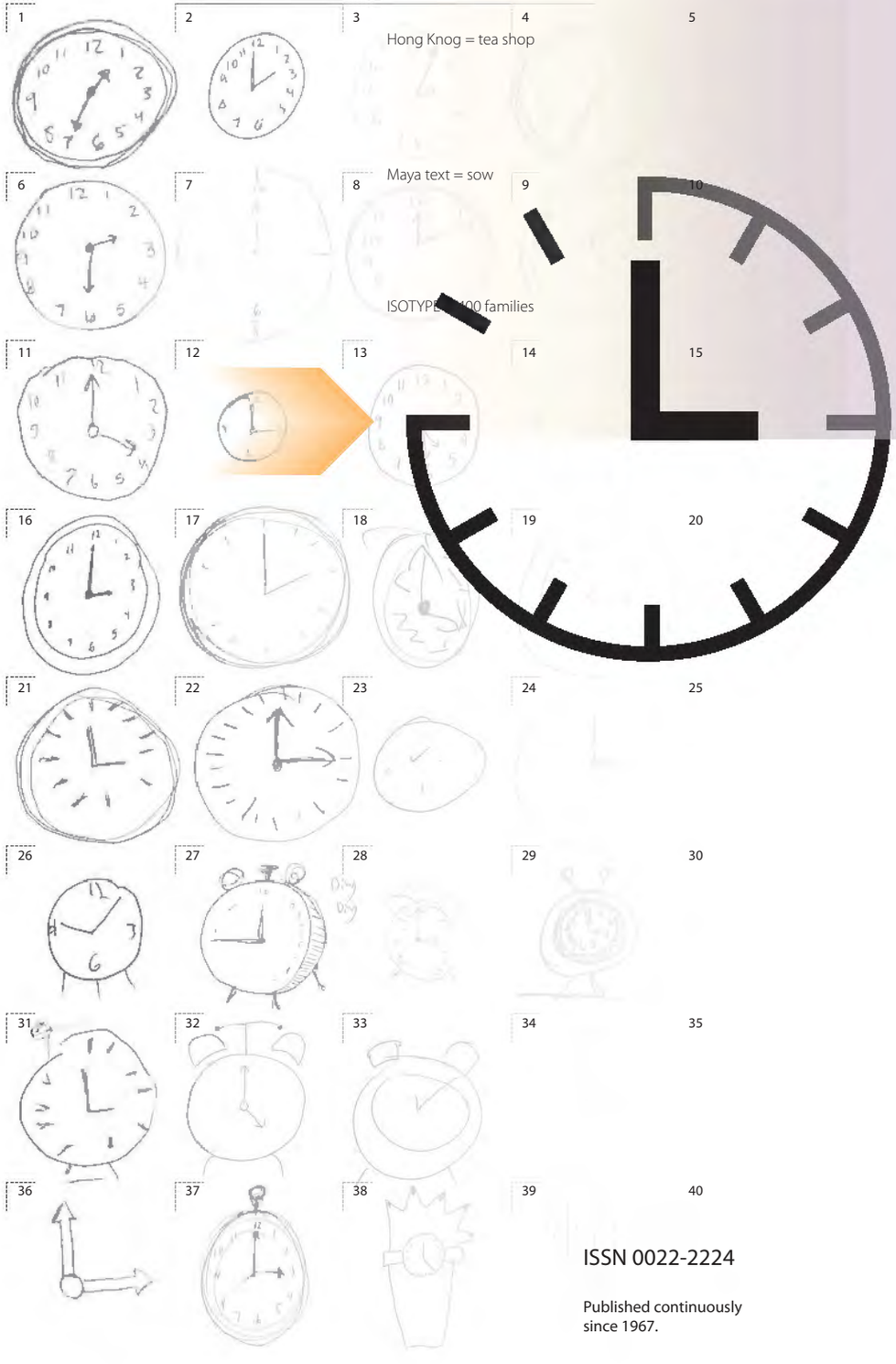

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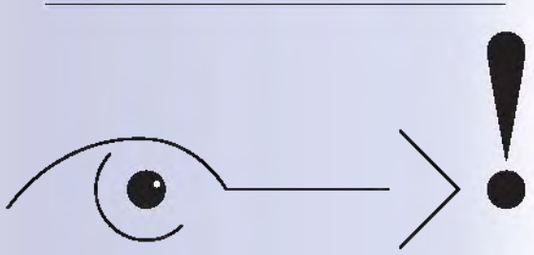

51 . 2

Visible Language

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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.

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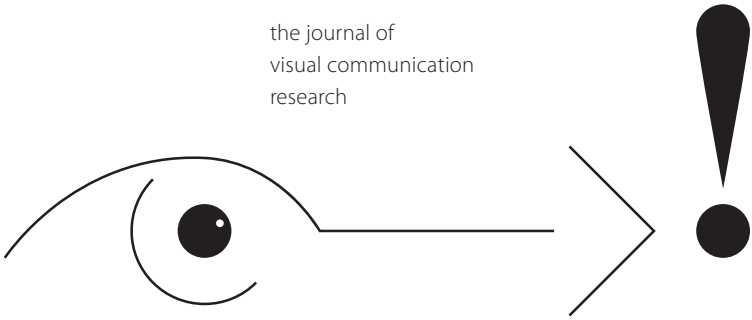

special issue:

Symbols _ Icons _ Pictograms

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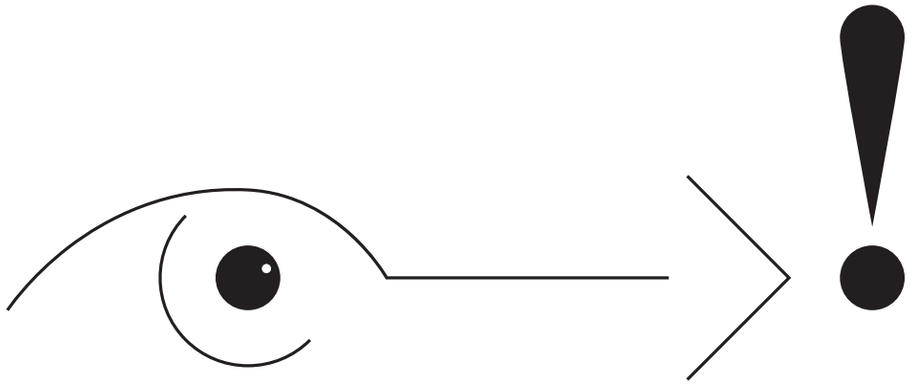


I noted in the previous issue, *Visible Language* 51.1, that people have communicated with visual symbols / icons / pictograms for thousands of years. To punctuate that point - four articles in these issues are on ancient Mesoamerican hieroglyphic communication systems: two in 51.1 "Tz'ihb 'write/paint': 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

Design by Consensus:

A New Method for Designing Effective Pictograms

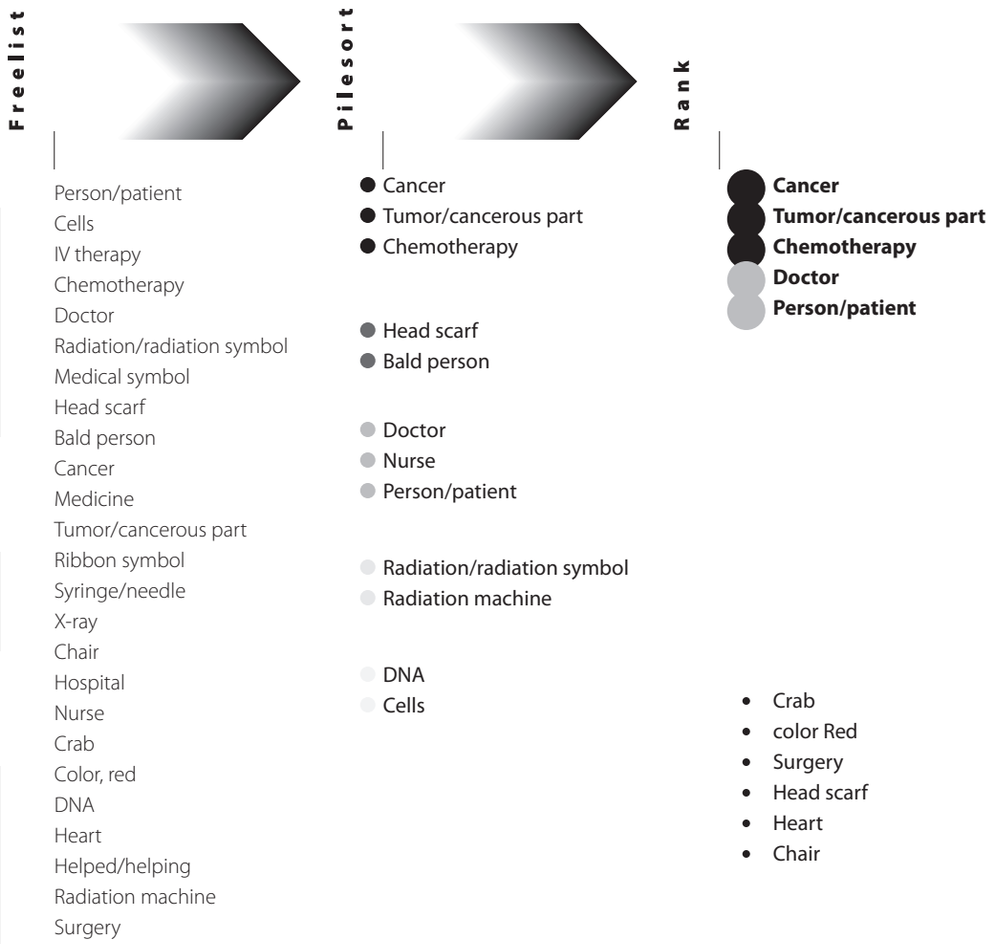
Alisa Strauss
Mike Zender

A pictogram is useless if people cannot comprehend its meaning. Current pictogram design practice typically involves a designer envisioning what might represent a concept then drawing a pictogram that they think represents it. In this the designer is informed by their own experience and perhaps some study of pictograms with similar meanings. Unfortunately, this practice has been proven to frequently fail. Our previous studies have shown that designers create more comprehensible pictograms when they are aware that most pictograms consist of several icons and graphemes, know which of those to include, and understand how to draw each icon.

This study focuses on one of these essential processes: what icons people expect to see in a representation of a concept. It explores the use of consensus analysis techniques in determining - before even a rough draft of the pictogram is created - which icons are most needed. Once data obtained via freelisting, pilesorting, and ranking were analyzed using consensus analysis, the symbols that should be included in each pictogram were determined. Pictograms were then designed using those icons and were evaluated for comprehension. Results indicate that using techniques of quantitative ethnography to guide pictogram design improves comprehension of the resulting pictogram.

keywords

icon design
design methods
consensus analysis



Introduction

Pictograms today are ubiquitous and utilitarian. They facilitate succinct communication on smart phones, computer screens, and airport signs. Indeed, pictograms are descendants of some of the earliest known forms of writing and as such have been a functional part of daily life since before the pyramids were built.

Pictograms are used, ideally, to communicate quickly and effectively with people in a variety of contexts. Otto Neurath employed designer Gerd Arntz to create the ISOTYPE (International System Of TYpographic Picture Education) pictograms in the 1930s with the goal of creating a universally understood visual language system that was not affected by language or culture (Cat, 2014; Lee, 2008). Pictograms have been used wherever universal communication is desired: a variety of transportation contexts, public information systems, equipment operations and safety warning labels, understanding of medications, and of course the operation of computer devices of all sorts.

Pictograms promise to communicate apart from verbal language and are thus free from language's limitations. But that does not free these visual symbols from confusion over the definition and classification of pictograms themselves, variously called icons, symbols, logos, indexes, signs, and glyphs. Lacking established terminology we use the following taxonomy based on terms used in a variety of fields that deal with this topic including design, semiotics, linguistics, and anthropology.

Grapheme
Graphemes are the small elements that may or may not have meaning on their own, but that we can group together to form icons. An example of this would be an oval, which by itself does not have a specific meaning, but when placed with other graphemes could represent a head or an eye.

Icon
Icons may be made up of one or more graphemes and represent a simple concept or thing. An example of this would be a face, which could be formed simply by combining one large oval with two smaller ones.

Pictogram
Pictograms are made up of icons and represent complex concepts, stories, or data sets. An example of this would be combining an icon of a face with an icon of a bandage to form a pictogram representing the concept of "head wound."

Traditionally, the pictogram design process involves a designer creating a pictogram that they think represents the referent. This design is refined and if a set of pictograms is made, they are altered so they are drawn in the same style. The pictograms may then be shown to users to see if they understand the meaning correctly and, if not, revisions will be made and the new pictogram will be tested. Ideally, through a series of revisions and comprehension tests, the end result is a pictogram that can be understood by those who view it.

Figure 1.

Tire Inflation Pressure icon

Pictograms can communicate effectively but often don't. Evaluation of a "tire inflation pressure low" warning symbol mandated by law on passenger vehicles (Figure 1) revealed that it was not understood by 60% of drivers: 46% couldn't even identify the symbol as a tire (Woodyard, 2010), a far cry from universally understood visual language. Our own pictogram comprehension studies show depressingly similar results. Only eight of a set of 54 universal medical pictograms that were carefully designed to cross language and cultural barriers were comprehended correctly by American subjects at the 85% comprehension level required by ANSI for safety symbols, and just three of those same 54 pictograms were comprehended at 85% by subjects in Tanzania (Zender & Cassady, 2014, 78-79). Indeed, 19 of the 54 pictograms were correctly identified by fewer than 10% of Tanzanians. That failure rate of 90% for 19 medical pictograms was for a Tanzanian subject pool roughly half of whom had advanced medical training. Clearly, there is ample room for improvement in typical pictogram design practice.

In pursuit of improved pictogram comprehension, many have studied the ways in which people understand pictograms. There are those who think that comprehension of an icon or pictogram is dependent on context: both the context of the icon or pictogram and the context of the person (Werner & Kaplan, 1963). In other words, a person's previous experiences affects comprehension as much as the physical context of the pictogram. Some hypothesize about the difference made by the use of images that resemble the objects they represent versus the use of more arbitrarily symbolic representations have on comprehension (Daddesio, 1995). Others have proposed key pictogram qualities to be: the degree of representationalness

- concrete to abstract for example (Wileman), or *complexity* – a lot of visual information compared to less visual information (Lesch et. al., 2013); or *concreteness* – the extent which a pictogram represents physical objects or actions experienced in the world; or semantic distance – how closely related the image is to the concept (McDougall et. al, 1999). Our studies have found that confusion frequently occurs when people are unaware that a pictogram is intended to be read metaphorically rather than literally (Zender & Cassedy, 2014, 92). It is clear that careful attention to the referent's meaning and semantic range during pictogram design can improve comprehension (Zender & Mejia, 2013) and that adding multiple icons to provide more context, making the pictogram more complex rather than more simple, can improve comprehension (Lesch, et al. 2013; Zender & Mejia, 2013).

A number of pictogram studies have focused on cross-cultural impacts on pictographic communication. Easterby and Zwaga asked users from two different cultures to rank how well they thought pictograms depicted their intended meanings (Easterby & Zwaga, 1976). They intended to find the one best pictogram that was effective in both cultures for each referent, however what they found was that there were conflicting results so that they had to then select the pictograms that scored the highest in both cultures and then test how well people understood them. They found that people could attribute meanings to all of the pictograms, just not always the correct meaning (Easterby & Zwaga, 1976). Useful conclusions of the study include the finding that "pictorial quality of the symbol (as opposed to its degree of abstractness) is an important feature in recognition," and that giving subjects matching tests, tests where they are asked to match a pictogram to a meaning, provides biased, misleading results (Easterby & Zwaga, 1976). A more recent study of cross-cultural pictogram comprehension in the USA and Tanzania revealed that lack of knowledge of the referent concept was a greater factor in miscomprehension than cultural misunderstanding (Zender & Cassedy, 2014, 91). For example, if one has no idea what an MRI is, then they will not comprehend an MRI pictogram no matter how well designed it may be. This corroborates findings on the importance of prior knowledge in comprehension.

Previous studies by the authors suggest that most pictograms are crafted including several discrete icons integrated in a shared space (Zender, 2007, 60). If these icons are well-chosen to match the meaning of the referent and drawn as people expect then comprehension might increase. These recent studies suggest that aside from context the most significant determinants of pictogram comprehension are knowing what icons to include in a pictogram and how to draw those essential icons. It is this recent understanding that this paper exploits.

The study reported here demonstrates that the methods of consensus analysis can be used to inform the design of a pictogram - before even a rough draft of the pictogram is created - by determining what icons users expect to see in a pictogram with a certain meaning and that this, in turn, can contribute to designing more effective pictograms.

Consensus analysis enables a researcher to determine the "culturally correct answer" to any question asked of informants in a culture (Borgatti & Halgin, 1986). Through the use of three separate data collection techniques, freelisting, pilesorting, and ranking, and consensus analysis of those data, this study contends that it is possible to determine what icons need to be included in a final pictogram design to maximize user comprehension before the pictogram is drawn. To test to see if this is a valid method to be used to aid in the design of effective pictograms, user comprehension testing was conducted on the pictograms generated in this study to determine how well they were understood by people viewing them.

Methods

Consensus Analysis

The goal of this study was to determine by cultural consensus what icons should be included in a pictogram representing a complex referent before the creation of the pictogram, thus allowing a designer to generate a more widely comprehended pictogram. Determining cultural consensus is achieved in part through the use of consensus analysis. Consensus analysis "specifies the conditions under which agreement between people can be seen as a sign of knowledge or 'getting it right'" (Borgatti & Halgin, 2011). In other words, consensus analysis provides an empirical means by which a researcher can measure and describe the cultural knowledge of participants in a study (Romney, Weller, & Batchelder, 1986).

To accomplish the goal of this study, apt referents for the pictograms had to be determined. A referent is the word or phrase to which a pictogram refers. Based on a previous study of pictogram comprehension among people from the United States and Tanzania (Zender & Cassedy, 2014) three pictogram referents were chosen that had poor comprehension among all study participants. These pictograms had been designed using the traditional method wherein a designer draws what they think represents the referent, tests it, and makes revisions.

The referents chosen for this study, "outpatient", "oncology", and "psychiatry," all had very low comprehension rates (0%–36%) among people with and without medical training from the United States and Tanzania (Zender & Cassedy, 2014, 78-79). The referents were defined here by combining definitions for the referents from multiple sources into a single, clear definition for each as follows.

Oncology
the branch of medicine specializing in the diagnosis and treatment of cancer (Google, n.d.-a; Medicine, 2015; Merriam-Webster Dictionary, n.d.-a; Oxford English Dictionary, n.d.-a).

Outpatient
a person who goes to a doctor's office or hospital for treatment but who does not spend the night there (Google, n.d.-b; Medicine, 2015; Merriam-Webster Dictionary, n.d.-b; Oxford English Dictionary, n.d.-b).

Psychiatry
the branch of medicine specializing in the study and treatment of mental, emotional, and behavioral disorders (Google, n.d.-c; Medicine, 2015; Merriam-Webster Dictionary, n.d.-c; Oxford English Dictionary, n.d.-c).

These definitions were used in all phases of research to provide informants with a common definition of each referent when participating in this study. Presenting participants with a definition at the time when they were asked to provide information helped ensure that everyone understood each referent in the same terms. Participants in this study had either medical training (i.e. attending and resident physicians) or no medical training (i.e. graduate and undergraduate students, other adults in various non-medical lines of work). Attempts were made to try to get an equal number of medical and non-medical study participants in each of the data collection phases of this research.

A series of quantitative research methods were used to determine the cultural consensus on how pictograms depicting the three referents, outpatient, oncology, and psychology, should be constructed. These data were collected in three phases. First freelist data was collected and analyzed by looking at relative frequencies, then information on pilesorting was assembled, and finally ranking data acquired. Both pilesort and rank data were examined using forms of consensus analysis. After the data collected in these phases was analyzed, the results were used to design pictograms which were then tested to see how well people comprehended their meaning.

Freelisting

The first phase of data collection involved freelisting (Borgatti, n.d.), a qualitative research method used here to determine what users expected to be seen in each pictogram representing a given referent. This data collection technique involves asking subjects from the same culture to list all of the things that they think are in the cultural domains of oncology, outpatient, and psychology. A cultural domain can be defined as "a set of items or things that are all of the same type or category" (Borgatti & Halgin, 1998). For example, to determine what vegetables populate the cultural domain of "vegetables commonly eaten by Americans," one would ask American informants to list all the vegetables they think are commonly eaten by Americans. There are no rules as to what participants can list or how many things they can list, hence, freelist. In this study, subjects were asked to list the elements they thought should be included in pictograms meaning psychology, oncology, and outpatient.

The use of freelisting in anthropological research is not new (Borgatti, n.d.; Furlow, 2003; Gravlee, et al. 2013; Libertino, et al. 2012; Smith & Borgatti, 1998). Freelisting has not, however, been conducted on a visual element like a pictogram before. For this reason, a special freelist survey page was designed to help informants create their freelists in this study. In anthropology, freelisting is most commonly conducted as part of semi-structured interviewing (Borgatti, n.d.). The instructions on the cover sheet take advantage of what is known to psychology as the priming effect (Kahneman, 2011; Molden, 2014), the fact that the mind, immediately after being exposed to an idea, can more readily think of other related ideas. In this case, subjects were shown images of pictograms as part of the instructions for how to freelist in order to get them thinking about pictograms and the icons that compose them. Priming was thought to be important since most participants in this study were unused to designing pictograms because they were either medical professionals or in other fields of study or work. Collection of freelist data is quick. On average, participants took no more than a minute or two to complete each freelist.

