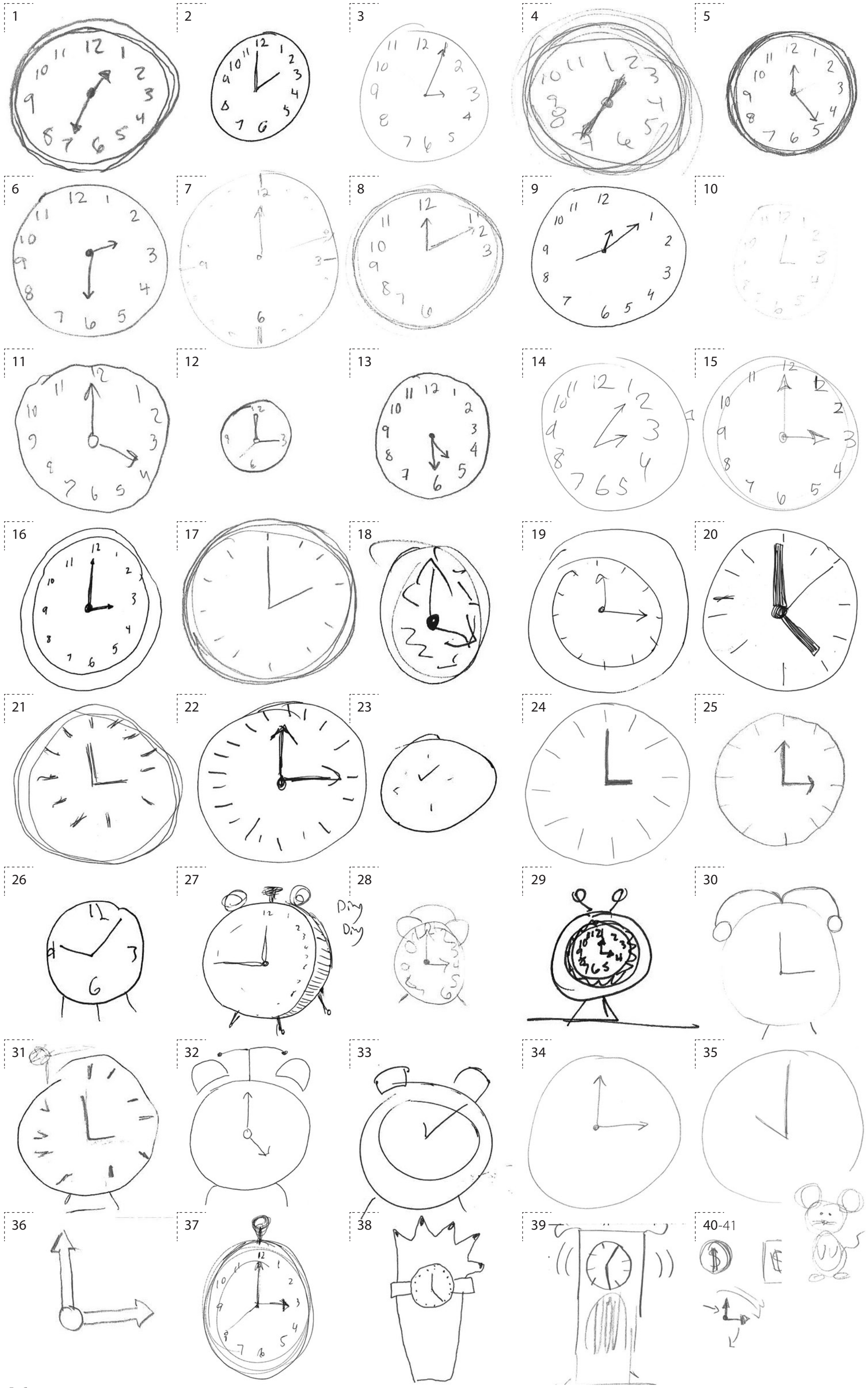


Figure 6 *(opposite)*

DrawIt data for "clock" from n=41 university students

Describe Viable Options within Essential Elements

A DrawIt survey administered to 38 different freshmen design students (n=38) who were allowed 20 seconds to draw "computer" produced a slightly different kind of unified result. A total of 35 of the 38 students drew a keyboard+monitor while 2 drew a keyboard+mouse only and 1 drew an Apple logo only. That is 92% agreement that the essential elements to represent a computer are a keyboard+monitor. However, within this overall similarity a clear division was apparent between 23 drawings of a traditional tower computer configuration represented by a keyboard+monitor+CPU box and 12 drawings of laptop computer represented by a joined keyboard+monitor: 60.5% desktop computers, 31.5% laptop computers (see *figure 7*). Note that 11 of 12 laptop drawings were from the front, one is from the back showing the Apple logo. Indeed, 6 of the 38 drawings included the Apple logo while 2 included the Windows logo. Such is the dominance of the Apple brand among design students! While the results are similar for "clock" at 98% agreement on clock face+hands and "computer" at 92% agreement on keyboard+monitor, there are also subtle differences. The computer results show a greater division between 60.5% desktop and 31.5% laptop configurations than the 83% with numbers/tick-marks versus 17% hands-only division in the "clock" data. DrawIt data suggests that a symbol designer drawing a computer should certainly include a keyboard and monitor but that they might reasonably use either a desktop or laptop configuration, perhaps depending on the audience.

Distinguish Subordinate Concepts from Base-level Elements

Finally, the same 38 design students (n=38) who completed a DrawIt survey for "computer" were also asked to draw a "toothbrush," producing a slightly different kind of unified result (see *figure 8*). A total of 35 of 38 drawings had a line with several short equal length lines perpendicular to it on one end representing a handle+bristles or toothbrush for 92% agreement. Of those 35, 10 or 26% also included toothpaste on the toothbrush, 1 included a tooth with the toothbrush, 1 drew a tube of toothpaste and a glass, and 1 happy soul just drew a smiling mouth with teeth! These results corresponded to a separate 2016 DrawIt survey of eleven (n=11) 6–10-year-olds who also drew "toothbrush." (see *figure 9 numbers 1-11*) All 11 drawings showed a handle+bristles, only 1 included toothpaste. Of the 11 children, 3

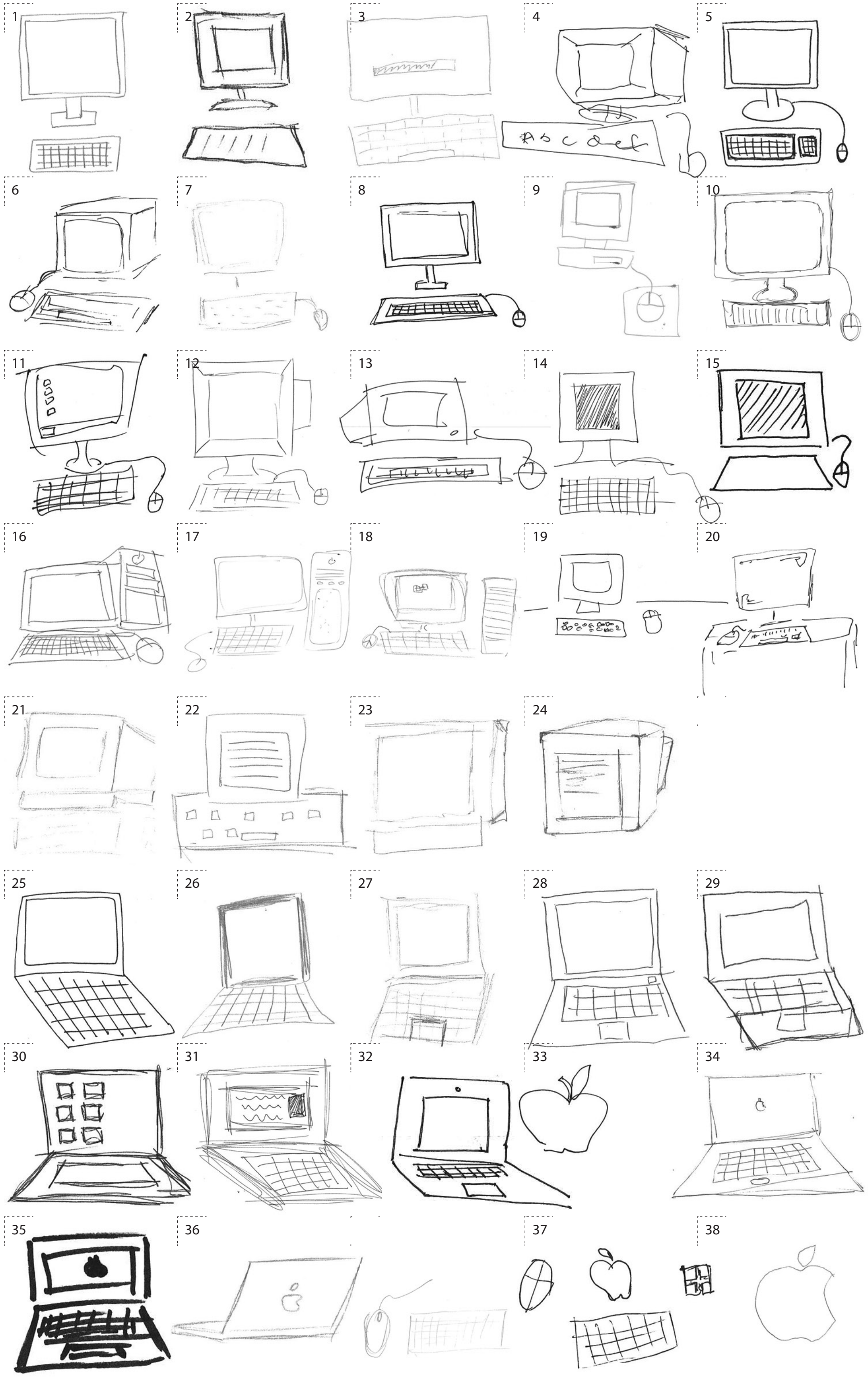


Figure 7 *(opposite)*

DrawIt data for "computer" from n=38 university students

were careful to note in their writing and their drawing that their toothbrush was "ulactick" (electric). Another DrawIt in 2016 with a different group of 20 (n=20) 12–18-year-olds for "toothbrush" also had 100% agreement on handle+bristles including 2 with toothpaste, 1 a mouth, and 1 indecipherable. (see *figure 9 numbers 12-31*) These results from three different samples of different ages at different times all show between 92%–100% agreement on the essential elements for a toothbrush. These are similar to the "computer" and "clock" surveys which had 92% agreement and 98% agreement respectively. However, there are subtle differences. The absence/presence of toothpaste or mouth is more similar conceptually to the absence/presence of numbers on the clock face than it is like the division between desktop and laptop computer configurations. Thinking back to Tversky's use of Rosch et. al.'s categorization, a desktop computer and a laptop computer and a regular and electric toothbrush are *subordinate* objects (a level lower than computer or toothbrush), whereas numbers and tick marks or toothpaste and mouth are parts of a *basic level* category object. A DrawIt informed designer might use this knowledge to create a *supraordinate* icon for computers generally as opposed to a *basic level* computer symbol for a type of computer.