The items listed by study participants during freelisting were used to generate the lists of items in each referent's cultural domain used in the next two phases of study, pilesorting and ranking. It is recommended, when trying to have cultural consensus, to have at least 30 informants when collecting freelist data (Borgatti, n.d.). In this study, freelists were obtained from 54 participants for the referent oncology, 54 for outpatient, and 51 for psychiatry. There were about equal numbers of participants with and without medical training, and the ratio of women to men was about 2 to 1 (Strauss, 2016).

While some freelist items were listed only once by one participant, there were a number of items that were listed by more than one person. Table 1 shows the responses for each referent ordered from most frequently mentioned to least for all items listed by more than one participant.

Table 1.

Results of freelisting by participants for three referents, oncology, outpatient, and psychiatry. Each column lists items in the cultural domain for the referent listed at the top. The number next to each item is the frequency with which it was mentioned by informants.

Top items mentioned, ordered by frequency

Oncology		Outpatient		Psychiatry	
Person/patient	22	Person/patient	54	Person/patient	35
Cells	22	Leaving	23	Brain	30
IV therapy	13	Walking	23	Emotion(s), faces with emotions	23
Chemotherapy	12	Door	17	Couch	15
Doctor	10	Hospital	14	Doctor	15
Radiation/ radiation symbol	10	Doctor	10	Lying/lying down	11
Medical symbol	9	Office	9	Expression(s), faces with expressions	9
Head scarf	8	Bandage or cast	8	Sitting	8
Bald person	7	Entering	8	Chair	8
Cancer	5	Exam table/bed	8	Pill(s)	7
Medicine	5	Clock	7	Talking/speaking	6
Tumor/ cancerous part	5	Day/daytime	7	Listening	6
Ribbon symbol	4	Stethoscope	7	Color, blue	4
Syringe/needle	4	Sun	6	Medical symbol(s)	3
X-ray	3	Time	6	White coat	3
Chair	3	Injury or affliction	5	Analyzing/ examining	3
Hospital	3	Medical symbol	5	Healing signs	2
Nurse	3	Car	4	Medicine	2
Crab	3	Hospital sign/symbol	4	Notepad	2
Color, red	2	Sitting	4	Question mark(s)	2
DNA	2	Healed/fixed	3	Taking notes	2
Heart	2	No sign	3	Brainwaves	2
Helped/helping	2	Waiting room	3		
Radiation machine	2				
Surgery	2				

The terms listed in Table 1 are those that were used in the next two phases of data collection. The cutoff for which items would be used in the pilesorting and ranking phases was that they had to be mentioned by more than one participant (Borgatti, n.d.) so that they are more likely to be part of the larger cultural domain. The lists of terms are not all the same length because of the nature of the data obtained from the study participants (Strauss, 2016).

Pilesorting

While the goal of freelisting is to elicit the basic elements of cultural domains from study participants, pilesorting is used to allow informants to show which items within a cultural domain are similar or related somehow. The method used here is known specifically as unconstrained or free pilesorting (Borgatti, 1999). Participants were given a set of cards for each referent. Every card in a set had a different item from the domain for a referent, as determined via freelisting, written on it. The sets of cards were randomly ordered so that no two participants received their cards in the same order. Each respondent was then told to simply, "group the cards into piles based on how similar they are." No instructions were given on the criteria that should be used to form piles and there were no minimum or maximum limits on the number of piles that could be created or how many cards could be in a pile, hence, free pilesorting.

As with freelisting, the pilesorting technique should be conducted with a sample size of at least 30 participants (Borgatti, et al. 2002; Borgatti & Halgin, 1998). In this study, for each of the three referents, 40 participants completed pilesorts, 25 female, 15 male. The sample was almost evenly divided between those with and without medical training (Strauss, 2016). Pilesorting sounds complex, but participants were able to complete the task for all three referents in 5-10 minutes on average.

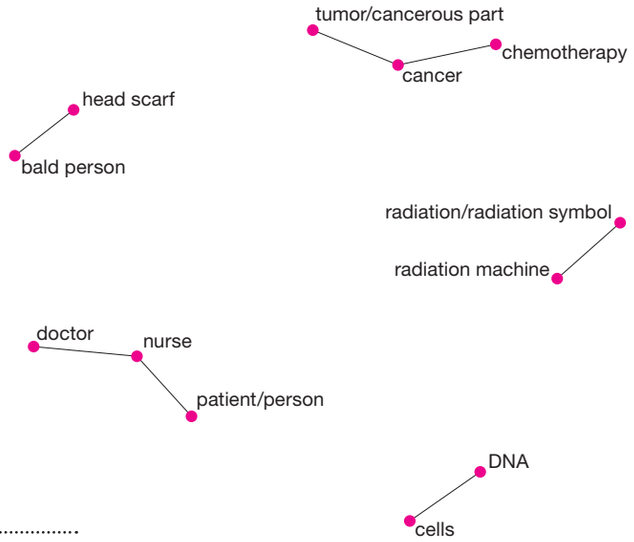
Once collected and recorded, the data was analyzed using UCINET, a social network analysis software package (S. Borgatti et al., 2002), and Netdraw, a network visualization software package (Steve P. Borgatti, 2002). All the pilesort data was entered into UCINET which converted the raw data into a set of matrices. One matrix was generated for each study participant describing what items in each cultural domain they did and did not group together. UCINET was then used to analyze how frequently items within a cultural domain were placed in the same pile by all the users in the study. The output of this process is an aggregate proximity matrix. Values in an aggregate proximity matrix range from 0, meaning that items were never placed together in the same pile by participants, to 1, meaning that items were placed in the same pile together by 100% of informants. In other words, the aggregate matrix shows the agreement, or consensus, among all the participants in the pilesorting exercise as to what items in each cultural domain are thought to be similar or related to each other. Although the matrix itself can be difficult to read, it becomes very useful as data that can be worked with in Netdraw. Netdraw uses multidimensional scaling (MDS) to display the items in the proximity matrix as a set of points in space, using the aggregate proximity matrix values to determine the distances between the points representing the items in space (Borgatti et al. 2002). Thus, in an MDS display of the proximity matrix, items that are closer to each other spatially are items that were more frequently grouped together by informants when they did the pilesorting.

There was not 100% agreement among any sample of participants as to what groups items belong. For that level of agreement to occur, every informant would have had to have grouped every item into the same number of groups with the exact same items in each group. Figure 2 shows

an example of clusters formed using MDS. The clusters of items were used to help determine what elements should be included in each pictogram. Clusters do not represent importance to the cultural domain, they simply indicate that participants think that items clustered together are related to each other in some way. Because the clusters help to show what items users think are related, they indicate elements that might be combined into one icon to enhance comprehension of the pictogram. For example, in the domain of oncology, bald person was closely tied to head scarf, suggesting that bald people might be depicted wearing head scarves (Strauss, 2016).

Figure 2.

Items in the cultural domain of oncology that were grouped together at least 70% of the time by study participants. Items not shown here (see Table 1) did not consistently group with other things at this level of agreement.



Ranking

In the ranking phase of research, study participants were asked to rank the items in each referent's cultural domain in terms of importance to include in an icon with that referent's meaning. Ranking data was collected by presenting participants with a list of all the items in each cultural domain which they then ranked by numbering them beginning with 1, which the most important item in the domain. The purpose of this was to determine which items in each cultural domain were more important to the people surveyed and, therefore, more important to include in a pictogram representing each referent. Ranking items took only 1-2 minutes on average for each of the 37 participants in the group which was almost equally divided into those with and without medical training (Strauss, 2016).

Ranking data for each referent, oncology, outpatient, and psychiatry, were analyzed using consensus analysis in UCINET. Consensus analysis calculates the degree of agreement among participants that is present in their responses (Borgatti et al. 2002; Weller, 2007). In other words, consensus analysis shows whether there is broad agreement among informants about what they have ranked. To do this, all ranking data from all informants for each referent were entered into UCINET. The consensus analysis calculations carried out by UCINET begin by treating each informant's rankings as a matrix and then averaging the responses of all the respondents for the referent (each referent is analyzed separately). This resulting matrix is an agreement matrix that "provides a reasonable estimate of answers that is easy to understand and statistically sound" (Weller, 2007). The agreement matrix is symmetrical, with a diagonal of unknown value. UCINET determines the values for this diagonal by factoring, or creating a mathematical model to complete the agreement matrix (Mertler & Vannatta, 2005). The values for this first factor are referred to as the competence scores for the informants (Borgatti et al. 2002; Weller, 2007). UCINET also provides the first and second eigenvalues for the competence scores. Eigenvalues are used in factor analysis to describe the variance explained by a factor (Mertler & Vannatta, 2005). Importantly, consensus analysis only works if there is enough agreement between the informants that there is a single factor that can explain competence (Weller, 2007). To test to make sure this is the case, one must look at the eigenratio, calculated by dividing the largest eigenvalue by the second largest eigenvalue. If the eigenratio is greater than 3, then one can say that there is broad agreement among everyone in the sample, or in other words, there is consensus (Borgatti & Halgin, 2011; Weller, 2007).

While no participants in this study had very low or negative competence scores, indicating they were not giving the "correct answers" when they ranked items (Borgatti et al., 2002), eigenratios indicated that there were two separate cultures in the study population consisting of those with and those without medical training (Strauss, 2016). The mean competence of those with medical training and those without medical training were compared using a two-tailed T-test, a test used to determine whether two samples are statistically different from each other for each referent (Kohout, 1986:300-301). This test indicated that there is a statistically significant difference between the two groups for all referents (Strauss, 2016).

As a result, two consensus analyses of the ranking data for each referent were conducted, one for rankings made by those with medical training, and one for the rankings made by participants without medical training. The rankings of items for each of the referents was used to indicate the amount of importance to give to different clusters of symbols as determined via pilesorting when designing the pictograms for the three referents.

To design pictograms based on the data collected from informants, both the groupings of potential pictogram icons as determined through pilesorting and the relative importance of icons determined through ranking were used. The MDS outputs based on how participants sorted symbols into piles shows what symbols they think are more closely associated with one another. To see which elements or groups of elements were more significant to study participants, an average rank score was used. The average rank score was calculated by averaging the rank assigned to each item by persons with and without medical training to achieve a single rank score. Interestingly, though there is not total agreement between the groups (which is why their rank data needed to be looked at separately), it is quite similar with most elements being ranked relatively the same in terms of high, medium, and low importance (Strauss, 2016). Figures 3, 4, and 5 show the average rank scores for each of the three sets of data. In all cases, the highest rank an item could have is 1.

The main hypothesis being tested here is that quantitative analyses typically used by anthropologists studying cultures can be used to determine what elements should be included in a pictogram, before it is designed, to improve user comprehension. To test this, two different sets of pictograms were designed based on the results of the data collected from participants via freelisting, pilesorting, and ranking. It was decided to divide the domain item samples approximately into fourths as an arbitrary way of creating divisions in the data. To treat each domain equally (because there are different numbers of items in each domain), this made the one-fourth cutoff 5. Therefore, one set of pictograms was created using the five elements with the highest average ranks (more if there was a tie for fifth place). If the hypothesis is correct, this set of pictograms should have high levels of comprehension when tested because they are composed of elements that informants said were important to include in the pictograms for each referent. The other set of pictograms was designed using the same set of data, only they were made using the five (or more in the case of a tie for fifth place) items with the lowest average ranks. This second set of pictograms should have low comprehension when tested because they are composed of items that participants said were the least important elements to be included to convey the meaning of the pictogram. The calculated average rank scores can be seen in Table 2 for all three referents.

The following figures show the pictograms that were designed on the basis of the consensus analysis results. In order to minimize differences in comprehension that could possibly result from the way informants react to different art styles, the pictograms were all designed using the same artistic style. This style was also intentionally designed to look as commonplace as possible. This was done to avoid adding in a confounding element

Figure 3.

Oncology

Items in the cultural domain of oncology that were grouped together at least 70% of the time by study participants. Size and color of circles indicate how highly each item was ranked. Items listed in a column at the far left did not consistently group with others at this level of agreement.

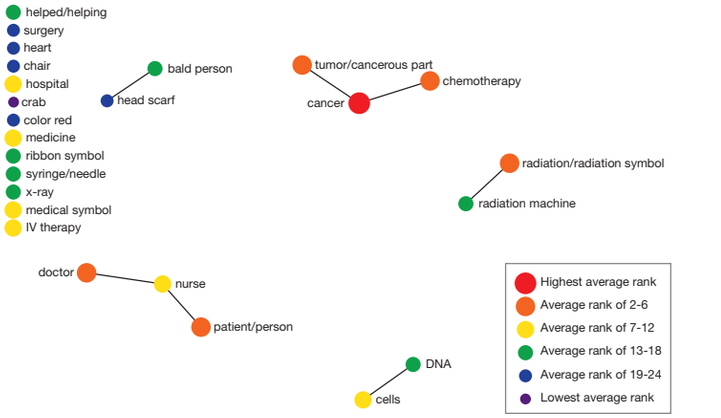


Figure 4.

Outpatient

Items in the cultural domain of outpatient that were grouped together at least 50% of the time by study participants. Size and color of circles indicate how highly each item was ranked. Items listed in a column at the far left did not consistently group with others at this level of agreement.

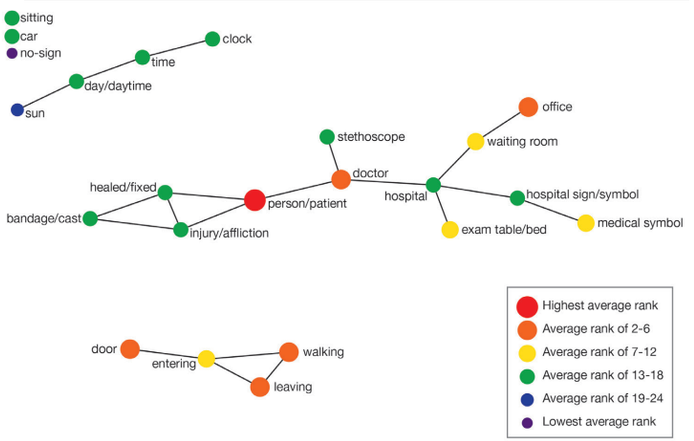


Figure 5.

Psychiatry

Items in the cultural domain of psychiatry that were grouped together at least 70% of the time by study participants. Size and color of circles indicate how highly each item was ranked. Items listed in a column at the far left did not consistently group with others at this level of agreement.

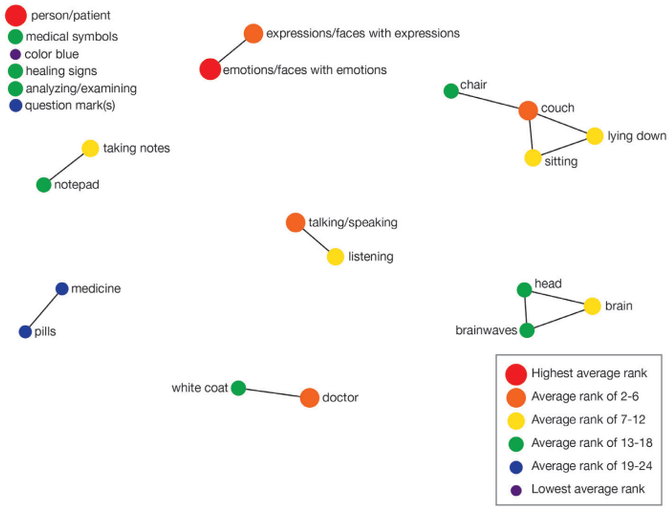


Table 2.

Average rankings for items in the three cultural domains. Items used to make pictograms can be seen in bold. Highest ranked items are at top, lowest at bottom.

Average rankings for cultural domain items

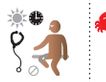
Oncology		Outpatient		Psychiatry	
Rank		Rank		Rank	
1	**Cancer**	**1**	**Person/patient**	**3**	**Emotions/faces with emotions**
3.5	**Chemotherapy**	**2.5**	**Walking**	**3**	**Person/patient**
3.5	**Patient/person**	**4**	**Leaving**	**4**	**Talking/speaking**
3.5	**Doctor**	**5**	**Doctor**	**4**	**Doctor**
4	**Tumor/ cancerous part**	**5.5**	**Office**	**6**	**Expressions/faces with expressions**
5.5	Radiation/ radiation sign	**5.5**	**Door**	**6**	**Couch**
9.5	Nurse	7	Entering	8	Lying down
9.5	Cells	10.5	Exam table/bed	8.5	Listening
10.5	IV therapy	10.5	Medical symbol	9	Taking notes
10.5	Medicine	11.5	Waiting room	10	Brain
10.5	Medical symbol	13	Hospital sign/symbol	10.5	Sitting
11	Hospital	13	Hospital	12.5	Chair
12.5	Radiation machine	14	Injury/affliction	12.5	Notepad
14	Ribbon symbol	15	Time	14	Brainwaves
14.5	Helped/helping	15.5	Bandage/cast	14.5	Head
15.5	X-ray	15.5	Car	16	Analyzing/examining
16.5	Syringe/needle	**16.5**	**Stethoscope**	16.5	White coat
17.5	DNA	**16.5**	**Day/daytime**	17.5	Medical symbols
18	Bald person	**16.5**	**Clock**	**18**	**Healing signs**
20	**Head Scarf**	**17.5**	**Sitting**	**19**	**Pills**
20	**Surgery**	**17.5**	**Healed/fixed**	**20**	**Medicine**
23	**Color, red**	**19.5**	**Sun**	**20.5**	**Question mark(s)**
23	**Heart**	**23**	**No-sign**	**23**	**Color, blue**
23.5	**Chair**				
24.5	**Crab**				

that could be created by representing icons in unfamiliar ways. To do this, image research on how others have most commonly depicted people and icons that appear in each icon was conducted. In particular, the Noun Project website, which is a repository of icon and pictogram designs made by designers from around the world ("Noun Project - Icons for Everything," n.d.) and Google image searches were used to find frequently used depictions of icons. Every effort was made to make the somewhat random-seeming set of icons that composed the pictograms made from the lowest ranking items in each cultural domain look like a coherent pictogram. The resulting pictograms can be seen in the following figures (*figures 6-11* next page).

The pictograms were treated as two separate sets with some study participants receiving a set of three pictograms made with the highest ranking symbols and others getting the three pictograms that were made using the lowest ranking symbols. All participants (for total numbers, see Table 3) in the comprehension tests were not participants in any of the previous phases of research. Participants in the comprehension portion of this study included those with and without medical training. The proportion of the study population who took comprehension surveys with medical training ranged between 25-33% for the six icons. Because those with medical training did not have different levels of comprehension compared to those without medical training, the comprehension results discussed here include all participants, regardless of medical training. All informants were asked for each icon to answer the same question: "In a single word or brief phrase, what does the above pictogram mean?" The total number of responses for each pictogram can be seen below in Table 3.

Table 3.

Total number of participant responses to surveys asking for people to tell the meaning of the pictograms in this study.

	Pictograms using highest ranking graphemes and icons			Pictograms using lowest ranking graphemes and icons		
	Outpatient	Oncology	Psychiatry	Outpatient	Oncology	Psychiatry
						
Number of participant responses	56	57	57	50	48	48

It is believed that though approximately equal numbers of surveys asking for responses to pictograms based on high-ranking symbols and low ranking symbols were distributed to participants, the number of responses to the latter is the result of participant frustration. Subjects who received pictograms made based on low-ranking symbols tended to voice frustration at not being able to understand what they were looking at much more frequently than those who received the other pictograms (Strauss, 2016). Because participation is voluntary, informants were told at the beginning of the survey that if they did not wish to participate, they could simply hand back in their blank consent form and survey. No blank consent forms and surveys were returned by those who received the set of pictograms based on high-ranking symbols; six sets of low-ranking pictograms were returned blank. In addition, participants who received high-ranking symbol based pictograms provided meanings for all three of the pictograms. Informants who received sets of pictograms based on low-ranking elements sometimes skipped providing a meaning for one or more of the pictograms in the set. This is again believed to be a result of the frustration that was voiced by participants because they could not understand the pictograms.

Figure 6.

Oncology

Icon designed to mean oncology using the highest ranking items in the cultural domain of oncology. Terms with arrows indicate where/how the domain items were used to make the icon.

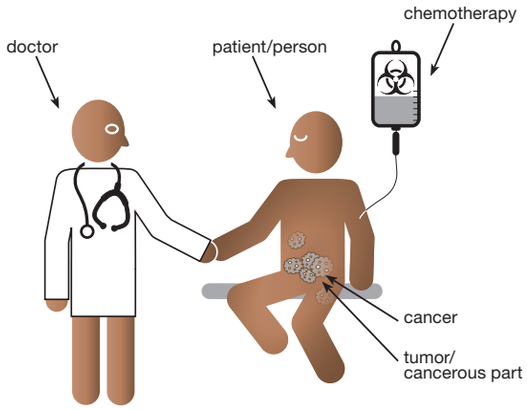


Figure 7.

Outpatient

Icon designed to mean outpatient using the highest ranking items in the cultural domain of outpatient. Terms with arrows indicate where/how the domain items were used to make the icon.

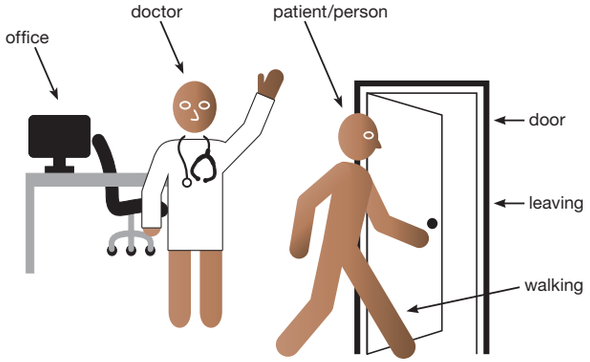


Figure 8.