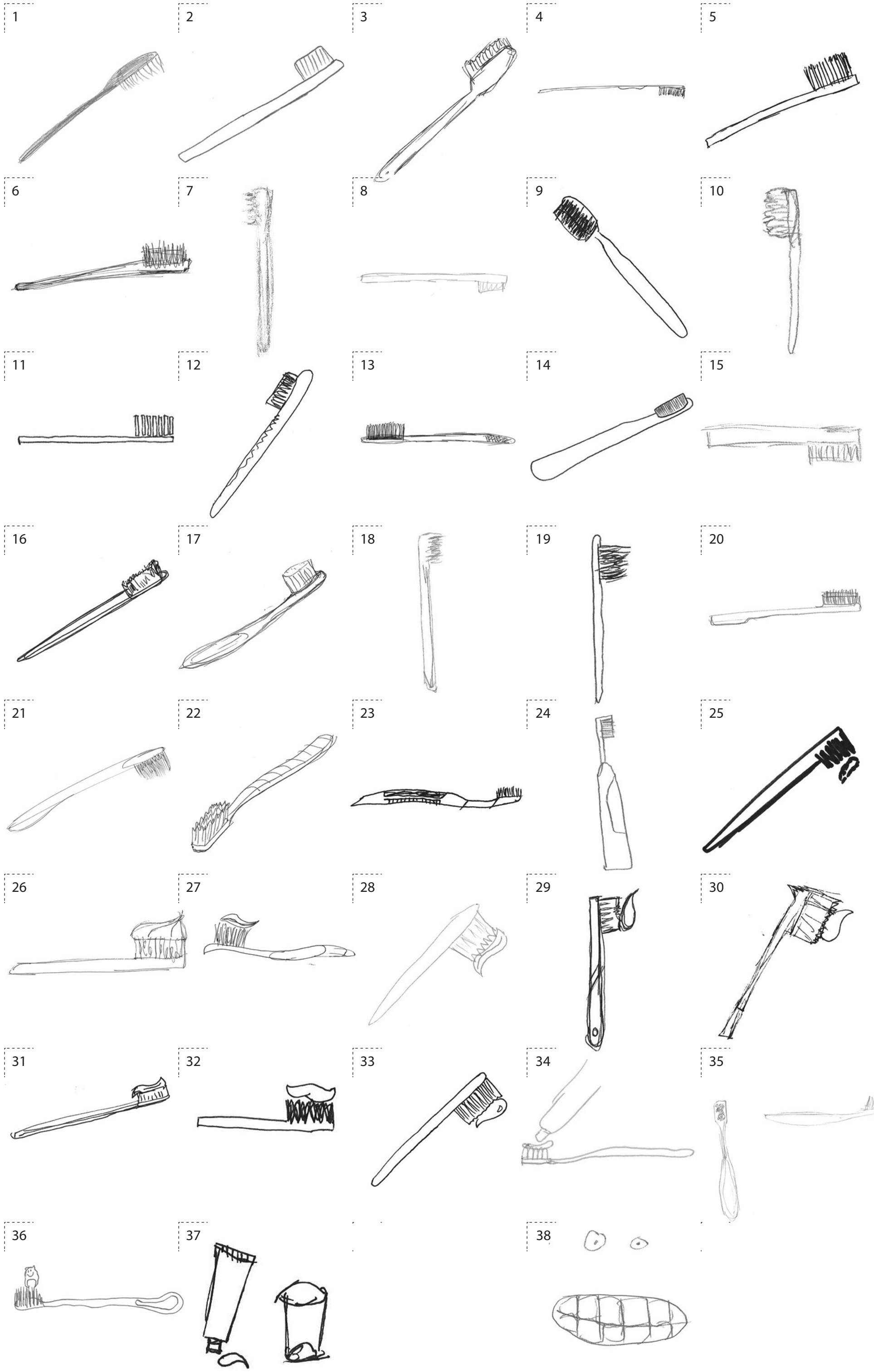
These examples show consensus to the degree that is unlikely to be random. Further, the data suggest that DrawIt produces results that intuitively align with reality: most but not all clocks have numbers; computers come in two major configurations; toothbrushes often have toothpaste on them. At the same time, this shows how DrawIt informs design in ways that might not be predicted by guessing: digital clocks do not represent "clock" to most people; a keyboard and monitor are essential to represent "computer," and for a "toothbrush" toothpaste may be helpful but is optional. It also suggests how DrawIt might inform designers creation of icons that intentionally work at the difficult-to-draw *supraordinate* level as well as the *basic* and *subordinate* levels.

Figure 8 *(following L.)*

DrawIt data for "toothbrush" from n=38 university students

Figure 9 *(following R.)*

DrawIt data for "toothbrush" from n=11, 6–10 year-old students and n=20, 12–18 year-old students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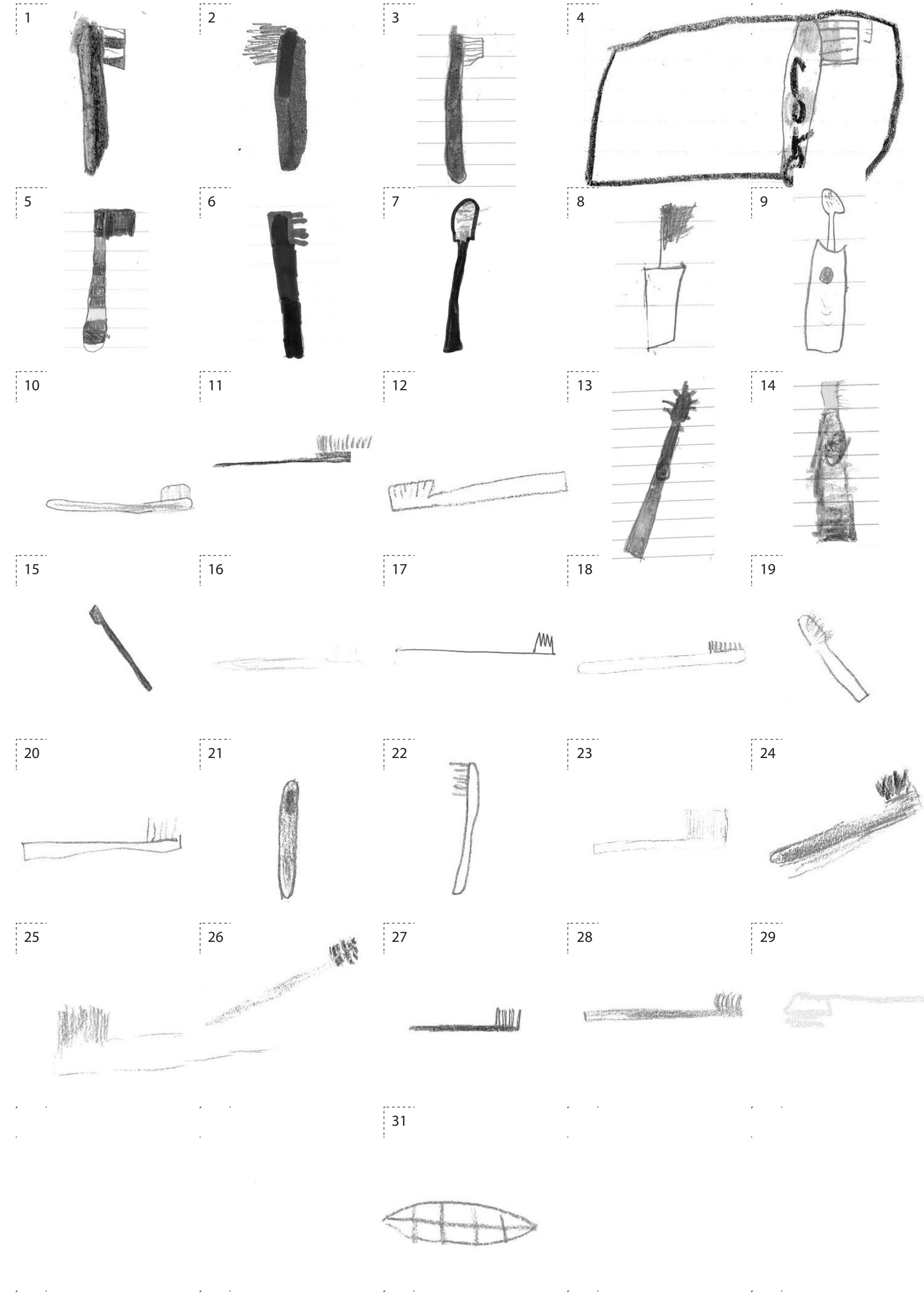
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Diverse Results

Indicate Cultural Groupings

We have also seen instances where a DrawIt has produced highly diverse results that are quite informative. The usefulness of diverse data was made obvious initially when a group of about 20 graduate students, about half from China, produced two very different groups of images when asked to draw "lunch." The American students drew pizza or a sandwich and a drink whereas Chinese students drew a bowl with rice. Food is a well-known cultural marker, and this example suggested that DrawIt diversity might indicate the presence of cultural clusters with different brain icons.

Identify Multi-object Categories

The same group of 20 (n=20) 12–18-year-olds that had 100% agreement for "toothbrush" were also asked to draw the object "chips." (see *figure 10 numbers 1-20*) The goal was an icon to represent "crunchy food" and previous study had shown this to include "chips." For "chips" the 20 participants drew 8 different things: 6 drew a rectangular bag with words or labels such as "Chips" or "Lays," 3 drew a bag with multiple tan (or black) ovals for chips, 3 drew multiple tan/brown (or graphite black) chips and no bag, 2 drew a single tan/brown chip, 2 drew oval chips with parallel lines inside–presumably a wavy potato chip, 2 drew tan triangles, and 1 drew a tall cylinder labeled "Pringles". Perhaps P&G should attend to their market share. The result is 30% drew bags, 15% drew bags+chips, 15% drew multiple ovals, 10% drew a single oval, 10% drew a single oval with parallel lines inside, 10% drew triangles, and one misguided teen drew a poker chip! That person's parents had better check their bank account balance. This diverse gathering of drawn objects is easily interpreted as representing "chips" yet their diversity suggests that this object category is not best represented by a single object with multiple components the way a laptop computer is defined as a keyboard and monitor but is instead an object category defined as the aggregation of several different but conceptually related objects. This diverse DrawIt data suggests that a symbol designer drawing chips would be well advised to include a variety of objects: a bag with a label plus tan/brown chips and possible some triangles.