Psychiatry

Icon designed to mean psychiatry using the highest ranking items in the cultural domain of psychiatry. Terms with arrows indicate where/how the domain items were used to make the icon.

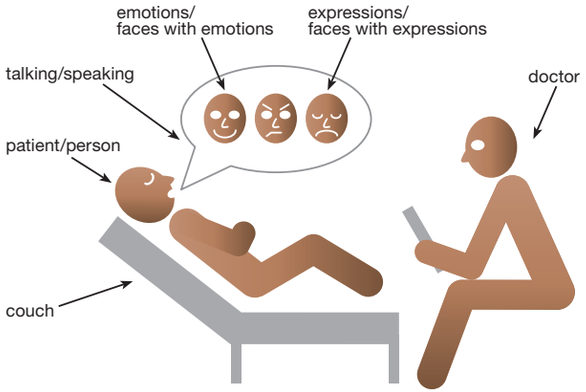


Figure 9.

Oncology

Icon designed to mean oncology using the lowest ranking items in the cultural domain of oncology. Terms with arrows indicate where/how the domain items were used to make the icon.

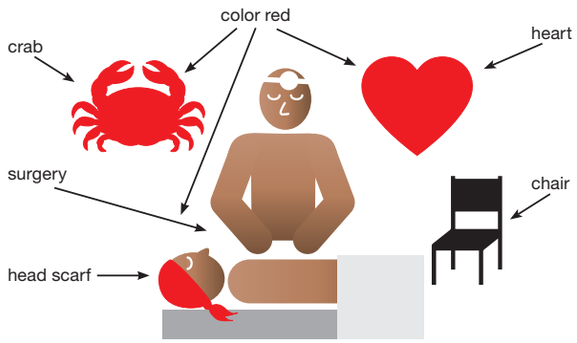


Figure 10.

Outpatient

Icon designed to mean outpatient using the lowest ranking items in the cultural domain of outpatient. Terms with arrows indicate where/how the domain items were used to make the icon.

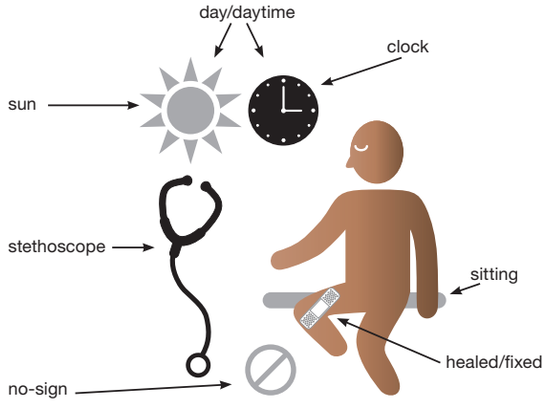
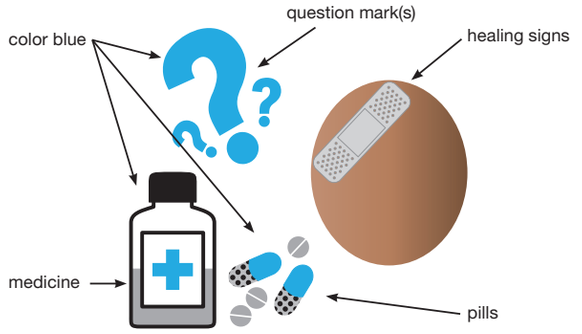


Figure 11.

Psychiatry

Icon designed to mean psychiatry using the lowest ranking items in the cultural domain of psychiatry. Terms with arrows indicate where/how the domain items were used to make the icon.



Results

To determine if consensus analysis is truly a valid way of determining what icons should be included in a pictogram to enhance comprehension, this study did several things. To select referents that were difficult to depict in pictogram form successfully, the three most poorly understood pictograms from Zender and Cassedy's (2014) pictogram comprehension study led to the selection of their three referents, oncology, outpatient, and psychiatry. Clear definitions of each referent were written by combining information from several sources to be used throughout the study (Strauss, 2016). Once freelisting had been used to determine what items were in the cultural domain for each referent, consensus analysis of pilesorting and ranking of those domain items were conducted to determine what symbols should be included in each pictogram. To test if the hypothesis that consensus analysis is a useful tool for improving icon design, two sets of pictograms were made, one using the highest ranking domain items for each referent, and another using the lowest ranking items.

Responses to the comprehension surveys were scored as either correct or incorrect. Responses were deemed correct if the respondent wrote down either the referent word or any word or phrase that was synonymous with the referent. Because the referents for these pictograms were medical in nature, to ensure that participant responses were correctly categorized as correct or incorrect, all responses were reviewed by Eric Warm, MD, Richard W. & Sue P. Vilter Professor of Medicine, Director, Internal Medicine Training Program at the University of Cincinnati, and practicing physician at UC Health. Results of comprehension tests for pictograms from the Zender and Cassedy study, the pictograms made using high-ranking elements, and the pictograms made using low-ranking elements can be seen here (*figures 12-14*).

The International Standards Organization (ISO) recommends a level of 67% comprehension for a pictogram to be considered successful and the American National Standards Institute (ANSI) recommends 85% comprehension for a successful safety pictogram (American National Standards Institute, 1991; International Standards Organization, 1984). Most pictogram comprehension studies aim to achieve the ISO standard of 67% (for examples see Piamonte, et al. 2001; Wolff & Wogalter, 1998; Zwaga & Boersema, 1983). By the ISO standard of 67%, only one pictogram, the one made using high-ranking symbols for the referent psychiatry, was successful with 72% comprehension. This indicates that the items that were ranked as being in the top-ranked quartile were clearly significant symbols needed to depict psychiatry.

Of greater significance here is the improvement to pictogram comprehension made using solely the results from freelisting and consensus analysis of pilesorting and ranking data. As can be seen in Figures 12-14,

Figure 12.

The frequency with which people correctly understood the meaning of pictograms with the intended meaning of "oncology."

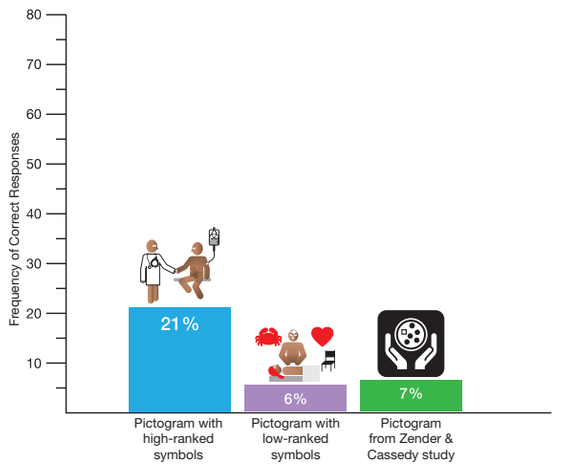


Figure 13.

The frequency with which people correctly understood the meaning of pictograms with the intended meaning of "outpatient."

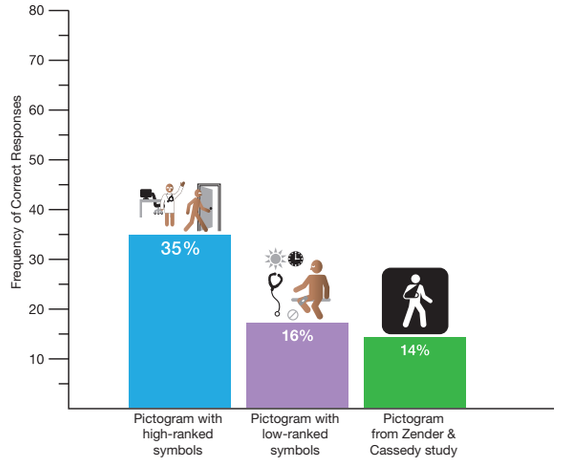
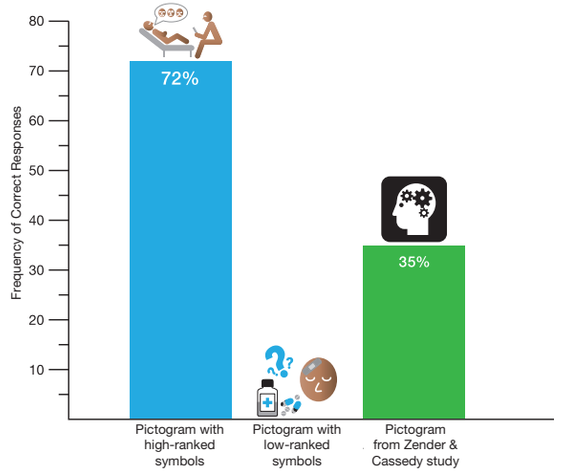


Figure 14.

The frequency with which people correctly understood the meaning of pictograms with the intended meaning of "psychiatry."



comprehension of the pictograms designed using high-ranking symbols determined through consensus analysis was 2.1 to 3 times as great as those designed and tested in Zender and Cassedy's study (2014). This shows that consensus analysis is a useful tool that can aid in the creation of successful pictograms.

In addition to comprehension, those working on designing pictograms also concern themselves with critical confusions. A critical confusion is a response that is the opposite of the intended meaning of the pictogram (Wolff & Wogalter, 1998). The ANSI recommends that for a pictogram to be considered successful, no more than 5% of responses should be critical confusions (American National Standards Institute, 1991). When looking at the pictograms designed using the high-ranking symbols, critical confusion was rarely, if ever, seen. For the referent psychiatry, one response, "patient is manipulative," was far enough away from the intended meaning that it could possibly be considered to be a critical confusion giving a critical confusion level of 2%, however, since it still deals with emotions, it probably is not. For the referent oncology, there is one blatantly incorrect response, "cookie infusion," which would make the critical confusion level 2%, however this response is not the opposite in meaning, it is simply extremely (and most likely intentionally) wrong. Finally, for the referent outpatient, there is no response that can be considered to be an example of a critical confusion. Thus, even though all three referents do not satisfy the ISO comprehension level requirement, the lack of critical confusions indicates that these pictograms are very successful first drafts.

Also interesting to note are the responses for each of the three pictograms made using high-ranking symbols that were not categorized as being correct. For the psychiatry pictogram, 64% of the incorrect responses mentioned moods, emotions, or changes in moods and emotions, all things dealt with in the realm of psychiatry. If those responses were added in to the correct responses, the comprehension level for the psychiatry icon would be 96%, well above both the ISO and ANSI requirements for a successful pictogram. For the outpatient pictogram made using high-ranking symbols, there were four major topics of incorrect responses: 24% mention leaving, 21% say good-bye, 18% say the patient is discharged or the exam is over, and 34% mention the patient is healthy or cured. Many of these are ideas encompassed within the concept of outpatient so combined with the correct responses, comprehension of this pictogram would be 98%, again very high. Oncology was the referent with the lowest comprehension and incorrect responses to this pictogram included some common themes: 27% said treatment, curing, or cure, 25% said it showed disease or infection, 20% said doctor's appointment, and 5% thought it showed a doctor greeting a patient. Because the pictogram does show a disease and a treatment, if those responses were also included as correct responses, comprehension of the oncology icon would be 63%, almost high enough to be considered successful by ISO standards.

Comprehension of pictograms made using the lowest ranking items in each referent's cultural domain were very low, ranging from 0% to 16%. To compare the actual numbers used to generate the charts in Figures 16-18, please refer to Table 4. Note that value for percent correct for pictograms from the Zender & Cassedy (2014), the comprehension numbers for those with and without medical training in the United States were averaged together. This was done to determine comparable scores; the comprehension surveys done here included Americans with and without medical training.

Table 4.

Raw data on pictogram comprehension for all the pictograms discussed in Figures 14-16.

Icon	Total Number in Sample	Total Correct	Percent Correct
Oncology A	56	12	21%
Oncology B	50	3	6%
Oncology C			7%
Outpatient A	57	20	35%
Outpatient B	48	8	16%
Outpatient C			14%
Psychiatry A	57	41	72%
Psychiatry B	48	0	0%
Psychiatry C			35%

A = Pictogram made using highest ranked symbols
B = Pictogram made using lowest ranked symbols
C = Pictogram from Zender & Cassedy's study (2014)

The significance of the low comprehension rates for the pictograms made using the lowest-ranking icons lies in the fact that all the symbols that participants ranked were actually determined by informants in this study. People defined the cultural domain for each referent by telling what they thought should be included in a pictogram with each given meaning. The ranking of those items and the pictograms made from the lowest-ranked of those items shows that while some icons may be associated with a referent in the minds of people, they are not necessarily needed or helpful in conveying the meaning of the referent.

An examination of the incorrect responses to the pictogram comprehension testing for the pictograms made using the lowest-ranking symbols can give some insight into what made them so ineffective. For the oncology pictogram made with low-ranking symbols, there were four common categories of incorrect responses: 37% said it showed heart problems, heart surgery, CPR, or a full code, 13% mentioned death, dying, or dead, 11% mentioned a shellfish or seafood allergy, and 13% mentioned a pirate.

Clearly, the crab (cancer means crab) confused several people into thinking about shellfish allergies (and also a couple of respondents into the idea that pubic lice were involved). Though the symbols red and headscarf were part of the cultural domain for oncology, together they represented pirate a surprising number of times. Most significantly, the heart, possibly because it is such a clear, frequently seen symbol, dominated incorrect interpretations by causing people to provide meanings having to do with heart problems and procedures.

The outpatient pictogram made with low-ranking symbols seems to have confused participants because there were so many symbols that could not be combined to create coherent meaning. The majority of incorrect answers mentioned an injury (20%) or that someone was waiting for a doctor (15%). Though both of these things may happen in an outpatient setting, they were not correct enough to be included in the count of comprehension. Interestingly, for those incorrect responses that mentioned time, 24% said that the action in the icon was happening during the day and 10% at night. Despite the fact that there is a sun next to the clock, participants may have been influenced into guessing night because the clock face is dark.

The psychiatry pictogram formed from low-ranking icons had the lowest comprehension of all the pictograms, 0%. Though every symbol in the pictogram was determined by the study population to be in the cultural domain of psychiatry, clearly these low-ranking symbols are ancillary at best to the visual definition of the referent psychiatry. The majority of incorrect responses stated that the pictogram depicted either confusion about medications (28%) or medicine taken or prescribed (20%). 14% of respondents said the pictogram showed either concussion or headache and 6% said the pictogram meant questions or confusion.

Overall, the results of comprehension testing for both sets of pictograms, those made with the highest-ranked symbols and those with the lowest-ranked symbols, indicates that consensus analysis of ranking is an important part of this process. Freelisting allowed participants to define the cultural domain for each referent. Pilesorting enabled informants to group symbols together however they thought they should be grouped and consensus analysis of those results showed what icons the group as a whole thought were associated with other symbols. Finally, each participant ranked symbols in the cultural domain of each referent from most to least important to include in a pictogram with that meaning. Consensus analysis of rank data showed that medical and non-medical people ranked differently, but comparison of their aggregate lists showed marked similarity. Because the informants determined the important symbols, showed what symbols were the most important to include in each pictogram, it is not surprising that comprehension of those pictograms made using the highest-ranked symbols was higher than both pictograms made using other elements in the cultural domain that were low-ranking and pictograms from a previous comprehension study that were designed without user input at the outset of the project.

Conclusions

Pictograms are used around the world to, ideally, communicate ideas and information to people quickly and effectively. The effectiveness of a pictogram is dependent upon how easily it is understood by those viewing it. While designers have spent many years working on how to better draw pictograms, most attention has been paid to how the pictograms look and then, after the designer is satisfied with its appearance, showing the pictogram to users to see if they understand its intended meaning. This study seeks to add a new item to the pictogram designer's toolkit that will enable them to create more effective, that is, more easily understood, pictograms.

The results of this study indicate that consensus analysis is a useful tool that the designer should add to their repertoire when working to design pictograms (Strauss, 2016). The pictograms designed for the three referents in this study were understood correctly by more than double the percentage of the Zender & Cassedy icon comprehension study. This increase was with first-draft pictograms made without any testing or revision of the icons.

The results also suggest that all means of collecting user input are not equal. The five lowest ranking items were all the result of user input but scored very poorly compared to the top five items. One can envision collecting informal input from a very small number of subjects such as in a focus group that would yield the lower raking items which, as this study shows, would misguide the designer. The larger the sample size, the more accurately the participants surveyed represent the population at large. We recommend never collecting data from fewer than the minimum recommended sample size of 30 (Borgatti & Halgin, 1986; S. Borgatti et al., 2002; Borgatti & Halgin, 1998).

Designing a comprehensible pictogram takes more than the ability to draw well. Designers must know what to draw. While aesthetics make pictograms pleasing to the eye, no pictogram can be considered successful, regardless of how attractive it is, if users cannot correctly understand its meaning. To develop more successful pictograms in the future, it is recommended that designers begin with consensus analysis techniques as demonstrated here as the starting point of the design process. This will allow designers to enter into the design process of designing, testing, and refining at a much more advanced stage because users were consulted before the pictogram was designed to learn what they expect to see in the pictograms.

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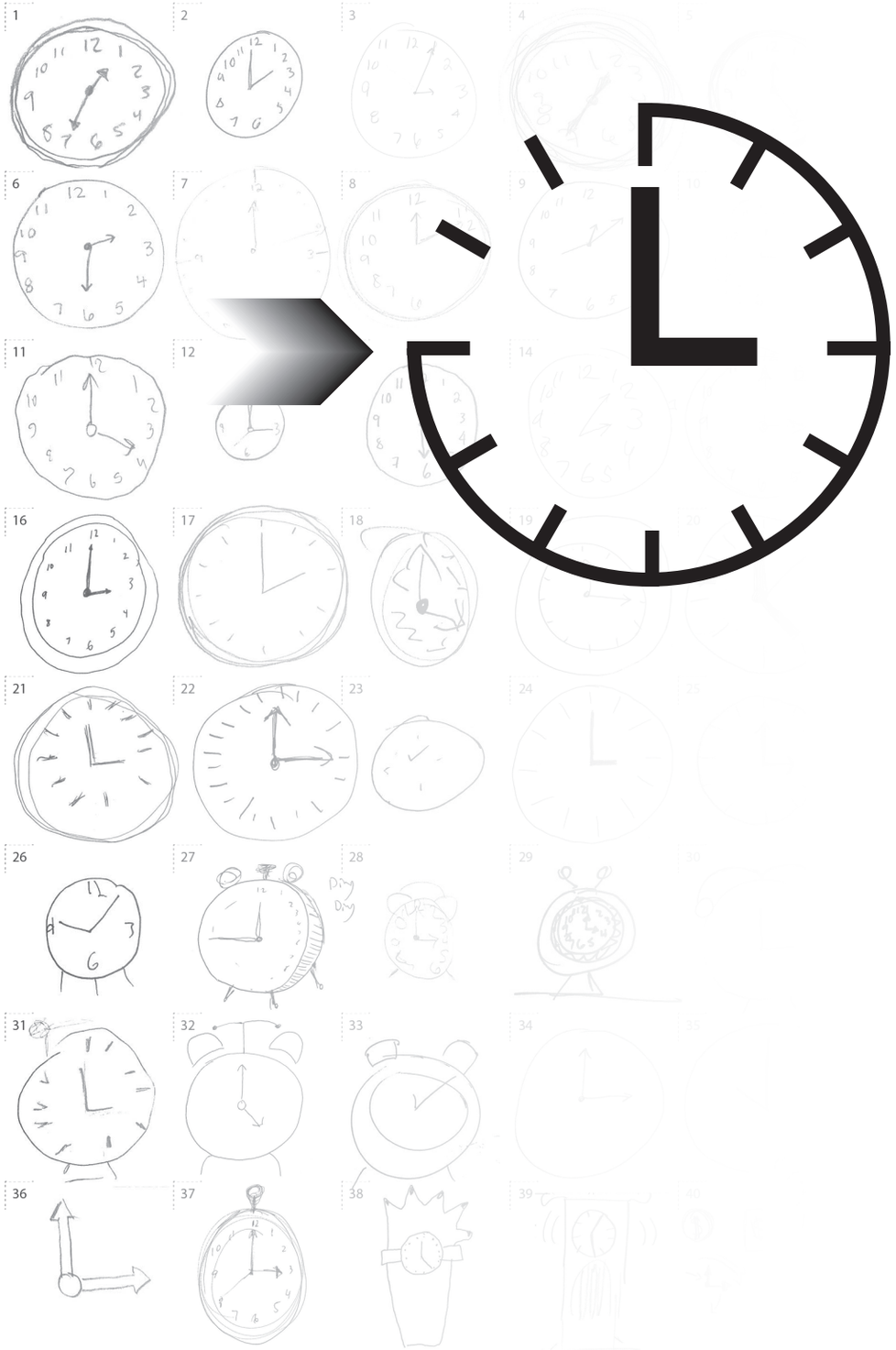


DrawIt:

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.