Inform Complex Concepts

Another DrawIt with diverse results suggests a concept that has multiple related mental objects. The class of 38 design students (n=38) who completed a DrawIt survey for "computer" and "toothbrush" were also asked to

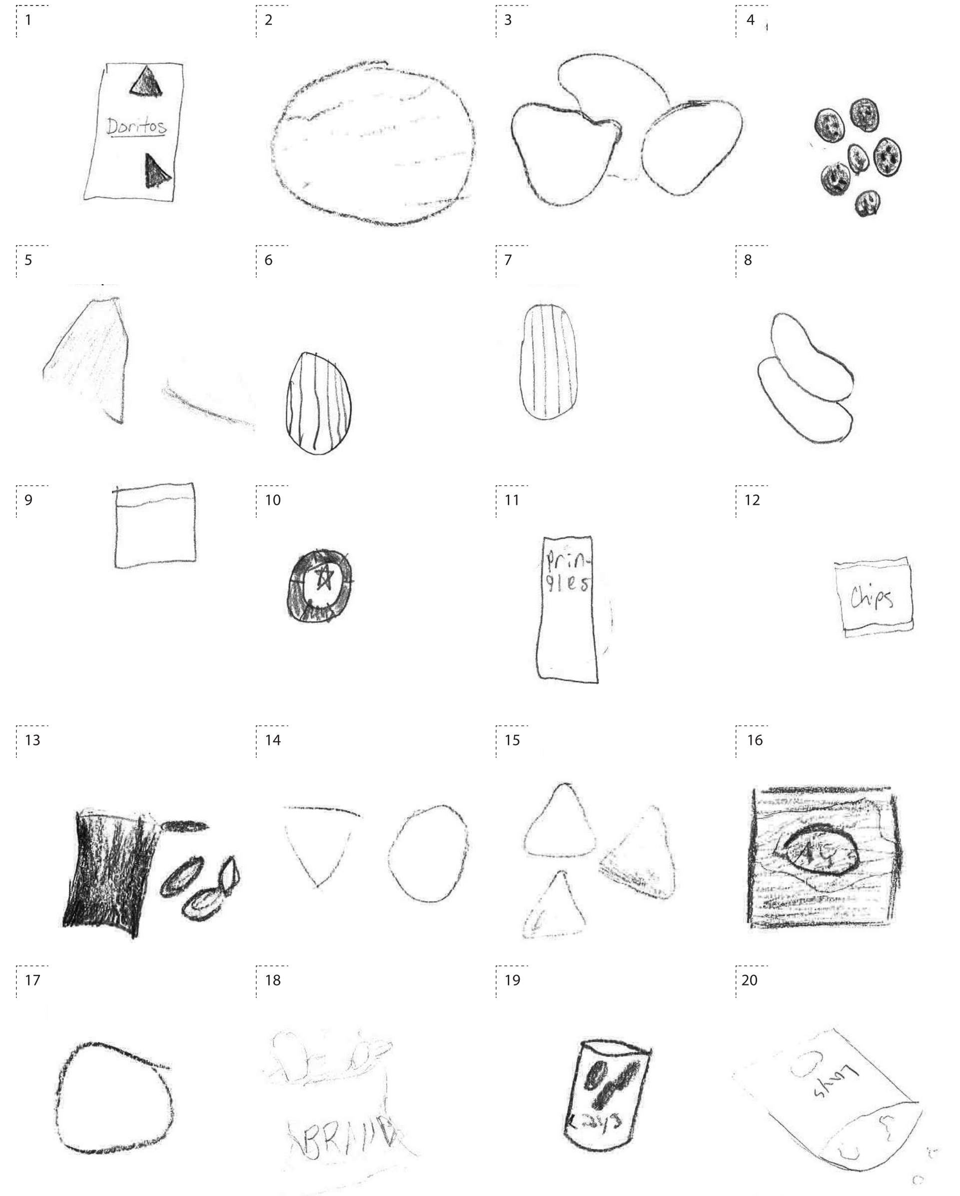

Figure 10

DrawIt data for "chips" from n=20 12-18-year-old students

Figure 11 *(opposite)*

DrawIt data for "diabetes" from n=38 university students

draw a "diabetes." Figure 11 shows the results organized by object and object combination. A total of 15 drawings included food. Eight of the 15 drawings showed food alone, such as donuts and candy. The remaining 7 drew food plus something else: 3 drew food + a syringe, 2 drew food + an obese person, 1 drew food plus a blood test strip, and 1 drew people talking about food. You can see from Figure 11 that hard candy was identically drawn even though in one drawing the candy object is combined with a syringe. Similarly, donuts were identically drawn whether alone or combined with a test strip or hard candy and pie. Note that participants combined food, syringes, test strips, insulin pumps and people with no single combination predominating. No one combined all of them at once, perhaps due to time, or perhaps because they do not all go equally well together. Another group of 41 students drew the concept "MRI." The results fit a similar pattern of diversity as "diabetes." These diverse DrawIt results reveal clusters of visual objects and conceptual relationships that a symbol designer can draw upon to describe a complex concept.

Reveal Poorly Asked Questions

Finally, diverse answers can be indicative of a poorly done DrawIt survey. In the "chips" example above one participant drew a poker chip. The student researcher who administered this DrawIt survey failed to describe the context to participants in writing. In this case, the context of medical instruction to avoid crunchy foods such as chips after a tonsillectomy was provided only verbally. One participant apparently either missed or forgot that context when they did their drawing resulting in the coin-like circle with the star in the center: a gaming or poker chip. Another example of a poorly designed DrawIt survey occurred when DrawIt participants asked to draw "shot" were not given the medical context and as a result, many drew bullets and/or guns rather than the anticipated syringes and arms. This kind of diversity is entertaining but not very productive.

In addition to observations from data that is unified and data that is diverse, we have found that DrawIt data provides new insights, avoids misinformation, and is both reliable and valid.

Discover new insights

Perhaps the most enjoyable DrawIt experiences occur when unexpected creative insights pop out of the data. In 2013 we were designing icons to help communicate medical side effects to children invited to participate in medical research studies at Cincinnati Children's Hospital. One of the side effects to be drawn was "diarrhea." Several children drew something that had

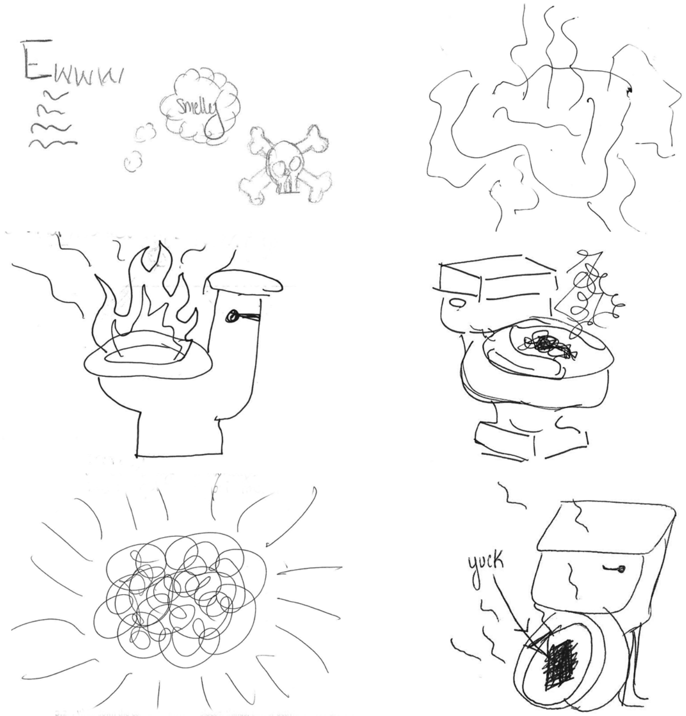

Figure 12

DrawIt data for " diarrhea" selected from n=38 university students

not occurred to any of the designers: wavy smell lines! Unfortunately, these original children's drawings are unavailable, but in 2017 a group of 41 design students were given a DrawIt survey that included "diarrhea" as an attempt to replicate the original. (see *figure 12*) There were those wavy smell lines again, p;us some flames! DrawIt can inform designers in ways they had not imagined.

The "diarrhea," "MRI," and "diabetes" examples illustrate that DrawIt informs the drawing of complex concepts that heretofore have been difficult for designers to communicate with visual symbols. DrawIt can tap not only the brain icons of simple objects but can evoke visual associations for supra-ordinate level concepts and processes.

Avoiding Misinformation

I wrote above that making symbol design decisions based on online search could be misleading. In collaboration with Children's Hospital of Eastern Ontario (CHEO) a team of students were drawing an icon to represent mandatory "rest" in the context of a child resting at home after surgery and refraining from aggressive activities like playing outdoors or engaging in sports. An online search identified the key objects to draw were a person lying down sleeping (65% of images) and a bed (25%). After several weeks of carefully drawing children sleeping in bed, design student Korina Wray

Figure 13

DrawIt data for "rest"

was disappointed that her symbol did not score well as "rest" in preliminary comprehension studies (50% estimated comprehension). So she conducted a DrawIt survey asking people to draw "rest" in a post-operative context (see *figure 13*). She found that "rest" was not the same as sleep, that a TV and snacks were frequently involved, and the characteristic rest posture was feet up and hands behind the head or feet up with a blanket over the lap. Designing an icon based on these was successful (judged "successful" by 90.3% of Comprehension survey respondents).