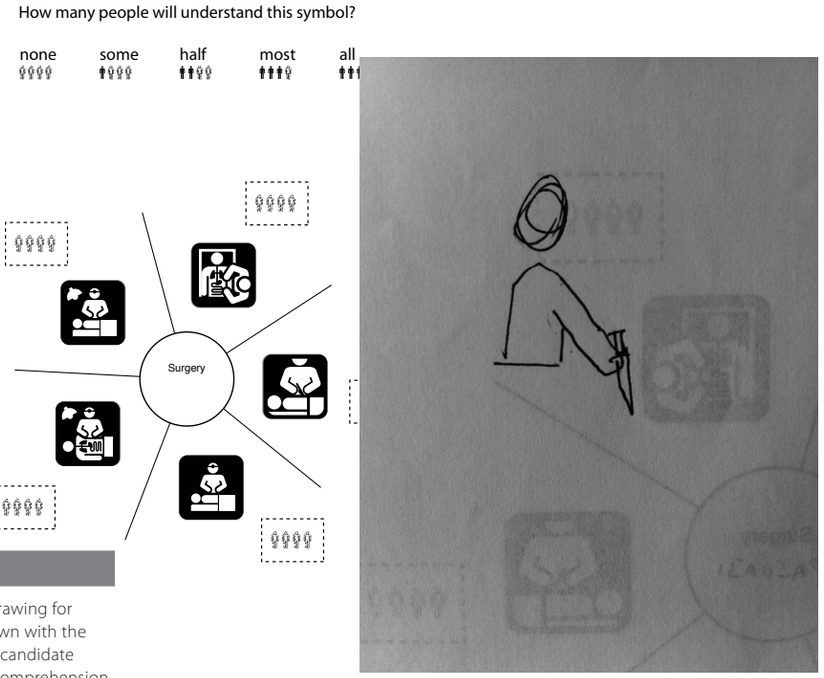


Figure 1

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

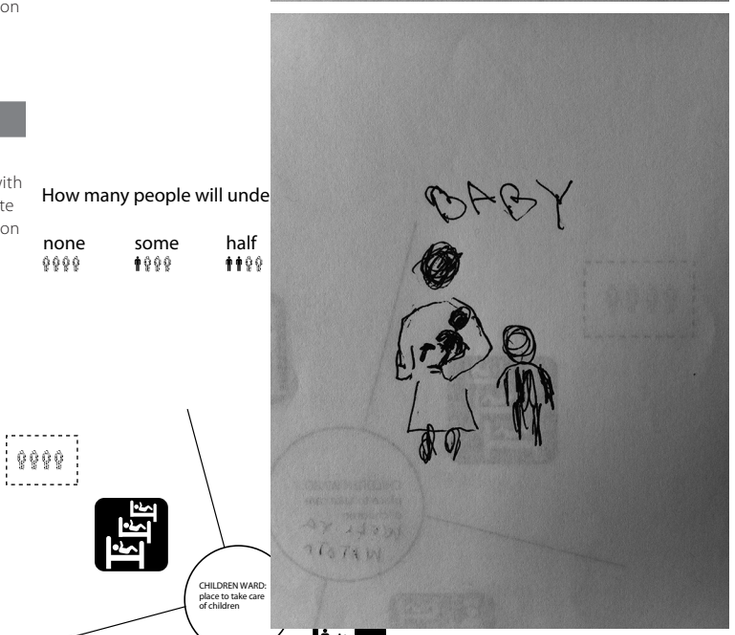


Figure 2

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.

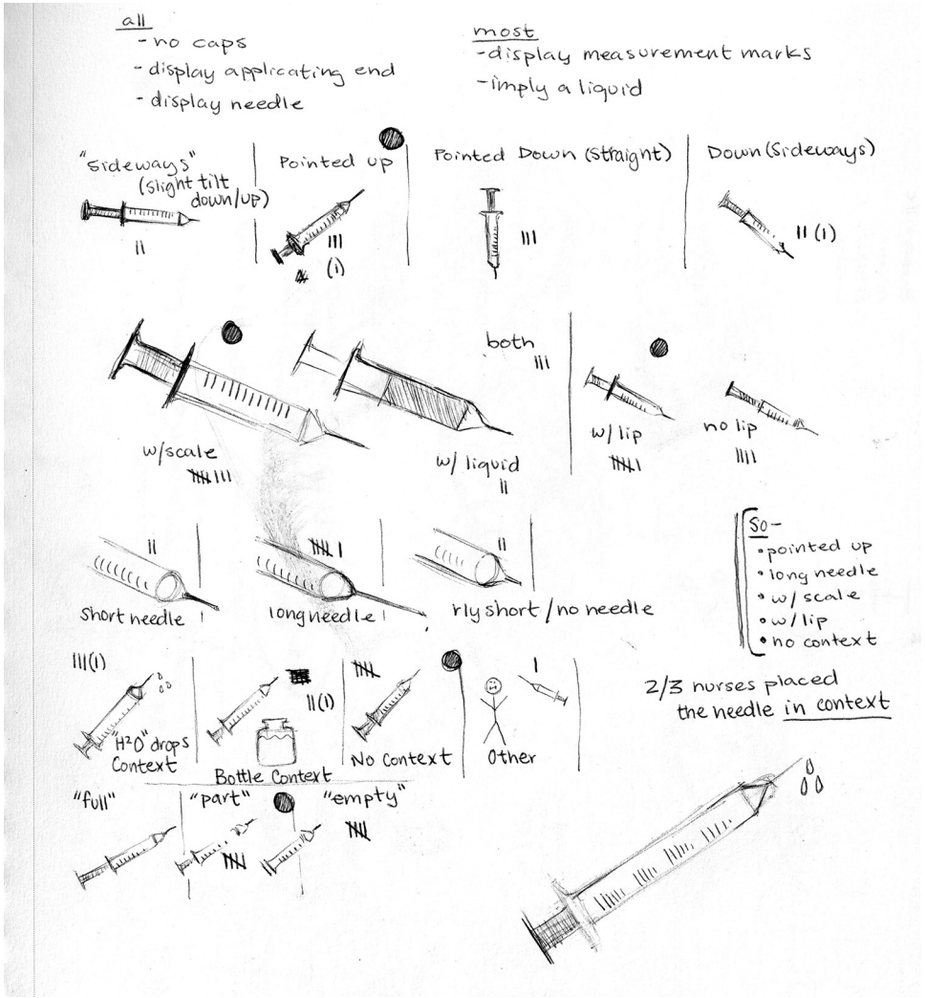


Figure 5

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.

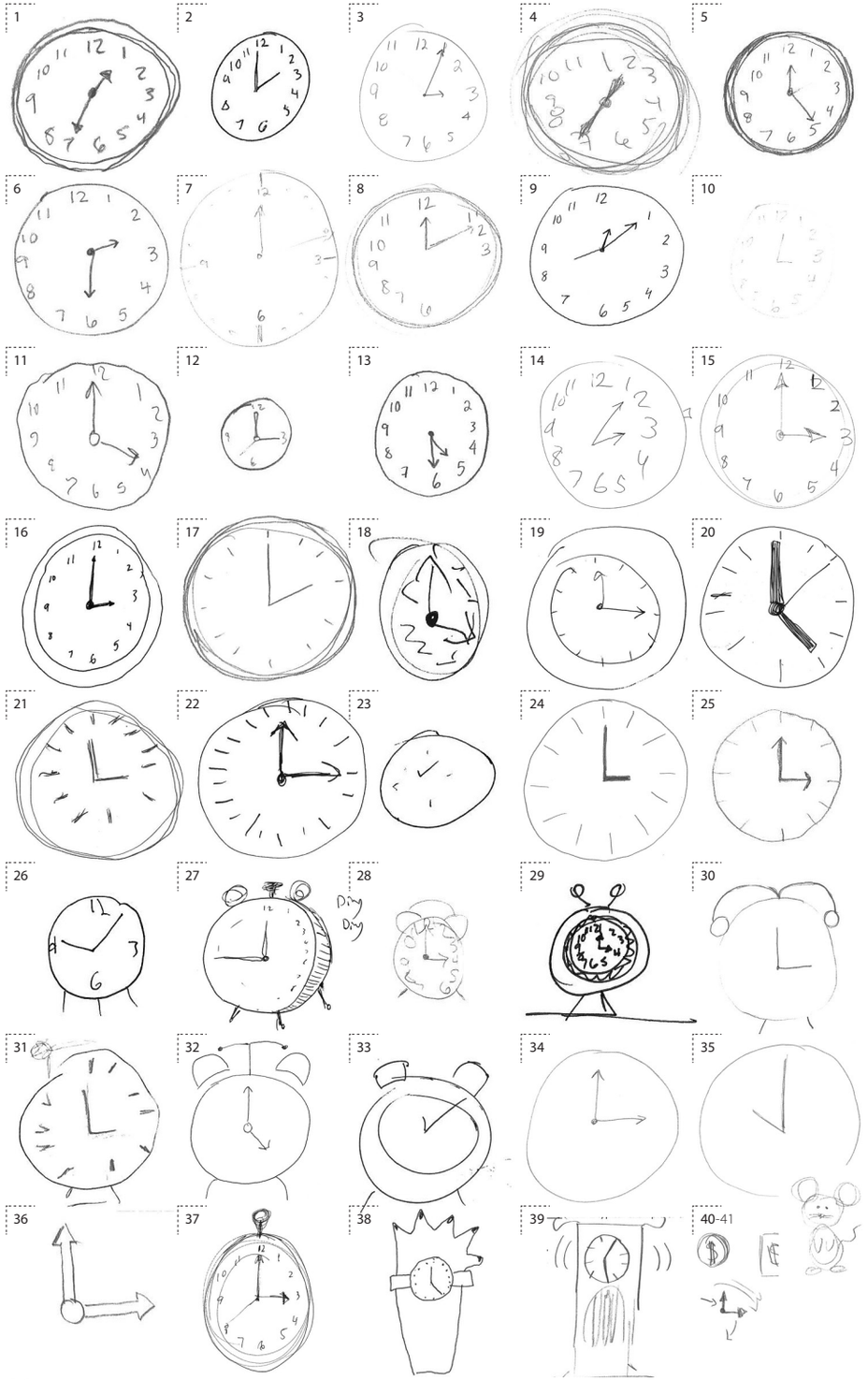


Figure 6 *(opposite)*

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

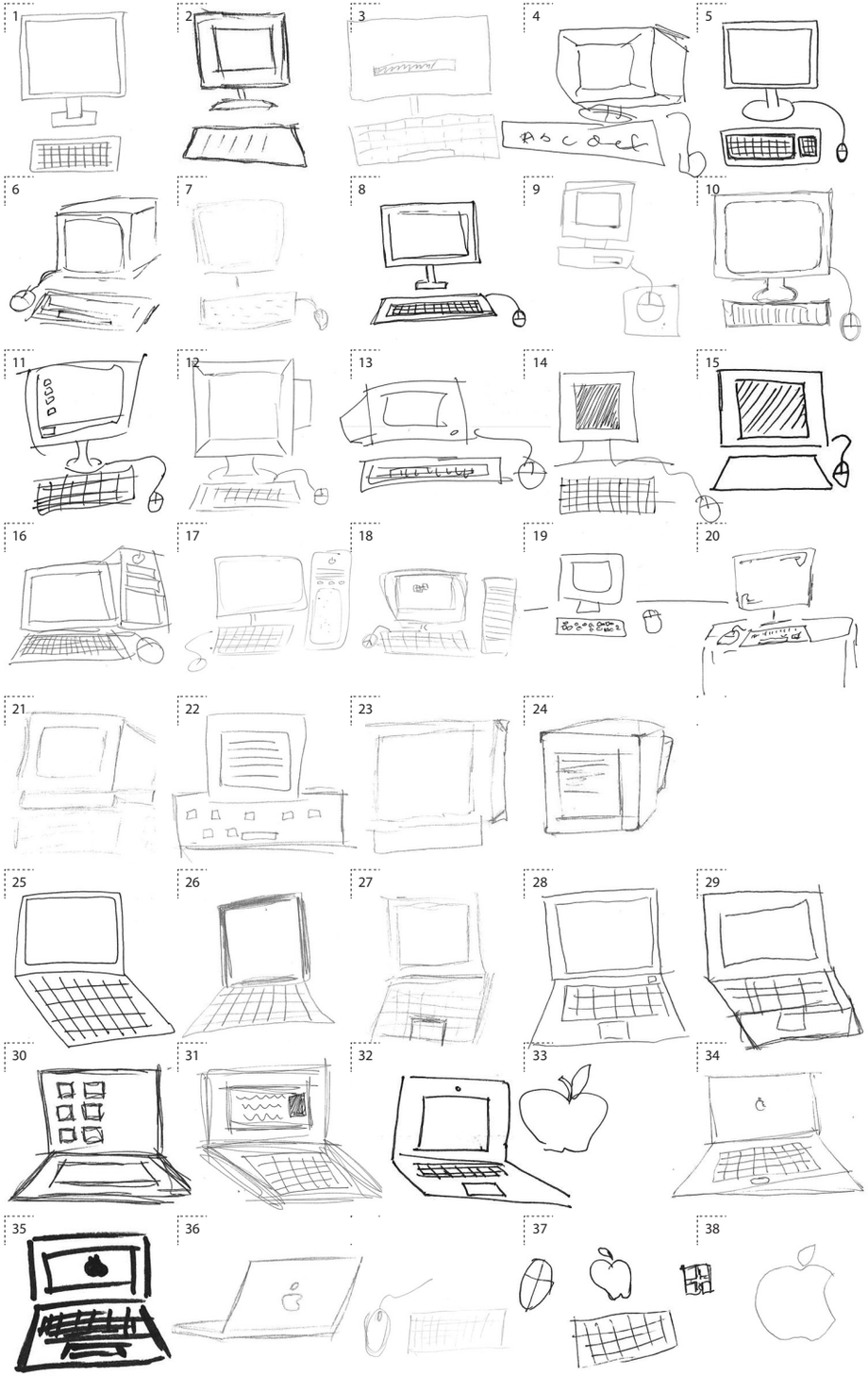


Figure 7 *(opposite)*

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.

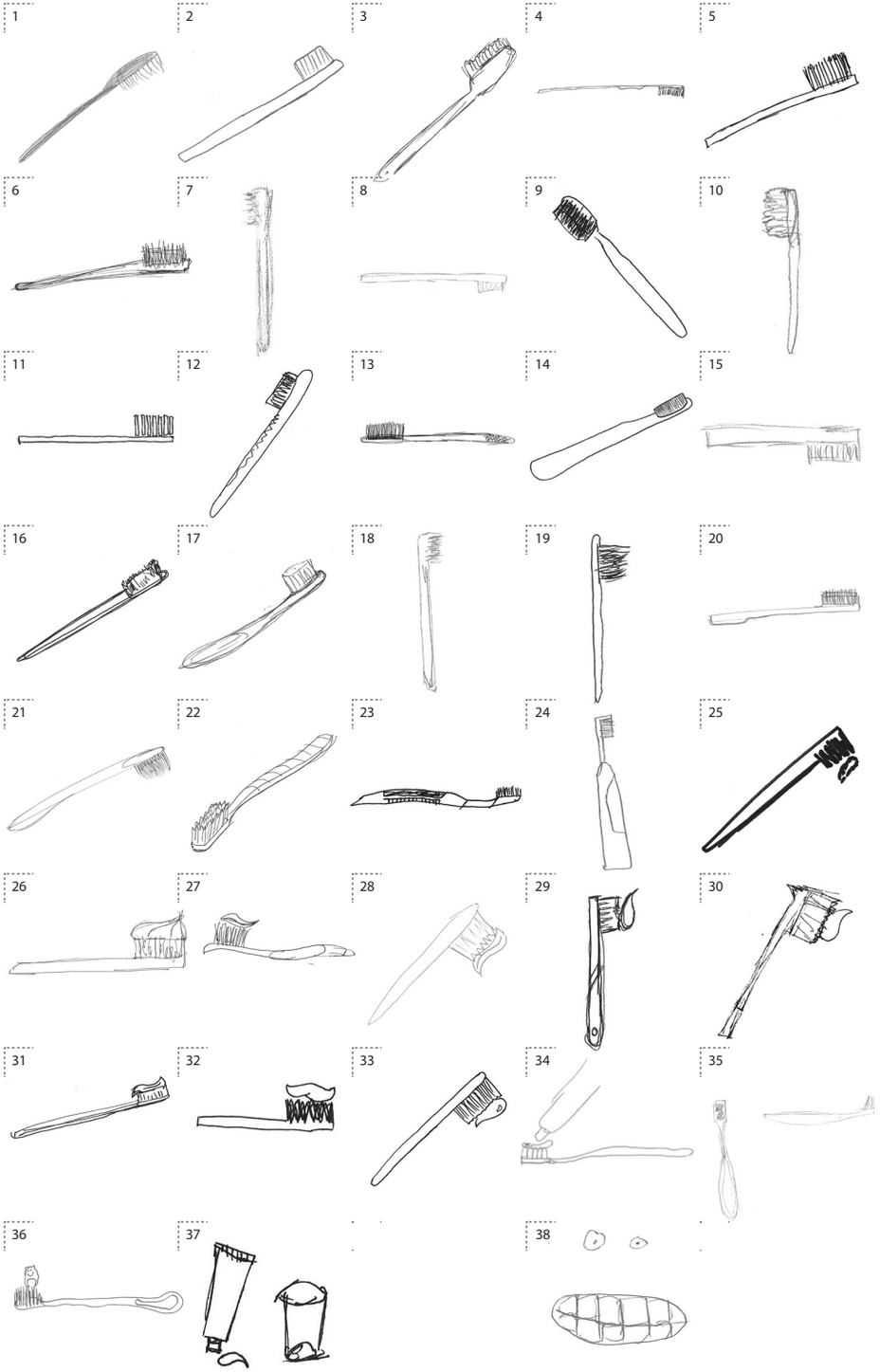
These examples show consensus to the degree that is unlikely to be random. Further, the data suggest that DrawIt produces results that intuitively align with reality: most but not all clocks have numbers; computers come in two major configurations; toothbrushes often have toothpaste on them. At the same 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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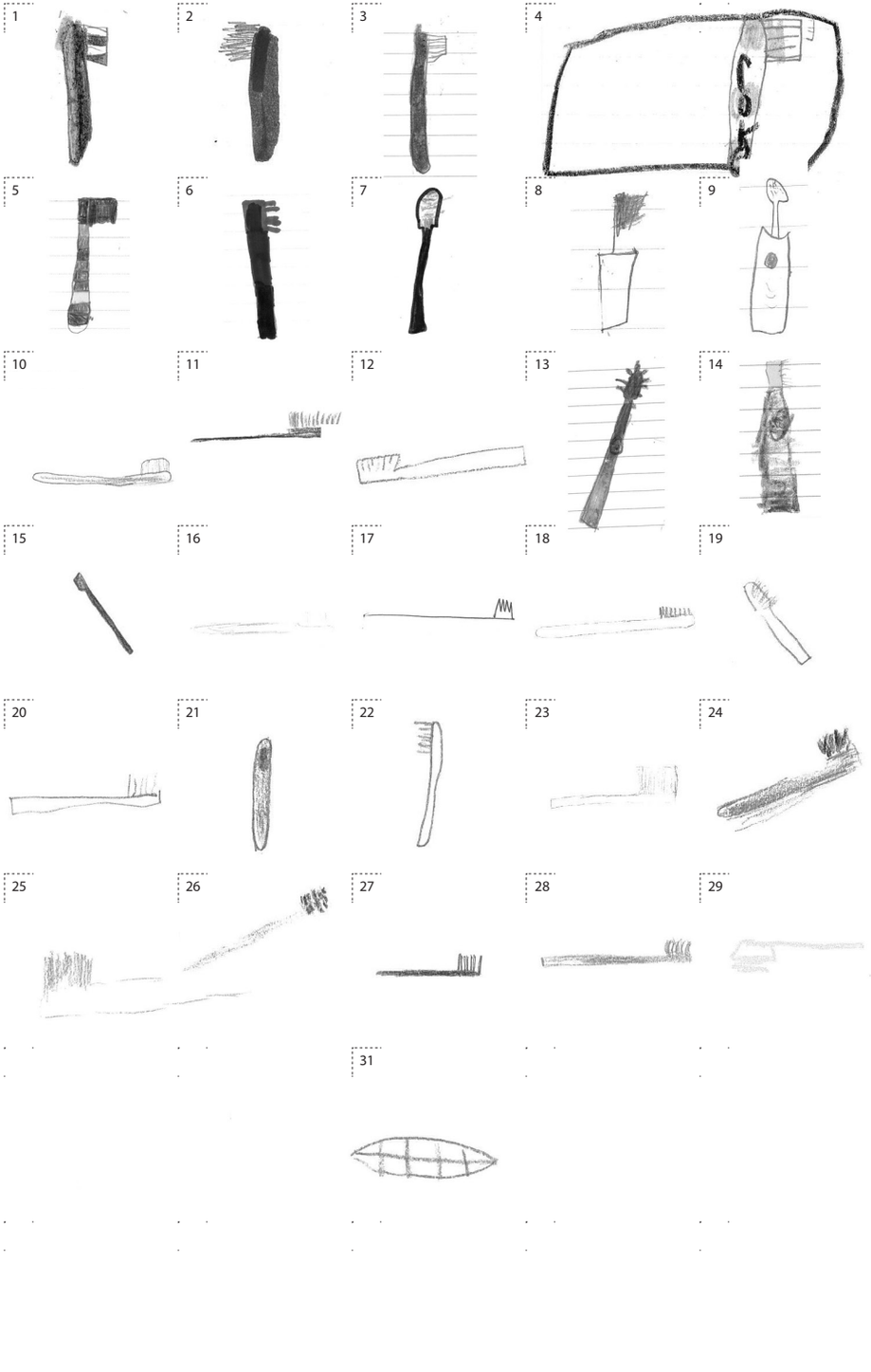
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Diverse Results