Validity and Reliability

The studies described above were done following the DrawIt research protocol described in the methods section and approved by UC Institutional Review Board (IRB) study #2013-2415. The DrawIt studies were part of the author's research program in symbol design. The consistency of results within studies and the replicability of the results across different studies over time suggest DrawIt's reliability. The insights gained and the increases in comprehension scores for icons designed based on the data suggest that DrawIt is valid, that is, that it delivers useful data. The inspiration for this method from findings in the disciplines of visual perception and psychology and the similarity between the DrawIt findings with findings in psychology many years previous further suggests that the DrawIt method is theoretically well-grounded.

DrawIt Limitations

The preceding descriptions of DrawIt results referred to rectangles as "bags" and multiple lines perpendicular to another line as "bristles." These are admittedly researchers' interpretations of what are technically participants' abstract visual forms. The defense for interpreting simple forms this way is that our brain interprets objects by identifying simple combinations of simple visual forms: activation patterns. DrawIt analysts understand the combination of visual forms using explicitly the same process our cerebral cortex uses tacitly and instantaneously. This has proven reliable but not infallible. At times DrawIt analysts are puzzled over a drawing and must either guess or abstain.

DrawIt clearly provides reliable insights. It also seems to improve outcomes. In the "rest" icon for example, prior to DrawIt the candidate icons that emphasized sleeping scored a maximum of 50% estimated correct comprehension (Comprehension Estimation survey). After a DrawIt survey revealed that the key concepts often included TV and cold food the re-drawn "rest" icon achieved over 90% successful comprehension. The student, Korina Wary, felt that the 40% improvement was attributable to DrawIt insights. Other examples point in the same direction. But we have not done controlled studies to demonstrate that DrawIt alone improves icon comprehension. All our studies to date contain factors such as other possible increases in designers' knowledge and experience during the design process.

So what?

The DrawIt method may sound interesting to some readers, but to others, the question "So what?" may have been lingering for some time now. Isn't this method trivial, simplistic, childish?

"Communication design is symbol design" is one answer. While typography uses word symbols, iconography uses pictures. DrawIt informs how to create effective pictographic symbols, a staple of visual communication design.

"An apt foundation for symbol design" is another answer. Communication design has entertained competing theories to guide practice. Some, such as semiotics, are based in linguistics. Findings in visual perception provide a particularly appropriate visual ground for a theory of visual communication. DrawIt is visual communication through and through.

"User-centered" is a further answer. In gathering user input DrawIt bypasses words and gets right into what is in people's minds. DrawIt engages people mentally in a sustained process of representation and because people are busy drawing their time for discussion and conscious mental reflection are limited, leading to what appear to be honest results. An additional benefit of tapping into people's mental imagery is that it's founded on hard-wired neurobiological perceptual processes common to all people. This means that DrawIt results are not as subject to variations in age, language, and literacy as user-survey methods based on language. DrawIt delivers user insight where language fails.

Designers guess a lot when they draw a symbol. That's been standard practice. DrawIt has been shown to not only reduce guesswork but inspire innovation. "Innovation" is the final answer to "so what." Design has been said to be the process of converting existing states to preferred ones. Designers don't just create what already exists, but something new. So how can knowing the images people already have in their heads help create something new? Knowing what people think enables designers to take liberties, to explore novel variations and unexpected interpretations, to both connect with and expand upon what is in people's minds. Apart from DrawIt, designers innovate in the dark, ignorant of whether their novel approaches support or hinder their symbolic communication. DrawIt informs the symbol design process.

Acknowledgements

I wish to thank my many collaborators over the years, particularly students in my Research Methods, Design Ideation, and Design Thinking courses who have participated in or administered much of the research shown here. All the studies described here have been conducted under the supervision of the author with undergraduate and graduate students at the University of Cincinnati, Myron E. Ulman Jr. School of Design under IRB research protocol 2013-2415 and/or with various medical collaborators at the University of Cincinnati, Cincinnati Children's Hospital, and Children's Hospital of Eastern Ontario under their institutionally approved research protocols.

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