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

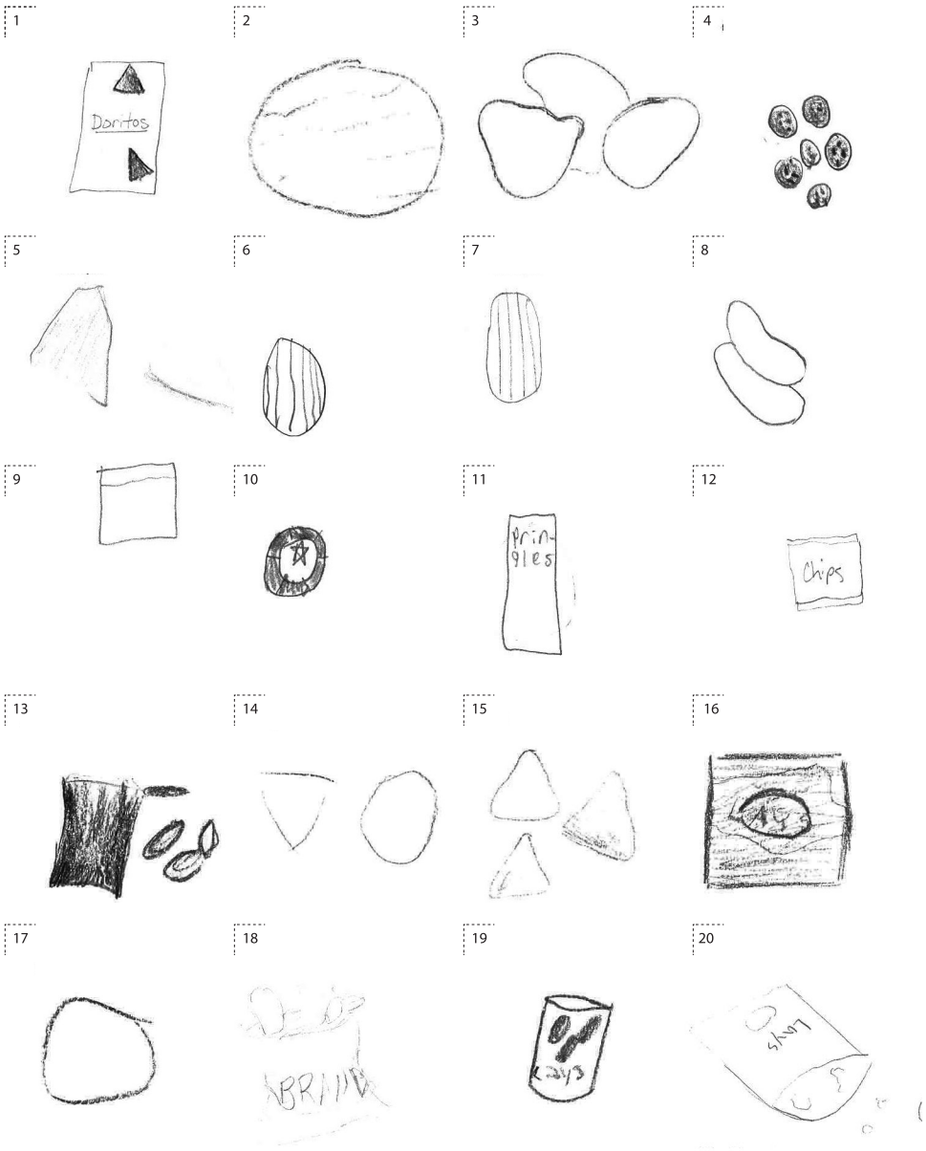

Figure 10

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

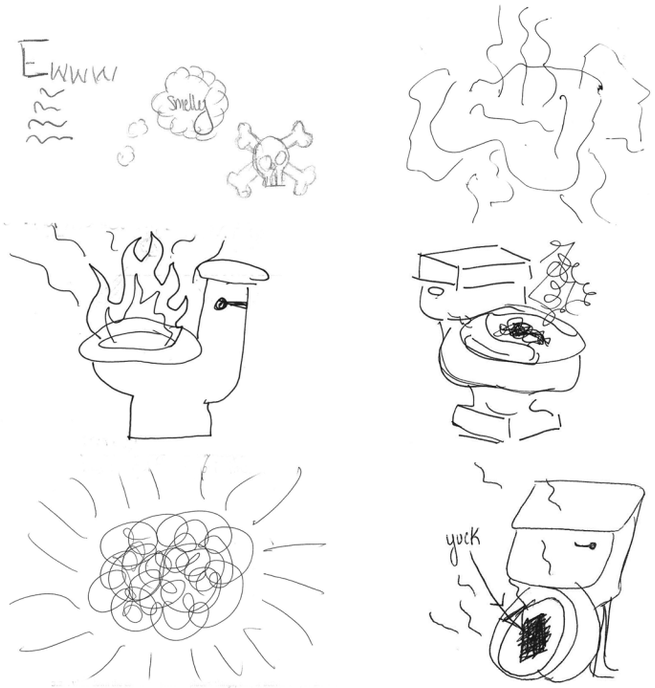

Figure 12

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

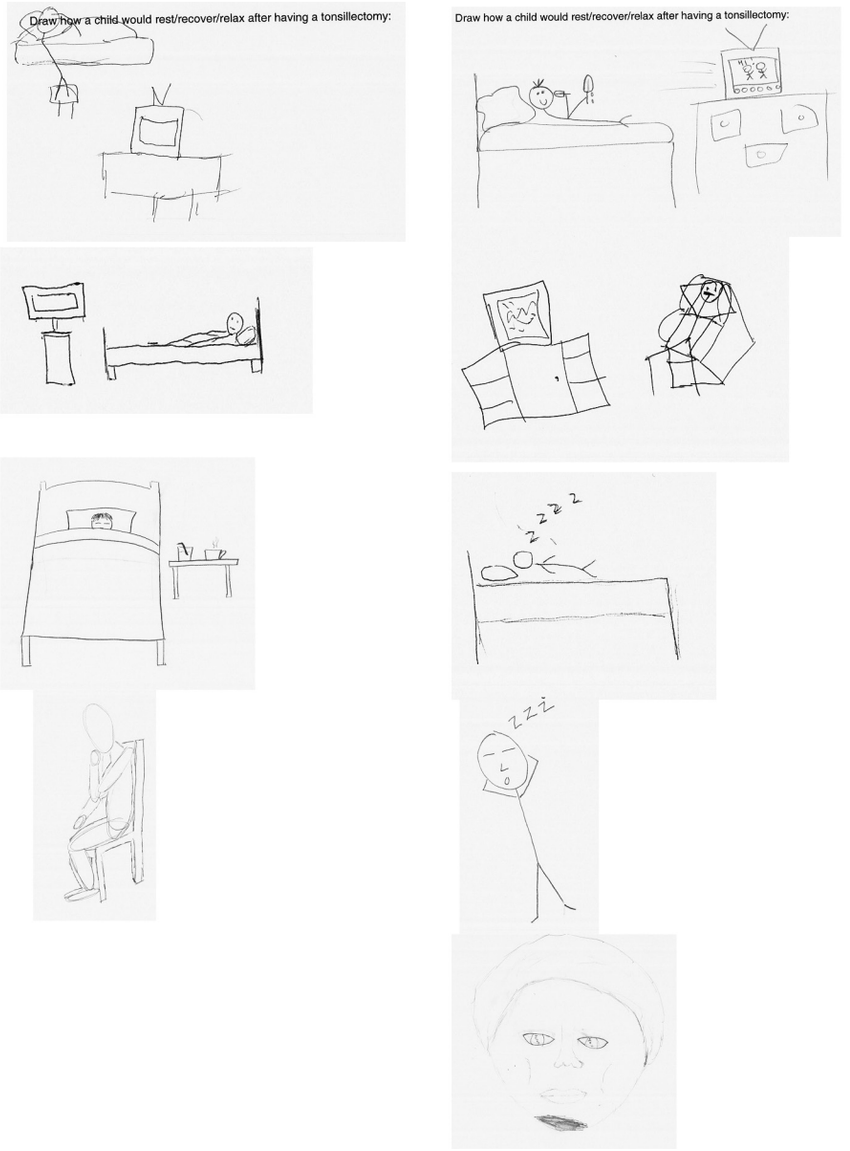

Figure 13

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. De-signing 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.

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meaning

Eagle as a calendrical signE

meaning

agle associated with the Northern region

meaning

Eagle representing the movement of the sun

Metonymic and Metaphoric Series in the *Codex Borgia*.

Plates 33-34.

Angélica Baena Ramírez

The main objective of this article is to understand how the metaphoric and metonymic graphic series helped to convey sequences of meanings and how they combined to provide a global interpretation of the content. As well, I will also analyze the relationship between signs with literal/fixed and metaphorical meaning, based on the context where the images are located and their association with other graphic signs.

I will take some examples from plates 33 and 34 of the *Codex Borgia* to explain how the Mixtec-Nahua semasiographic system worked and how the different signs were combined for the transmission of a message, which was not univocal, but which functioned as a tool for the priest to remember and recompose the information contained.

At the end of this research, an attempt will be made to provide an interpretation of plates 33 and 34, based on the understanding of the Mixtec-Nahua graphic system. I will try to prove that the apparent "chaos" contained in these plates, in fact serves to emphasize a mental and mythical concept that can be expressed in different ways, in order to provide the priest (tonalpouhque) with a mnemonic tool. The tonalpouhque could use the codex not just to remember information, but also to create new content.

keywords

semasiographic system
Codex Borgia
graphic series

Systems of Graphic Communication in Mesoamerica and Graphic Phrase Series

There is an interesting discussion in relation to the graphic systems of Central Mexico, particularly of the Mixtec-Nahua system, because it has been postulated that this is a logo-syllabic writing system, like Maya and Zapotec, although the Nahua writing system is restricted to names of places, people and trades (Lacadena, 2008).

For Gordon Whittaker (2011), there are three graphic communication systems, which coexist and complement each other: iconography, notation, and writing. Regarding the iconographic system, he points out:

> Iconography, traditionally prominent in religious, political, military, and sports contexts, but also increasingly employed to facilitate orientation in the public arena, codifies and represents information by means of graphic elements (variously called symbols, icons or semasiograms) of non uniform size arranged in sequence and a hierarchy in which the relative positioning and size of these elements carries meaning, and serves to represent, symbolize, and illustrate nonlinguistic data. (Whittaker, 2011, 936)

An iconographic system has conventions that can be understood independently of spoken language. A notational system distinguishes units of non-linguistic information, such as mathematical language. A writing system reflects language, and its components are morphograms (units of meaning) and phonograms (sound) (Whittaker, 2011, 935-937).

In what we know of the divinatory codex or tonalamatl up to now, there is evidence of the use of a notational system, which in addition to designating counts, was employed to give calendrical names to distinct gods and beings, as well as some rare examples of writing. In this regard, Juan José Batalla (2008, 302) notes that in the tonalamatl codices most of the information is transmitted exclusively by iconographic elements.

From a different perspective, Elizabeth Hill Boone proposes the use of the concept of semasiography and points out that semasiography (based on the Greek word semasia, which means "meaning") are systems of writing that do not have to go through speech to be understood (2010: 42).

On the other hand, the work of Katarzyna Mikulska (2008) also agrees that in the codices we find semasiographic writing and that it should not be considered something lesser than glottographic writing, given that it works properly within its context. As well, Vauzelle has analyzed the god's garments, confirming that the semasiographic system is based on polysemy and "each element does not convey a clear meaning that would allow it to be "translated" by a word or phrase, because the garments do not form texts. But it is possible to highlight the symbolic associations that are related to each element or its metaphorical and metonymic networks that may vary according to the context" (2017, 105).[1]

Mikulska (2015a, 351-352) states that the graphic communication system of Nahua-Mixtec tradition makes use not only of the iconic principle but also, occasionally, of the glottographic (a writing system of visual symbols for spoken language). Therefore, it would be more pertinent to speak of a "semasiographic principle", since there are no pure systems, taking into account that the graphic information can be verbalized. It should be noted that verbalization and reading are different, since reading implies the reproduction of an original and fixed model, while verbalization implies an interpretative and performative speech.

Tonalamatl codices, such as the *Codex Borgia*, served as tools to make predictions. They contain calendrical information that served to perform rituals and also encompass mythical information that could be verbalized in different ways, depending on circumstances. That is the reason I agree to consider this system as semasiographic, following the proposals of several researchers (Boone, 2007; Boone 2010; Mikulska, 2015; Wright Carr, 2011)

Daniele Dehouve (2009) has also pointed out that images in ancient Mexico were constructed using metaphoric and metonymic methods. She revisits the classic text of George Lakoff and Mark Johnson (1980), accepting their proposal that metaphors are not only a resource of language but a cognitive process. She mentions that metaphorical construction is a necessary condition of abstract thinking and, in addition to the metaphorical process, there exists a cognitive process through contiguity or metonymy: "there is a relationship of contiguity between the referent and the designated entity. In general, this is what happens with the definition by extension, which expresses the totality by the extension of its parts" (Dehouve 2009, 24).[2]

Metaphor, as intellectual process, is reflected verbally and ritually. For this reason, rather than limiting this process to pairing or diphrasism[3], she points out that there may be a larger phrase series and that the basis is

1 *Cada elemento no transmite um significado claro que permitiria "traduzirlo" por una palabra o una frase, porque los atuendos no forman textos. Pero es posible poner em evidencia las asociaciones simbólicas que están relacionadas con cada elemento o sus redes metafóricas y metonímicas que pueden variar según el contexto* (Vauzelle, 2017: 105).

2 *Existe una relación de contigüidad entre el referente y la entidad designada. De manera general, es lo que pasa con la definición por extensión, la cual expresa la totalidad por la extensión de sus partes* (Dehouve 2009: 24).

3 Montes de Oca defined diphrasism as "the juxtaposition of two terms that are associated to construct a unit of meaning that may or may not be different from that stated by each lexeme" (Montes de Oca, 2013, 39). *La yuxtaposición de dos términos que se asocian para construir una unidad de significado que puede ser o no distinta del que enuncia cada lexema.*

not diphrasism, but monophrasism (Dehouve, 2009). Recapitulating, metonymy is a way of conceptualizing one thing from the components and it has an affinity with all designated. On the other hand, metaphor is conceptualizing one thing in terms of something else.

It should be noted that these series do not always exactly correspond with the diphrasisms collected orally during the sixteenth and seventeenth centuries. In a recent work, Mikulska has proposed that:

> The graphic set of meaning undoubtedly lacks an exact correspondence between the graphic and the oral form. It can be given, but it is not an *a priori* condition because the goal is to represent some mental idea in graphic form. Oral expression is merely a verbal expression of the same mental concept and, since the same is true of graphic expression - which is the proper mechanism of the operation of semasiographic systems - sometimes the oral expression coincides with the visual. (Mikulska, 2015a, 387)

Taking into account the above, I consider that seeking these conceptual resources in images, rather than just linguistic ones, is feasible and appropriate, as already mentioned by the authors quoted. What is sought is the understanding of the mental concept behind the metonymic series and the visual metaphors that appear graphically. The painter can subtract or add graphic elements to convey meaning, depending on the available space (Mikulska, 2015a, 386).

This work is the continuation of an investigation that I carried out on plates 29 and 32 of this same codex (Baena, 2014). In the present research, I will focus on analyzing plates 33-34 looking for concepts of graphic meaning that clarify the overall significance of the images.

The *Borgia Codex*

The *Codex Borgia* is pre-Hispanic *tonalamatl*[4] that is currently deposited in the Vatican Apostolic Library. It is made in a folded strip format on screen and consists of 39 pages of 27 x 26.5 cm. Painted on both sides except the first and last, which have whitened exterior faces, that is, when the book is folded no paintings are observed, which means there is no possibility of damage or deterioration of its contents (Batalla, 2008, 272-273). This document presents several sketches that were later covered by stucco, which revealed restructurings of the image carried out by the painter or painters (Mikulska, 2015b, 172-177). The pigments used in the preparation of the

4 The *tonalamatl* is a ritual calendar consisting of 260 days. It was used for divinatory purposes, although it was not disconnected from the annual or solar calendar (Siarkiewicz ,1995, 12).

Codex Borgia were of natural origin for aesthetic purposes, because they produce a glossier finish than that of mineral pigments: "the underlying purpose of the development of color technology, based on organic materials to paint the pre-Hispanic manuscripts of Central Mexico, was the obtaining of a pictorial layer that was characterized by its luminosity" (Dupey, 2016, 160)[5].

Although the question of the place of provenance of this codex has not been solved, it seems most likely that its origin stems from the Puebla-Tlaxcala region (Peperstraete, 2006: 29; Boone, 2007, 227-228; Batalla, 2008, 207), possibly Cholula (Nicholson, 1994, 113-114; Milbrath, 2007, 157) based on archeological and iconographic evidence. Therefore, it could be argued that it was elaborated by speakers of Nahuatl, although it could be understood by speakers of other languages.

The central plates of the *Codex Borgia* have been very enigmatic for the investigators, because there are no parallel passages in other codices with similar content. Given its complexity, there are several perspectives and interpretations (Seler, 1980; Milbrath, 2007; Nowotny, 2005; Anders et al. 1993; Boone, 2007; Batalla 2008) about the central plates. I believe that the contributions of the researchers mentioned above are all very valuable and have undoubtedly helped to elucidate the meaning of these complex images. I will solely focus on analyzing a group of graphic series that appear in the central plates 33 and 34 of the *Codex Borgia*, in order to examine the indigenous process of the construction of the images and their meanings, depending on the context.

The Metaphoric Use of Colors in Plates 33-34. Red and Black Snakes Related to the Diphasism in Tlilli in *Tlapalli*.

In tlilli, in tlapalli: These words together refer to the concepts of knowledge and wisdom. Although this diphrasism has been translated as "black, red", it must actually be translated as "the black, the colorful", because *tlapalli* denotes all the pigments used to make the codices (Wright Carr, 2011, 287-288).

The color red has been associated with the term *tlapalli* (Boone, 2010, 31), being one of the colors used in the elaboration of the codices, particularly in the dividing lines of the sections of the different documents.

5 *La finalidad subyacente al desarrollo de una tecnología del color basada en materias orgánicas para pintar los manuscritos prehispánicos del México Central fue la obtención de una capa pictórica que se caracterizaba por su luminosidad* (Dupey, 2015, 160).

In tlilli in tlapalli have a metaphorical meaning, related not only to the elaboration of codices, but to knowledge and wisdom. Likewise, the expression *tlapalli tlilli nic tlalia* refers to "setting a good example" (Velázquez in Wright Carr, 2011, 288). "The direct reference is to the immemorial legacy that has been present since ancient times" (Montes de Oca, 2013, 160).[6]

In plates 33 and 34 (*figures 1 and 2*), as we can see, there are two different temples, surrounded by the black and red snake respectively. These colors are no coincidence because they refer metaphorically to the mythical place known as in Tlillan Tlapallan, the place of black and red/colorful. Seler had already pointed out this possibility, however, the German author, in his eagerness to maintain an astralist interpretation corresponding to precise astronomical cycles, states that both houses symbolize the west or evening sky (Seler, 1980 II, 24). Later however, he has problems justifying this idea and then accepts that *Tlillan Tlapallan* is associated with the east and the west.

The red temple of Plate 33 would be associated with the East and the Temple of Plate 34 with the West (Boone, 2007, 186). Or more suitably, Plate 33 is associated with the daytime sky and Plate 34 with the night sky (Mikulska, 2015c) and jointly represent the cyclic movement of the sun.

The *Anales de Cuauhtitlan* point out that Quetzalcoatl left Tollan with his followers after being deceived by his enemies and having broken his penance, and arrived to *Tlillan Tlapallan*. "Then he halted and wept and

Figure 1

The black Temple of Heaven (Codex Borgia, 1976, plate 33)

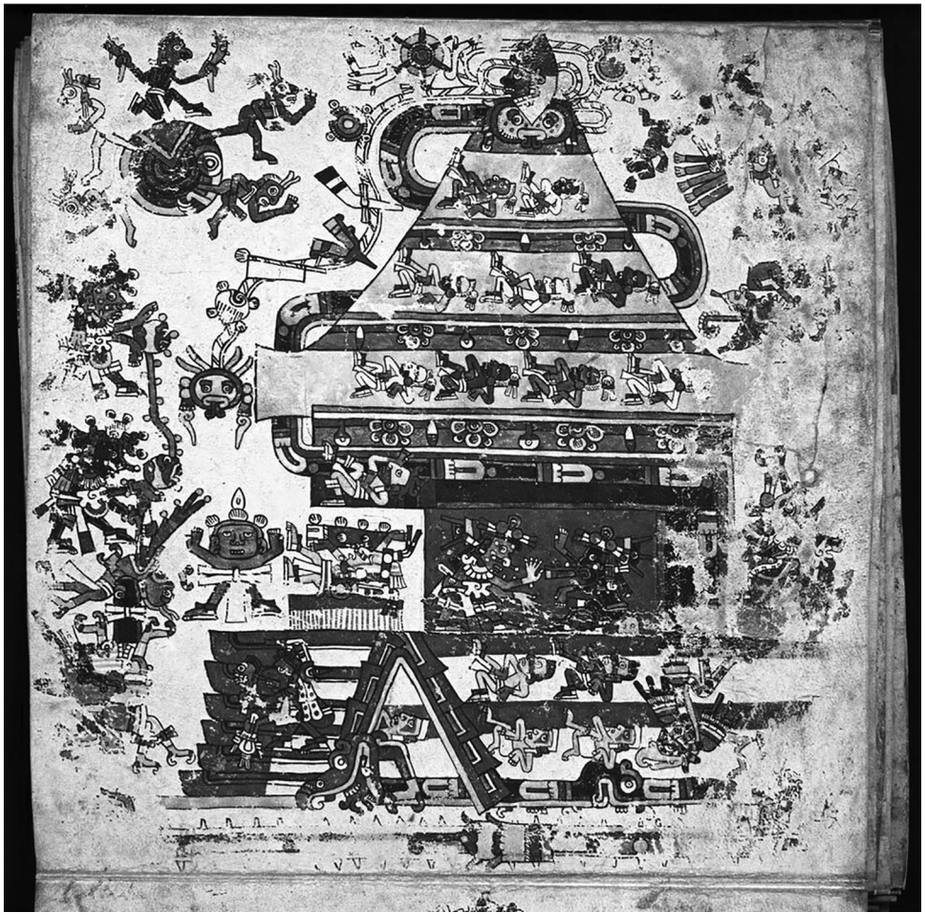
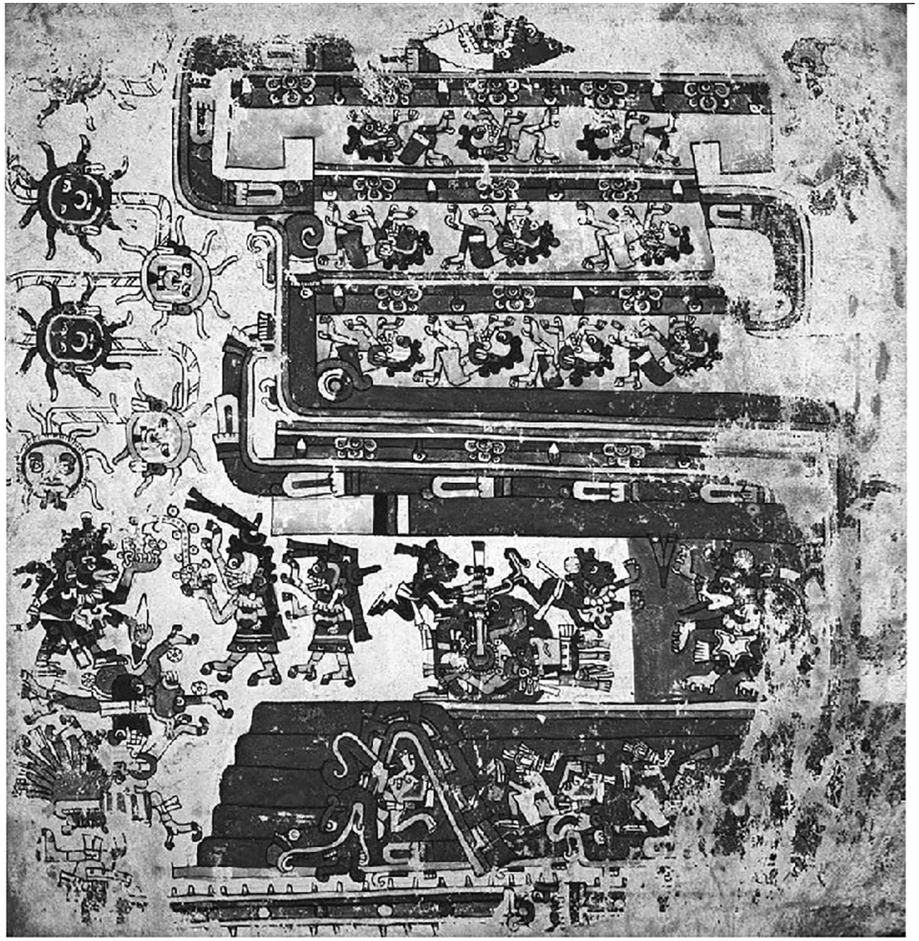


Figure 2

The red Temple of Heaven (Codex Borgia, 1976, plate 34).



6 "La referencia directa es al legado inmemorial que se encuentra presente desde tiempos remotos"

gathered up his attire, putting on his head fan, his turquoise mask, and so forth. And, as soon as he was dressed, he set himself on fire and cremated himself. And so the place where Quetzalcoatl was cremated is named Tlatlayan" (Bierhorst, 1992, 36).

As I have pointed out, this mythical place is related to the diphrasism *in tlilli, in tlapalli*, "the black, the colorful", which refers to the painted books, the colors with which the codices were made. The Temples of Heaven in these plates are associated with this diphrasism, because in these places were deposited the ancestral knowledge and they contain the basis of the cult.

For Elizabeth Boone (2007, 189) the black and the red snakes play a creative role, and relate them to the myth of the creation of Earth, where Quetzalcoatl and Tezcatlipoca separate the terrestrial monster, creating the earth and separating it from the sky (Garibay, 2005, 109). Anders et al (1993, 203) considered that these beings would correspond to the serpents of vision. Without denying the creative and ritual burdens that these serpents, I propose that the Temples of Heaven, being part of the body of the Red-Black Serpent, are designated as places of wisdom and knowledge, as *Tlillan Tlapallan*, through a metaphoric use of the colors.

In fact, according to the *Anales de Cuauhtitlan* (Bierhorst, 1992, 36), the complete toponymal would be in *Tlillan Tlapallan Tlatlayan*. The departure of Ce Acatl Topiltzin Quetzacoatl from Tollan to this mythical place, will serve as a model for the Nahuatl rulers, who ritually recreate the journey from Quetzalcoatl to *Tlillan Tlapallan Tlatlayan* during the funeral of the ruler or tlatoani (Johansson, 2015, 162). In the *Hystoire du Mechique* (Garibay, 2005, 116) the previous hypothesis is corroborated, since it is affirmed that after the death of Quetzalcoatl by fire, the custom of burning the dead bodies of the warriors and kings was established.[7] *Tlatlayan* means in Nahuatl "The place of burning" and that is the reason of the presence of the igneous elements in these images[8].

According to a myth, a god was thrown into the fire and thus the sun was created. As the star did not move, Xolotl sacrificed the rest of the gods by heart extraction and then himself, giving rise to this practice and worship of the sacred bundles, which were made with the clothes of the dead gods (Mendieta, 1993, 79-80). As I had pointed out above, when Quetzalcoatl had to embark on his journey to *Tlillan Tlapallan Tlatlayan*, he also had to sacrifice himself to become the star of the dawn and had to pass through Tlatlayan, "The Place of Burning," to be reborn as Tlahuizcalpantecuhtli or Venus.

In the Temples of heaven, place of wisdom and knowledge, the place of burnt, it is evident that the presence of the stars and igneous elements are combined. Both the sun and the fire give are a source of heat or *tonalli* (Mikulska, 2017, 54), as well as incineration and sacrifice by heart extraction.

In summary, in the context of these images, the red and black snakes are working in a metaphoric way, expressing a deep mythological concept. As well, they refer to the place *Tlilan Tlapallan Tlatlayan*, where Quetzalcoatl went to burn himself in order to become Venus. That is the reason for the presence of stellar elements (Mikulska, 2017, 47) and beings, because they were born thanks to a sacrifice by fire, according to different myths, including the creation of the sun (Boone, 2007: 188-189).

Methaphoric Ways To Express Cyclical Time

Graphic signs are polysemic (can mean multiple things) and their significance depends on the context in which they are found. For example, the rabbit or the deer, can function as a sign of the day (*figure* 3) or, in the case of the rabbit, it can act as a marker of the year.

Figure 3

Rabbit and deer as calendrical signs (Codex Borgia, 1976, plate 5).

In plate 33, the sun and the moon are attached from the thread that the spider weaves (*figure* 4). The representation of the sun as a deer and the moon as a rabbit respond to an ancient mythical tradition in Mesoamerica, where these animals play an astral role. In a myth of southern Durango (Medina Miranda in López Austin, 2009, 23) the rabbit does not have the strength to load the antlers and is forced to give them to the deer, which from then on will possess them. Among the Maya, Huichol, Totonacs of Cuahueyatla and Kekchíes, the deer appears clearly associated with the sun, but also with the hunter (Olivier, 2015, 277-281).

Both the rabbit and the deer were related to vagrancy and disobedience (Sahagún, 1999, 417), for being both eternal travellers of the firmament (Lopez Austin, 2009, 49-53). The rabbit is deeply associated to the

7 In Mexica society, the merchants were allowed to be cremated because they gained social status through time.

8 For example: the birth of fire ñuhus, the presence of fire serpents, the appearance of women dressed as priestesses of fire on the steps of both temples as the extraction of fire from the breast of a god and the birth of igneous spirits. In addition to the previous examples, the presence of Xolotl and Tlahuizcalpantecuhtli in these images is very important, since both gods have a fundamental role in incineration as a generative act.

moon (Sahagún, 1999, 431-432). The rabbit and the deer, associated to the sun and the moon, are a graphic metaphor of cyclical time.

Figure 4

The sun/deer and the moon/ rabbit. (Codex Borgia, 1976, plate 33)

The sense of the appearance of the sun/deer and the moon/rabbit in the thread is to symbolize the becoming of time, the duality of day and night, the continuous movement of the two stars. In addition, the rope symbolizes the connection between the sacred world and the human world through rituals and sacrifice (Díaz Álvarez, 2015, 87).

As well, the passing of time is emphasized by the presence of warriors killed in battle and dead pregnant women. Mikulska (2015a) analyses in depth the relations between the *macuiltonaleque* and the *tzitzimime*[9]. It seems to me very important to point out the proposal of this researcher (Mikulska, 2008, 239; 2015a, 147-156), since, based on the analysis of myths, ethnographic and iconographic material, she observes that *mimixcoa* (that possess an identity associated with *macuiltonaleque*), as well as dead women in childbirth *cihuateteo* or skeletal beings *tzitzimime* in their role of stars[10], have a joint role in indigenous narrative:

> It seems that the most important function of the *macuiltonaleque* together with the star-dead women was to introduce a state of chaos and subsequently restore order. Thus, in the images of the sky-temple of the *Codex Borgia* (33-34), it is surely a representation of the diurnal sky, and although there surely stands the function of warriors and dead women as companions of the sun, I would understand it in the sense that they help you mark the passage of time.
> (Mikulska 2015a: 155)[11].

9 One of its most important characteristics is that they are skeletal or defleshed beings (Dakin, 1996, 316). The *tzitzimime* appear in the contemporary myths as primordial characters to whom Quetzalcoatl had to overcome, under some of his invocations, to be able to give way to the creation of the present world (Stresser-Pean, 2011, 432-433).

10 I agree with the author when she states that in the female figures that appear on the roof of sheet 34 of the Borgia codex can be identified as *tzitzimime*, by their emaciated faces, and as cihuateteo, by their belly of previously pregnant women" (Mikulska, 2015a, 154).

11 *"Parece que la función más importante de los macuiltonaleque junto con las mujeres muertas-estrellas era introducir un estado de caos y posteriormente restablecer el orden. Así, en las imágenes de los templo-cielo del Códice Borgia (láms. 33-34), seguramente se trata de una representación del cielo diurno, y aunque seguramente allí se destaca la función de los guerreros y mujeres muertas como acompañantes del sol, yo lo entendería en el sentido de que ellos le ayudan a marcar el transcurso del tiempo".*

On the other hand, the appearance of the graphic sign "eagle", in this case works to complement the idea of movement of the sun and temporal becoming. The eagle sign could be a calendrical sign in the context of *tonalpohualli* (*figure 5*) or appear as directional from the Northern region (*figure 6*), but in this case, due to its position and the general context of the image, is associated with the movement of the sun. This animal reiterates again the idea of the movement of the sun from its ascent and descent by the Temples of the Sky, precincts of wisdom (*figure 7*).

Figure 5

Eagle as a calendrical sign. (Codex Borgia, 1976, plate 11).

Figure 6

Eagle associated to the Northern region (Codex Borgia, 1976, plate 50).

Figure 7

Eagle representing the movement of the sun. (Codex Borgia, 1976, plate 33).

Metonymic Series to Express Self Sacrifice and Sacrificial Activities

The sacrificial activity is represented by several graphic elements in these plates. The tails of the red and black serpents have sited at the top, a flint. The flint is associated with the Gods Tezcatlipoca and Quetzalcoatl[12] (*figure 8*). In Plate 33, the flint hangs on the thread of the spider and the objects attached to the sacrificial activity hanging on the thread are: *chalchihuitl*, a sacred stick, the spines of maguey, a flag, and a sacrificial feather.

These graphic elements form a graphic inventory associated with sacrifice (Dehouve, 2009; Mikulska, 2015a), which although it has some oral correspondence (Montes de Oca, 2013, 393), is not limited by it. The elements hanging from the sacrificial rope may be paired in other images, such as the sacrificial feather and the flag. The maguey spines may incorporate the thread (*figure* 9) or appear combined. In all cases, the associated signs create a metonymic series that refers to sacrificial activity (*figures 1* and *8*).

Figure 8

Rope with sacrificial elements. (Codex Borgia, 1976, plate 10)

12 Taking into account these elements and the facial painting of the character that appears in the flint, I consider that this is Quetzalcoatl, since from its descent to the ground lay the foundations for the emergence of political and religious power established by the god, as it also appears in the Mixtec codex.

Figure 9

Sacrificial rope and maguey spines. (Codex Borgia, 1976, plate 64).

Figure 10

Architype of sacrificial victim. (Codex Borgia, 1976, plate 33)

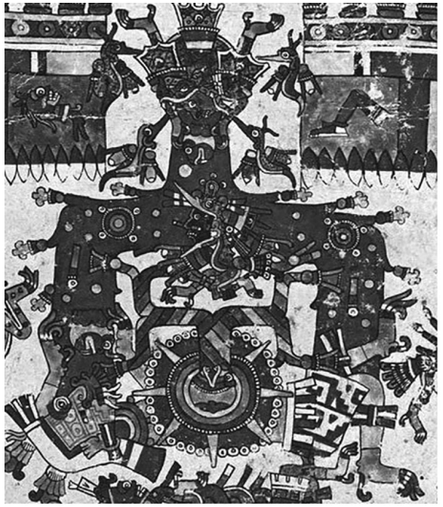


Figure 11

The *chalchihuitl* or jade sign combined with the flower sign and gold sign to express the "Preciousness" of the sacrificial blood. (Codex Borgia, 1976, plate 44).

Fig. 12

Chalchiuhatl, diphrasism to precious blood. (Codex Borgia, 1976, plate 10).

A frontal image of a character appears on Plate 33, which is not common in the Mixteca-Puebla style. He has a sacrificial feather on his head, he carries only a *maxtlatl* and his arms are outstretched. It seems to represent the architype of the sacrificial victim, which again emphasizes the idea of sacrifice (*figure 10*).

The jade or *chalchihuitl* appears on the rope as a marker of the preciousness of the sacrificial elements. The *chalchihuitl* sign and the flower, either together or individually are a metaphor of the precious and the valuable (*figure 11*) that does not correspond exactly to the oral diphrasism.[13]

As well, the *chalchihuitl* associated with water generated the diphrasism in chalchihuitl in atl or *chalchiuhatl* that means "precious water or blood" (*figure 12*). It has an oral correspondence, but we can see that graphic signs are not always limited to the orality (Mikulska, 2015a, 392-393).

13 The oral diphrasisms that use the ***chalchihuitl*** to express the precious, the valuable thing are: ***in chalchihuitl, in teoxihuitl***, "jade, turquoise***"; In chalchihuitl, in maquiztli,*** "jade, bracelet"; In chalchihuitl, in quetzalli, "jade, feather thin" (Montes de Oca, 2013, 177). The ***chalchihuitl*** graphic sign may appear alone or in combination with the sign "flower" to express the same meanings associated with sacrificial activity.

Conclusion

The temples (plate 33-34) metaphorically refer to *Tlilan Tlapallan Tlatayan*, a mythical place where Quetzalcoatl became Venus, a place of wisdom and knowledge (where the codices are kept), as well as the place where Xolotl became the Sun, after heading the Sacrifice of the gods, giving rise to the continuity of time. Here it was established the need for the extraction of the heart and self-sacrifice as a paradigmatic act.

The temples of Heaven in the codex are of an unusual size (Byland, 1993, xxiv) because they sought to emphasize their mythical origins and their transcendence. In the Mixtec codices, they are the seat of very important acts like marriages, births of founders of dynasties, as well as activities related to the power and the penitence.

I do not disagree with the proposal by Anders et al. (1993) when they affirm that these images refer to a specific ceremonial space, although I consider that what these plates present is the archetype of a space dedicated mainly to the Feathered Serpent, whose cult will be of enormous importance for the political and religious life of several places during the Postclassic period.

Through different images, it is sought to emphasize that the Temples of Heaven are places related to cyclical time, the cremation as a mythical model for the funerals of rulers, and the emergence of the stars from sacrifice. This visual redundancy serves to reiterate, complement and transmit graphic messages. *Tlillan Tlapallan Tlatlayan* is a metaphoric place that displays important religious meanings.

Graphic signs are polysemic and form association networks depending on the context in which they are found. Through the analysis of these plates, we can appreciate that the semiographic system was used in the elaboration of divinatory codices and that the meaning of the icons is not univocal (limited to one meaning), because these are related depending on the context. The graphic elements are grouped metaphorically and metonymically creating different complementary meanings.

The glottographic system seeks to transmit a specific and unique message, whereas in the semasiographic systems used in religious codex, the ritual specialist was a key participant in the construction of meaning, because the graphic elements create different levels of reading that are related or independent to each other.

Although the graphical elements have a relation with orality, they do not have an exact visual correspondence, which allows a permanent composition of signification. In the semasiographic systems, the priest played an active role in the transmission, elaboration and interpretation of the message embodied in the sacred codices, unlike the glottographic system, which seeks to specify information instead of creating it and recreating it through polysemous symbols. Both systems, semasiographic and

glottographic, are equally useful and rich, but they have a different operation because they have different objectives.

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The Written Adornment:

the many relations of text and image in Classic Maya visual culture

Daniel Salazar Lama

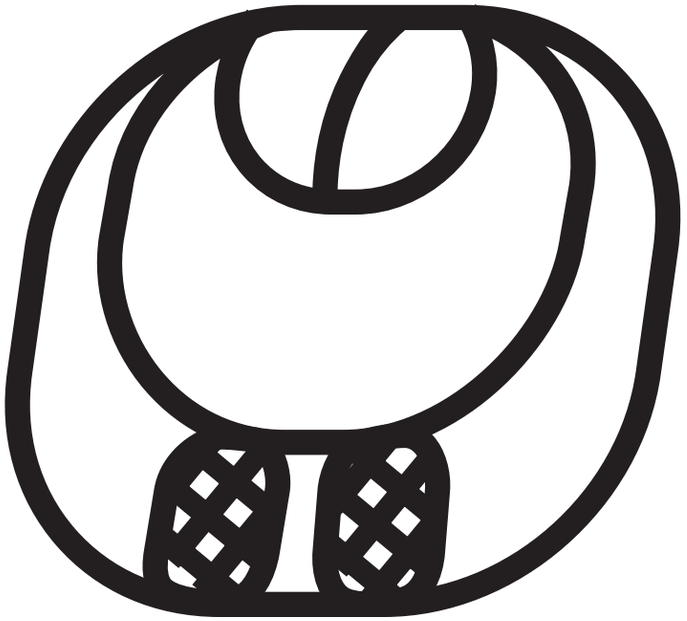
Rogelio Valencia Rivera

This article focuses on a complex and very common practice in the Mayan visual culture of the Classic period (250-600 AD): the integration of writing elements in images. This integration can be presented under many aspects and forms and fulfills several functions. The most important of them is to create a semantic complementation with the image, indicating what it is not able to express, such as anthroponyms (personal names) and place-names. In this text we also explore the many ways in which this assimilation takes place, and we propose clear and essential principles for the detection of assimilated text elements within the images. We also explore, albeit briefly, this same practice in other Mesoamerican visual cultures, with the intention of putting it into perspective and understanding it not as an isolated and exclusive practice of the Maya, but shared by many Mesoamerican groups over several centuries.

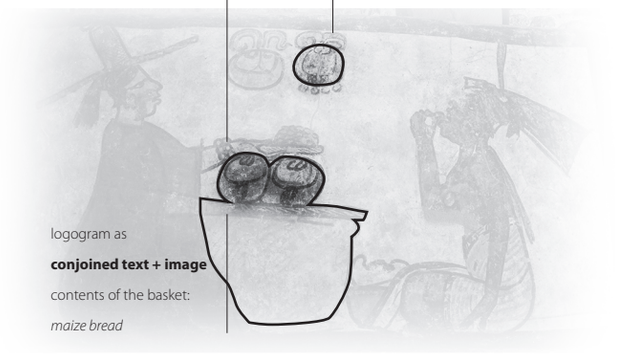
keywords

anthroponyms
place-names
pictorial assimilation
functional locus
embedded texts

maize bread



logogram as
conjoined text,
in this case, as part of
the name of a métier:
he/she of the maize bread



logogram as
conjoined text + image
contents of the basket:
maize bread

Introduction

One of the most striking features of Mayan writing is its use as part of the iconography employed to illustrate many of the scenes depicted in vases, friezes, paintings, stelae and all the various objects employed by the Maya to hold their artistic expressions and cultural imagery.

Writing might be used as part of the landscape, being held in the hand by the characters depicted, or portrayed as part of the headdresses of Mayan rulers, among many other possibilities. However, even if writing is integrated into the iconography, it does not lose its primary purpose, that of being used as a mechanism for the utterance of words and sounds.

Berlo (1983) defined three categories for textual sources in Mesoamerica: discrete texts, meaning normal independent texts, conjoined texts and images, and embedded texts. The last two categories are relevant to the matter of this paper. Conjoined texts and images refer to texts accompanying images where both maintain relative independence, and where the text can make direct references to the image, like names of its characters or short descriptions of its actions. Embedded texts include texts or script elements fused with the images themselves, and operate under the concept of "pictorial assimilation" established by Stone and Zender (2011, pp. 24-28). The analysis of the form in which the Maya employed this last category, embedded texts, is the main subject of this work. In Figure 1, both types of categories are illustrated.

Figure 1

Painting SE-S2[1] in Substructure I-4, Chi'k Nahb Acropolis, Calakmul (photograph by Rogelio Valencia).

Generally, when the text is embedded in the images, the use of writing implies name tagging (Mathews 1979; Houston and Taube 1987: 38-41) of rulers, gods, things, or places, but the location of the tag is integrated into the imagery of the scene, not as a separate entity, leaving it to the trained eye to discover it and apply its meaning to the whole composition.

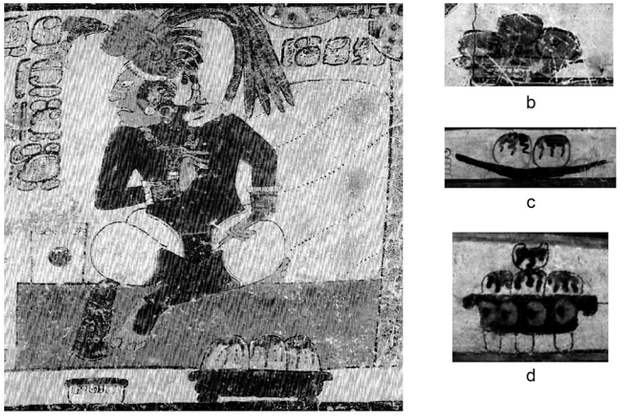
1. The nomenclature employed for the paintings is based on the one created by Carrasco and Cordeiro (2012: 12).

In Figure 1, the text on top of the image is a tag describing the whole scene. The text says: **AJ wa-WAJ-ji**, *aj waaj*, 'he/she of the maize bread', where we can appreciate the logogram **WAJ**, 'maize bread'. Yet we might also see the same logogram, duplicated, on top of the huge basket placed close to the woman offering food to the male character in front of her. In this case, the logogram is there to indicate the contents of the basket, and the produce the woman is offering, maize bread.

But the logogram is not the actual representation of the maize bread, as we have various examples from the Classic Period (McNeil 2010: 304; Rents-Budet 1994: 120) showing what they might have actually looked like (*figure 2*).

Figure 2

Examples of depictions of maize bread. a) K1599[2]; b) K5353; c) K6059; d) K6418.



So we can be sure that in the example from Calakmul (*figure 1*), the logogram unambiguously shows the word waaj to indicate the products offered by the woman, using the logogram for the word that names them.

There are some other examples of the use of writing in iconography, which will not be dealt with in this work. In particular, those where an object is not partially, or completely substituted by a group of writing signs, but shows the presence of glyphs on it. These include the representation of elements that usually have writing on them, and might have been depicted simply as they were, such as, thrones, ceramic vases, architectural elements, codices, or clothing. These elements are generally represented containing pseudo-glyphs, instead of indicating the actual writing painted or engraved on them, probably due to a matter of scale (Valencia 2010).

We can see one example of this use of writing in iconography in Figure 2.a, where a vase with a large red dot is represented on top of the bench where the main character is seated, which contains painted glyphs on

2. All the references of the ceramic vases are given with the numbers assigned by Justin Kerr in his catalogues.

its rim. In the same figure, we have another example on the vase represented to the side of the plate with the maize bread, which also contains glyphs on its rim.

In other cases, logograms are not used as writing but to signal the material something is made out of. This use includes the logogram for designating shining things to indicate something that reflects light or that is made out of jade; the logogram **TE**', 'tree, wood', to mark things made out of wood; and the logogram **TUN**, 'stone', used to designate things made out of this material. The logograms used in this way were called "property qualifiers" by Stone and Zender (2011: 13), and are not the subject of this paper either.

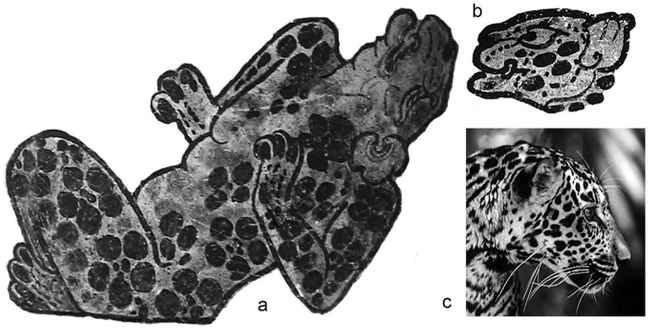
Writing and image in Mayan art

The principal characteristic that allowed the use of Mayan writing as adornment is its similarity with conventionalized iconic forms of the objects being named (*figure 3.c*) by logograms, syllabograms or a combination of both. Stone and Zender (2011: 11) indicate that Mayan hieroglyphs have an evident pictorial origin to mark this property of Mayan writing, where many of its signs show a high degree of iconicity.

For example, the logogram for the word 'jaguar', **BALAM**, is represented by the use of the head of this animal (*figure 3.b*), which is always similar to the representations of the head of the same feline in scenes where the whole body of the animal is depicted (*figure 3.a*). It is also known that full figure glyphs were used in Mayan writing, which would imply the possibility of using, not only the head, but the whole animal as the image associated with the logogram for **BALAM** in texts.

Figure 3

Use of the image of a jaguar in Mayan art and writing. a) Full body in iconography (K791); b) Head as a logogram (PC.M.LC.p2.70[3]); c) Head of the actual animal (Getty Images).



3. The codes starting in PC, are images from the Dumbarton Oaks Libray and Collections, Washington, DC.

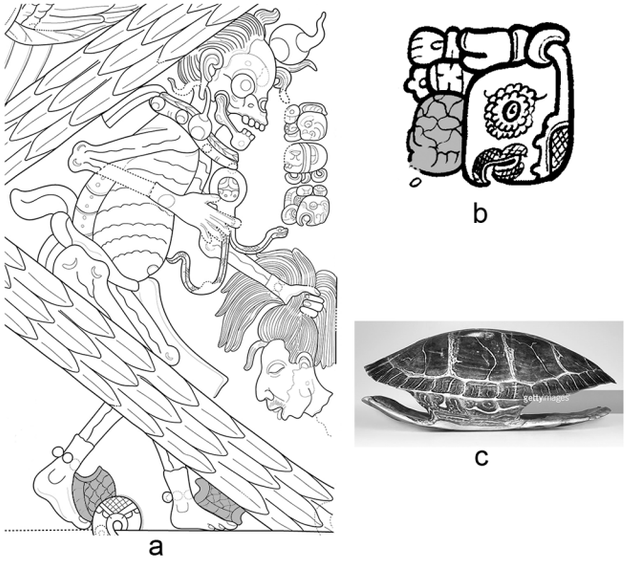
One is writing (*figure 3.b*), but the other is the conventionalized image for the animal being named (*figure 3.a*), and their similarity permits their interchange. This level of iconicity shared by both elements, logogram and image, would have permitted the substitution of the referential object being represented by both (*figure 3.c*).

Put another way, writing elements use the image of familiar objects pertaining to Mayan culture, and this permits interplay between word and image that was exploited by the Mayan scribes in certain conditions, which we will explore further in this paper.

In Figure 4, we have an example of this playful way of illustrating things. One of the characters in the 'Four Eras' stucco mural from Toniná is named Ahk Ok Chamiiy, written **a-OK-CHAM-ya** on the text tag close to its head. We can translate this name as 'Death with turtle feet'.

Figure 4

Use of the logogram **AK** (shaded gray) in writing and iconography. a) Tonina 'Four Eras' Stucco Mural (drawing by Daniel Salazar); b) The **AK** logogram in the name K'ihnich Ahkal Mo' Nahb, bench from Temple XIX, Palenque (drawing by David Stuart); c) Turtle's carapace, for comparison (Getty images).



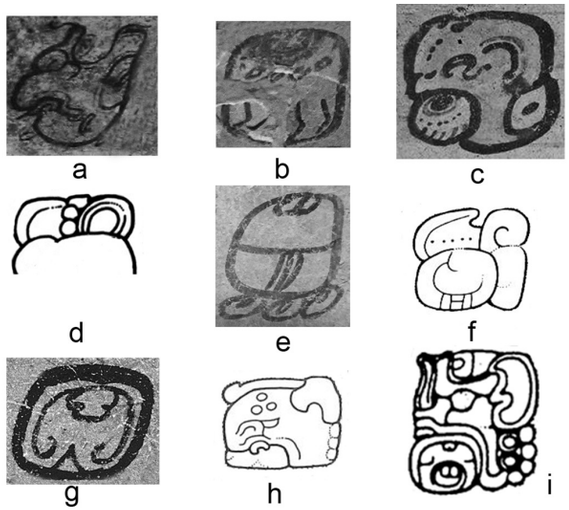
Even though the name of the character is written phonetically on the name tag, we can see that in order to signal the special characteristic on this being, the Mayan artist added the logogram **AK**, *ahk*, 'turtle' (Zender 2005), to each of its feet, to produce the embedded text *ahk ok*, as foot is written *ok* in Classic Maya (*figure 4a*). We can compare the logogram on the foot of the death god with the one used to write the name of one of the lords of Palenque (*figure 4b*), K'ihnich Ahkal Mo' Nahb, on Temple XIX's bench (Stuart 2005), and we can see that they are the same (both shaded gray in *figure 4a* and *4b*).

There might be some argument about the nature of the use of these logograms, claiming that they are being used semantically and not phonetically. It is true that there exist some examples of this semantic use of logograms. Take for example the creation of new logograms, using other logograms. In this case, an object was added to a previously created logogram, or two or more were combined, in order to create a new one. But in the process, the logograms used lose their sound equivalence, and they are only used semantically. Stuart (1995: 39) called these forms, 'representational logograms'.

In Figure 5 we can see some examples of this type of semantic behavior of the logograms.

Figure 5

Examples of representational logograms. a) **TI',** 'mouth' (K1440); b) **HA',** 'water' (Dzibilnocac Capstone 5, photograph Rogelio Valencia); c) **UK'**, 'to drink' (PC.M.LC.p2.147); d) **TI'**, 'mouth' (Copan Stela I, drawing Linda Schele); e) **WAJ**, 'maize bread' (Dzibilnocac Capstone 5, photograph Rogelio Valencia); f) **WE'**, 'to eat' (Yaxchilán Stela 35, Drawing Ian Graham); g) **WINIK**, 'man' (PC.M.LC.p2.70); h) **KOJ**, 'cougar' (Piedras Negras Stela 8, drawing Ian Graham); i) Vampire (Tikal Stela 5 Jones and Satterthwaite 1982: *figure 6-7*).



In the first example (*figure 5a-c*) we see the combination of the logograms **TI'**, 'mouth' and **HA'**, 'water', where the second is put into the mouth, represented by the first, to indicate the act of drinking, which produces the logogram for the word **UK'**, 'to drink'. In the second example (*figure 5d-f*) we see a very similar construction. Here again the scribe put the logogram **WAJ**, 'maize bread' inside the mouth represented by the logogram **TI'**, 'mouth', where it expresses the action of eating, to create the logogram **WE'**, 'to eat'. In the third example (*figure 5g-i*) we see the same idea at work, but in this case the logogram **WINIK**, 'man', is put into the mouth of two animals, a cat, to produce the logogram **KOJ**, 'cougar'[4], which is a very aggressive feline, and a bat, to express the idea of a man-eating chiropteran. As we can see from all the examples, the location of a logogram inside the mouth provides the idea of eating or drinking, and permits actions or things related to this idea to be named.

4. Cougars are aggressive animals to humans (Beier 1991), while jaguars and other felines from Mesoamerica tolerate more human activity around their living zones.

Another example of the semantic use of logograms is the paired realization of the verb *tz'ak* in some inscriptions coming from Palenque (Knowlton 2002: 11-13; Riese 1984: 263-286; Stuart 2003). Tz'ak means 'to complete', and the Palenque realizations of this verb used combinations of logograms that were cultural complementary binaries, which together gave the idea of something complete, like *ek'-uh* (star-moon), *xib-ixik* (male-female), *waaj-ha'* (maize bread-water), *muyal-ha'al* (cloud-rain), *yax-k'an* (green-yellow), etc. Again, in these examples, the logograms are not used for their sound values, but for their meanings, to generate a new logogram.

Nevertheless, in the examples we are analyzing in this work, where the logograms are written along with the iconography, the main use of the logogram is phonetic, not semantic, as the phonetic realizations accompanying them clearly show.

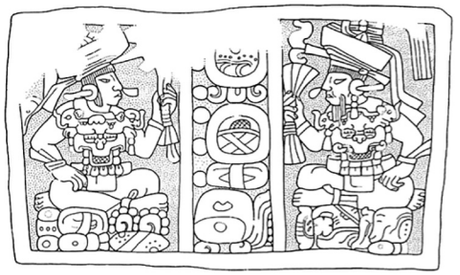
Adorning with writing

From a use centered on the description of material things, the Mayan artist soon realized that this iconographic artifact was much more useful when applied to abstract concepts and objects which were more difficult to illustrate graphically. This enabled the Mayan artists to start using tags to name abstract elements, such as rulers, gods, toponyms associated to locations, and abstract concepts (like measures for things or quantities), directly alongside the iconographic components or embedded in them.

One example of this idea could be appreciated on some of Copan's Altars, such as Altars L and Q, where the names of the various Copan lords depicted on them are transformed into the cushions they are sitting on (*figure 6*).

Figure 6

Examples of writing signs represented as cushions naming the lords sitting on them. Copan Altar L (drawing Barbara Fash).



In this example, we can see the cushions uttering the names **u-ki-ti to-TOK'**, Ukit Tok', and **YAX-PAS yo-AT-ti**, Yax Pas[aj Chan] Yo[p] aat, the two lords of Copan the monument is dedicated to. The names are shaped into the seats of the lords and they express their names using both, logograms, and syllabograms.

Another way the names of rulers or other characters were included in the image depicting them was to place the hieroglyphs on their headdresses (Zender 2014). This practice was extremely common, and was used not only to designate rulers, but also to name supernatural characters, such as God L or the one depicted on Figure 7.

Figure 7

Wak Chan? Winik. a) K3801; b) Unknown provenance Vase (Emmerich 1984: ***Figure*** 43).

a b

In Figure 7 we can appreciate the depiction of a deity whose name has been included as part of his headdress and his face. We see two logograms, one that seems to be T617, and the logogram **WINIK** over his head, while the number six (*wak* in Classic Maya) is on his cheek in the form of a dot and a bar. The variant of T617 presents some unusual features, which might imply that this might be a simplified form of the logogram **CHAN**, as it also appears on Sky bands. It is also relevant to say that T617 never appears associated with a number, but numbered skies are part of Mayan cosmology and this deity might belong to the one with the number six assigned to it (Boot 2008, pp. 23-24, note 6; Schaefer 2012; Nielsen and Sellner Reunert 2015). So the name of this deity might be Wak Chan? Winik.

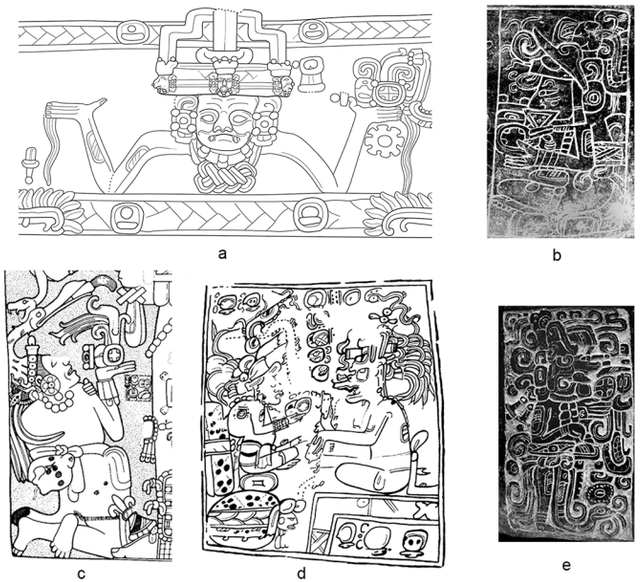
This interpretation agrees with the comments of Houston and Stuart (1998, pp. 83-85) about the fact that in Mayan art, the head (and the face) function as individual signifiers that contain emblematic devices that allude to personal identities. Moreover, Kelley (1982) has correctly observed this is a pan-Mesoamerican tradition with possible roots in Olmec art, as we see this same iconographic artifact in some monumental stone heads (for a detailed discussion see Houston 2004, pp. 295-296).

Yet naming characters was not the only purpose of the use of writing as adornment. In Figure 7a, Wak Chan? Winik is carrying something in his hand. What looks like an object, is in fact a group of hieroglyphs. This same group of glyphs is usually shown in iconography in the hands not only of supernatural beings, but also humans (*figure 8*).

In this case, the glyphs do not express the name of the character, as we can clearly see that they are not being held by the same personage, so it should name something that is related to them all. The glyphs could be read as *wuk ik' k'an*, 'seven black yellow'. In order to understand what this tag

Figure 8

Wuk ik' k'an. a) Placeres frieze (drawing Daniel Salazar); b) Wak Chan? Winik (K3801); c) Machaquilá Stela 2 (drawing Ian Graham); d) Capstone UPenn Museum (drawing Simon Martin); e) K'awiil (K3801)



a b c d e

means, we will refer first to another diphrasistic kenning that is similar to this one, *wuk yax k'an*, 'seven green yellow'.

The diphrasistic kenning *yax-k'an* has the meaning of abundance and wealth (Hull 2012: 100-103), as could be verified by the references to this term included in Colonial dictionaries. Fray Thomas de Coto (1983) incorporates various entries for these two terms coupled in his Cakchikel dictionary, such as: 'Para significar prosperidad usan de este nombre *q'anal y raxal*' (1983: 29), *'Ah q'an ah rax*, estos nombres significan abundancia de bienes y riquezas, y que no falte cosa alguna, con abundancia de gusto y contento' (ibid. 67), *'q'anal raxal*, bienes de fortuna' (ibid. 68). As has been noted by Stuart (2005: 100) in reference to the combination of *yax-k'an* that appears as one of the options for the logogram *TZ'AK*, this diphrasistic kenning is related to the whole cycle of the plant's growth, stating the dichotomy between ripe and unripe.

If we now turn to the difrasistic kenning *ik'-k'an*, we might infer that some similar idea relates these two terms. In Coto's dictionary we will find this entry associated with the term *q'ek*: 'ponerse alguna cosa negra dicen. Y esto es el cacao cuando lo asolean, o los plátanos que ponen a secar al sol, las vainillas, etc.' Coto (1983: 368). And regarding the term *q'an*: 'Usan también (esta palabra), por ponerse amarillas las frutas duraznos, peras, y de toda fruta que madura y sazona, aunque no tenga el color amarillo' (1983: 368).

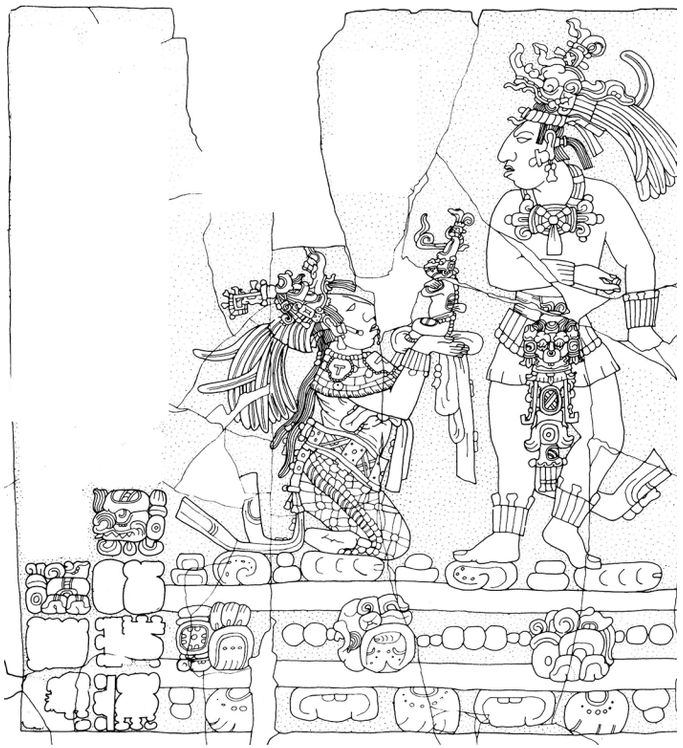
So both colours are equivalent terms for expressing the idea that some fruit is ripe, but in the case of the logogram **IK'**, this idea is related to fruits that turn black when they are ripe and ready to be consumed. Among these types of fruits we find one of the most important plants for the Maya, the cacao. Therefore, the combination of both terms in a diphrasistic keening helps to express the idea of a ripe fruit, and it might probably reflect the same connotation of highly valuable that the term *yax-k'an* has, as it

relates directly to cacao (Valencia 2016: 121-122). This implies the use of a synonymic diphrasistic kenning (Craveri and Valencia 27-33), instead of the usual antagonistic, or binary one. This also indicates that the whole plant's ripening cycle is represented by three colours instead of only two, green, yellow and black.[5]

The last case we will present of the use of writing as adornment is the one where the glyphs integrated into the iconography help to identify the location where the action is taking place. In Figure 9, we can see the inscription from Temple XIV at Palenque. It depicts K'ihnich K'an B'ahlam dancing in a place that shows an aquatic iconographic complex, as we can see water logograms, shells, ripples of water, and the logograms that are related to aquatic plants (Kettunen y Helmke 2013, p. 28). Along with these images and logograms, some other glyphs have been included to clarify the precise location where the action is taking place.

Figure 9

anthroponyms, place-names, pictorial assimilation, functional locus, embedded texts (drawing Linda Schele).



To the left of the image, we have maintained the part of the text that indicates the location of the action. There we can read *uhti Sak ... nal,*

5. We would like to thank Davide Domenici for this suggestion.

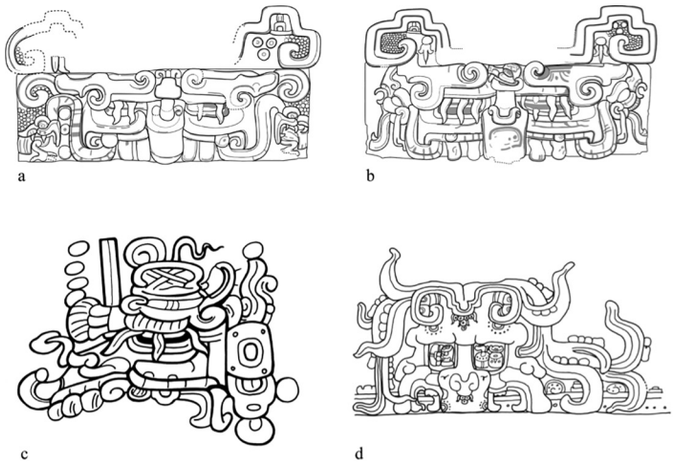
"at Sak ...nal". We can see that the glyphic compound that names the place is also included in the iconography, under the feet of the Mayan lord. But directly below the female character, there is also another group of glyphs in the iconography, used by the artist to indicate the exact place where the scene is unfolding. These glyphs could be read as **TI' K'AK' NAB**, *ti' k'ahk' nahb*, 'at the sea shore'[6], that specify which watery space is illustrated in the image.

In the same way, another example of toponyms embedded in the iconography occurs in a vase presented by Erik Boot (2008, Figure 1), which is painted in a style closely related to the Codex Style from the northern area of Petén (Guatemala) and the southern portion of Campeche (Mexico). In the image, the avian aspect of God D (Itzamn Nah Yax Kokaj Mut) stands over an enlarged bird head. According to Boot (2008, pp. 23-25) this bird's head is a glyphic representation of 6-SKY or **6-CHAN**, *wak chan*.[7] This glyph is integrated into the image as an iconographic component, and functions together with the many sky bands in the scene to designate the specific location in which the characters are.

The use of toponyms embedded in the representation of places is common in witz masks, which depict mountain locations. Figure 10 shows glyphs integrated into the zoomorphic face or in the head of a mountain. The most common place to put a toponym is the forehead (*figure 10a, b*); but

Figure 10

Glyphic compounds in *witz* masks. a) *witz* mask 2 from Balamkú frieze; b) *witz* mask 3 from Balamkú frieze; c) *witz* from Tomb 2 murals, Río Azul; c) witz from Temple of the Foliated Cross' tablet, Palenque. a, b and c: Drawings by Daniel Salazar; d: drawing by Linda Schele.



6. Kettunen and Helmke (2013, pp. 28-29; Figure 10) suggest that in this case the TI' sign works as the locative particle *ti*, "in". We consider that in this case, the logogram **TI'** uses its primary meaning, which is "mouth, edge, brink, border, rim", clearly indicating that the place where the action is taking place is the sea shore, the border of the sea.

7. Boot (2008, pp. 23-25) mentions that the bird's head is a substitute for T561 CHAN, "sky", in the hieroglyphic texts. In the eye of the bird is a small ax; this element is a diagnostic component in the head variant of number six.

other usual places are the top of the head (*figure 10c*) or inside the eyes (*figure 10d*). Together, glyphs and mask form a graphic representation of specific places with all their characteristics included, even their names.

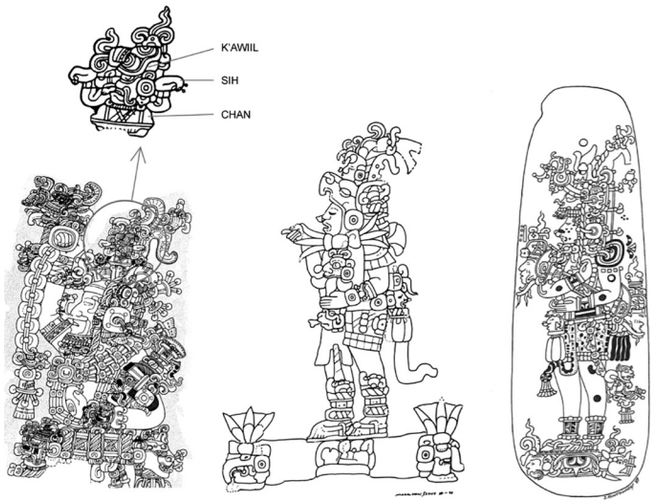
The *functional locus*

Even though the embedded text could be located anywhere inside the image, it was usually put in some very specific locations related to the main characters in the illustration. As we have seen in the previous examples, mountain masks employ three possible places to locate their toponymic glyphic compounds. Those locations became recurrent in the composition of imagery and made it easier for the knowledgeable viewer to look at the right place to search for textual information.

Another possible place to locate glyphs inside an image was the head of the characters represented in it, such as the example we have already seen of the deity Wak Chan? Winik, where his personal name is embedded in his headdress (in this case complemented with facial features). One of the clearest examples of this praxis comes from Tikal. Stela 31 (*figure 11.a*) represents the ruler Sihyaj Chan K'awiil with an elaborate headdress, which includes a glyph compound in the center. That set of hieroglyphs refers to his name in a perfect pictorial assimilation with the iconography around it.

Figure 11

Examples of functional locus. a) Detail of Stela 31, Tikal; b) Detail from the San Diego relief; c) Unprovenanced jade ax. a, c: drawings by J. Montgomery; b: Drawing by M. van Stone.



We have also seen that human characters appear with glyphic compounds in their hands, or examples where the text is embedded in the place they are located, such as the cushions the two Copán lords are comfortably seated on, or cases where the ruler stands over place names in some stelae, carving reliefs and jade axes. In Figures 11.b and 11.c, we see a reference to a toponym identified by another diphrasistic kenning, *chan-ch'e'n*, 'town, city' (Hull 2012: 105-107).

We call *functional locus*, the specific locations where the writing is put in relation to the rest of the elements in an iconographic composition. Salazar Lama (2014, p. 86) defines *functional locus*, as the zone in the image where some iconographic motifs (or in this case script elements) are located recurrently. Over time, this specific place in the composition presents an attached particular meaning and the motifs occupying that specific locus participate at the same functional level. Such is the case of the mountain's brow and occasionally the zone under the ruler's feet in the jade axes, or stelae, where both operate as a *functional locus* dedicated to toponyms, or the glyphic compounds shown in the hands of characters, where they function as offerings.

Theoretical approaches

Recently Werness-Rude & Spencer (2015, p. 56) have suggested that during the Classic Mayan period, image and writing had the potential to develop semantic complementation. In the examples already mentioned of script elements embedded in the images, we have tried to expose how this complementarity works to configure a complex system of visual communication. We think that in such a system the hieroglyphs specify and define what images could not display.

Taking this basic idea as a starting point, we propose that the function of text elements embedded in images is to promote and facilitate their denotative level. In this way, we follow Barthes (1986), Carrere & Saborit (2000, pp. 121-123) and Goodman (2010, pp. 19.21), and relate the denotative level with the recognition and correct detection of scene components.

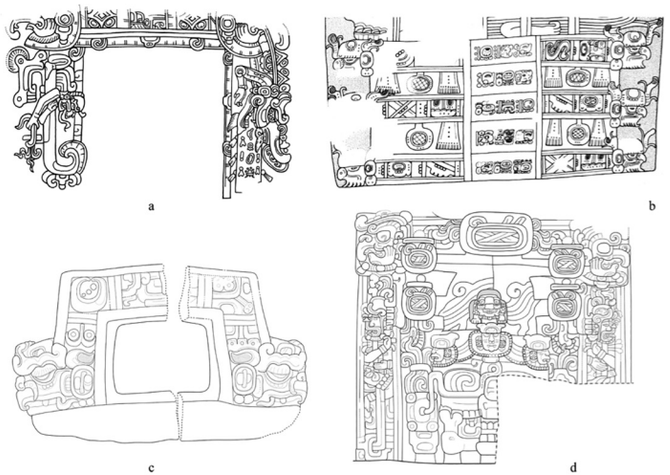
This interpretation of the function of embedded text elements makes sense when we consider that in Mayan art, the concept of portrait does not exist as it does in the traditional occidental way. In Stela 31 from Tikal (*figure 11a*) for example, the ruler Sihyaj Chan K'awiil has a standardized and schematic appearance shared with many other elite characters in early Mayan art examples, with no facial or corporal features that allude to personal identity. The only mechanism the viewer has to recognize the ruler is to look at his headdress and search for his anthroponym. The same idea operates in the other examples mentioned. In many cases the witz

masks represent generic mountain locations, but only by using associated toponyms do the images become clear and represent particular places.

In the monumental public art across the whole Mayan area, embedded script elements were common. In the so called "sky bands" (full of celestial motifs), for example, we have found two kinds of bird's heads attached to the corners or in both extremes of a horizontal strip (*figure 12.a, b, c*), which we believe is another kind of *functional locus* recurring throughout the classical period. As we have proposed Valencia & Salazar Lama in press), these bird's heads function as logograms and, can be read as **CHAN**, "sky". One of the birds was illustrated with the jaw in the shape of a hand, and was in use during the early classical period, and a second one presented a mirror on its forehead, and was in use during the Late and Terminal Classic. Here, the function of the bird's heads (together with the celestial symbols) is to show that the iconographic motif is the sky, reinforcing the nature of the space location.

Figure 12

Examples of bird's heads attached to the ends of sky bands. a) Detail from the Margarita stucco relief; b) Detail from Stela 32, Naranjo; c) Sculpture from Moral-Reforma; d) Mask from Bayal building, Xultún. a, c y d: Drawings by Daniel Salazar; b: Drawing by Linda Schele.



This function can be corroborated in the stucco reliefs from the Bayal building at Xultún (*figure 12.d*). In this example, the horizontal sky band is hidden behind the tree branches. The **CHAN** bird is the only part of the sky band that is still visible, and the viewer can recognize with certainty that the scene is taking place in a celestial location, being represented by the bird's head logogram occupying a particular *functional locus*.

The examples we have presented so far show that Mayan art is a highly denoted communication system. Carrera & Saborit (2000, pp. 79-81) designate these kinds of systems as hard coded ("código duro"). In such systems, the content and the values expressed are precisely segmented and the relationship between their components is stable. The result is a greater certainty in the communication process and the absence of polysemy or multiple interpretations.

Text and image integration through Mesoamerica

The idea of including text along with images was not only used by the Mayan artists, as it was a very common practice throughout Mesoamerica, because they were confronted with the same problematic, that of clearly indicating named elements in a composition, that could not be identified using their figurative characteristics exclusively.

Take for example the way Quetzaltehueyac and Icxicoatl are represented in the document 'Historia Tolteca-Chichimeca' (*figure 13*). In some scenes, one of these two characters is depicted with a long feather coming out of his mouth, and the other with one of his feet turned into a serpent. Yet they are also shown with their respective name glyphic compounds attached to their head, and these two ways of denotation are mutually exclusive, as they are not used at the same time.

Figure 13

Quetzaltehueyac and Icxicoatl in the document Historia Tolteca-Chichimeca. a) folio 7v; b) folio 16r; c) folio 2r. (all images from Kirchhoff et al. 1989).

In this case, the scribe makes a very clear distinction between name tagging, through the use of the glyphic compounds attached to the head of the character, and the writing embedded in the iconography, where the glyph for *coatl* is attached to the foot of Icxicoatl, exactly as in the Mayan case for Ahk Ok Chamiiy in Tonina.

It is clear from these examples that the scribe uses these two possible ways for name-tagging interchangeably, as Icxicoatl is not always represented with the snake replacing his foot, but with a normal human one and the glyphic compound attached to his head. The same happens to Quetzaltehueyac, where the associated glyphic compound is a human head with a quetzal feather coming out of his mouth, however, he is always represented in this way. With him, the scribe never opted to use the glyphic compound along with the illustration, as they are too similar and both are located on the same *functional locus*, the head.

One interesting detail about the two characters is that their human representations are exactly alike, meaning that we cannot distinguish one from the other, except for the glyphic compound attached to their heads, or because logograms have been attached to their images. This means that the resource of embedding text in an image is used exactly for the same purposes the Maya use it, for name tagging.

A special case of the fusion between text and image are the emblem-like names employed in Teotihuacan art (Domenici 2016; Taube 2002, pp. 350), or its Mayan counterparts, such as the Rosalila and Margarita stucco reliefs (*figure 14*); or the recently analyzed examples from ceramic vases K1152 and K1647 (Stuart 2013).

We consider an emblem-like name as an image that represents an anthroponym graphically, which in many cases serves as an identification icon. In Classic Mayan imagery this is a non-common device.

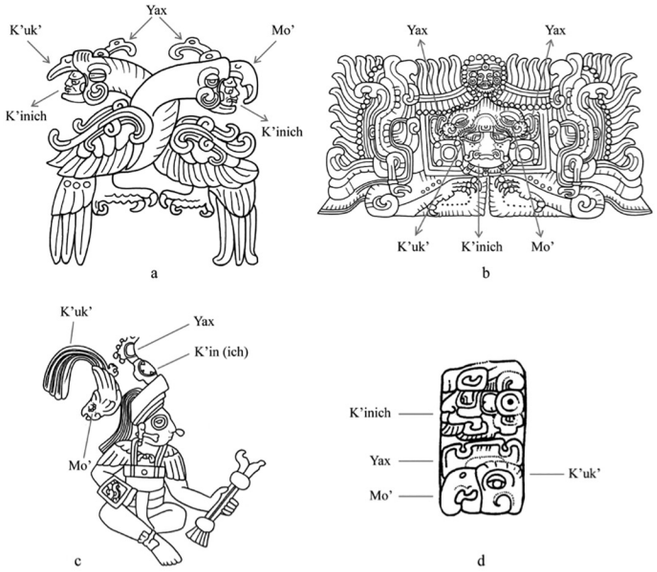
In the Copan Acropolis we find two paradigmatic examples that illustrate this concept perfectly: The Margarita and Rosalila stucco reliefs (*figure 14.a, b*). Both images are configured from different elements that together make up the name of the dynastic founder, K'inich Yax K'uk Mo' (Brave/Fiery/Hot Green Quetzal Macaw) in a graphic manner (Stuart 2004).

In these two examples the logogram **YAX** and logographic references to a macaw (*mo'*) and a quetzal (*k'uk'*), merge with the K'inich (solar deity) face to configure the name of the ruler. In the Margarita relief, the macaw and the quetzal are shown in full body version, with the sun god inside their mouths and the **YAX** over the head; in contrast, in the Rosalila example, both birds are shown only with diagnostic iconographic features (in a pars pro toto principle) fused in the headdress worn by the sun god,

8. According to the example of the ruler's name from the Motmot Marker (*figure 13d*), it is possible that the frontal section in the headdress in the Rosalila relief (now lost), was originally a macaw´s (*Mo´*) beak.

Figure 14

Copan's emblem-like name examples. a) Margarita stucco relief (detail); b) Rosalila stucco Relief (west wall); c) K'inich Yax K'uk' Mo' in Altar Q; d) The name of the ruler in Motmot Marker. Illustrations: a, b: Daniel Salazar; c: Linda Schele; d: Barbara Fash.



with **YAX** elements flanking it.[8] Some similarly fused elements are present on the headdress of K'inich Yax K'uk Mo' on Altar Q (*figure 14.c*) and forming his name in the text of the Motmot ballgame marker (*figure 14.d*).

As Nielsen (2003, pp. 227-229) has proposed, the reading order of the elements in the king's emblem-like names is far from explicit, and the images are basically iconographic in nature. However, we consider that these images make no sense as scenes, but acquire a full meaning when seen as graphic emblematic representations of Copan's first king's anthroponym.

Nielsen also suggests that the size of these emblematic devices – occupying great portions of the building's facades – is rare in Mayan art, and mentions that the way in which the two birds cross their necks is also extremely uncommon in Mayan art. Nielsen notes (2003, p. 228) that similar entwined feathered serpents appear in the Teotihuacan-style vessels in the Tikal's Problematic Deposit 50, and two twisted birds occur in the so-called "Maguey Blodletting Mural" from Teotihuacan, probably referring to names or titles in an emblematic writing system as well.

With this evidence, we agree with Taube when he suggests that Margarita, and by extension the Rosalila reliefs as well, are an "intentional allusion to Teotihuacan style mural texts" (Taube 2000, p. 29), as recent research indicates (Domenici 2016) the Teotihuacan writing system gave a high priority to these emblematic forms of writing names, alongside other forms of writing more similar to the Mayan one (Taube 2000, 2011).

Two more examples of emblem-like names come from two so-called Codex Style vessels (*figure 15.a, b*), and in both cases they seem to be related to Yukno'm Yich'aak K'ahk', ruler of Calakmul from 686 to 697 CE. Stuart (2013) has convincingly shown that the main figure in these two vessels is a compound showing jaguar paws and fire scrolling elements. The two

Figure 15.

Examples of emblem-like glyphic compounds with the name of Yukno'm Yich'aak K'ahk. a) Rollout of K1552; b) Rollout of 1647; c) Name variations of the Calakmul ruler Yukno'm Yich'aak K'ahk'. Drawing by Simon Martin, taken from Stuart (2013, ***Figure*** 3).

a

b

c

elements mentioned simply spell **ICH'AAK** (jaguar paw) and **K'AHK'** (fire), for Yich'aak K'ahk' (Claw of Fire), as we see in the name variants of this same king (*figure 14c*). Again, the whole compound in these vessels is presented in a pseudo-Teotihuacan style.

Final remarks

The evidence presented so far might give us the impression that iconography can be read, because it usually embeds texts in the images. But this is a misleading assumption, because the Mesoamerican artists only employed this resource in certain specific circumstances.

For Mesoamerican cultures, the separation of these two systems for encoding information seems a bit thin in some cases, with the clear exception of the Maya, but we should realize that our better understanding of their writing system sets them apart.

Especially problematic is the Teotihuacan case, where the emblem system for expressing names is completely figurative, yet we might also keep in mind that the Mayan writing system might become emblematic when full figure glyphs are employed for writing, or when the Mayan artist wanted to emulate the way in which a Teotihuacan artist would have written a name.

Figure 16.

Examples of images created with alphabetic characters. a) British Library, Harley 647, f. 9r; b) British Library, Add. 21160-31, f. 181v.

a

b

The assumption that iconography could be read is misguided, as we see from our own writing experience. Text and image had a clear separation in ancient Mesoamerican cultures, the same as they do in our own culture. Moreover, in alphabetic cultural traditions there have been some attempts to intermix text and image, as can be seen in the examples in Figure 16.

In Figure 16.a we have an example of a ninth century copy of a text written by Cicero called Aratea, a work of astronomy (British Library, Harley 647, f. 9r). The text includes a depiction of various constellations that are described by Cicero, but the images depicting the constellations are made out of written words, coming from another text written by Hyginus, called the Astronomica. The hare shown in the illustration is the depiction of Orion, because it shows the animal preferred as a prize by the hunter.

In Figure 16.b we have an image from f. 181v, from the British Library, Add. 21160-31, which includes some Torah documents[9]. Dating from the second half of 13th century, this document from Germany, written in Hebrew and Aramaic, uses letters from the Hebrew alphabet to form the silhouette of a rider and his horse. As we can see from these examples, the possible misunderstanding between text and image is not possible as the iconic distance between them is very large and we are used to differentiating them, as we still have some cultural contexts that let us do so.

In the case of the Mesoamerican cultures, we can affirm that the embedding of text only occurred in certain conditions and with a clear objective. So far, we have been able to determine that text embedding was only used to name things that were difficult to identify using iconographic means alone. The identification of particular people requires the presence of specific features that might narrow down the possible options to choose from. With regards to people, for example, the portraits of K'inich Hanab Pakal and Yukno'm Ch'e'n have been detected, among a few others, as examples where the Mayan artists tried to be realistic.

9. The documents included are: Pentateuch with Targum Onkelos (ff. 1-273), Haftarot (ff. 274-297v), and Five Scrolls (Hamesh megillot; ff. 298-318), Job ch. 1-31:2 (ff. 318v-329v), with masorah magna and parva (aka 'Yonah Pentateuch').

The ingenious use of the iconic value of writing by the Maya, helped them clarify the nature of some of the elements included in their iconography, but also helped them emphasize some particular meaning in cases where the element depicted could be misinterpreted or wrongfully analyzed. And they achieved all of this, whilst beautifully integrating the text into the images where they were supposed to be read.

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Bespoke Wayshowing in Hospitals

Per Mollerup

Wayfinding in hospitals causes problems for patients, visitors, and staff. Applying the principle of least effort on wayfinding points at a three-tier set of wayfinding styles with increasing mental workloads. These styles are walk-and-see, walk-and-read, and stop-and-study. While traditional wayshowing technologies facilitate the two first wayfinding styles, the third wayfinding style is best supported by individual wayfinding assistance, which is not given by traditional wayshowing technologies. This paper suggests addressing this problem by introducing bespoke wayshowing enabled by adaptive mass-customisation.

Keywords

hospitals
wayshowing
principle of least effort
interaction design
mass-customisation
touchpoints
information design

1

Wayfinding in hospitals

Wayfinding in hospitals can be a burden for already worried patients and visitors as well as for staff that on the top of their own wayfinding problems are frequently approached by other wayfinders who cannot find their destination. The wayfinding problems in hospitals result from three causes: the complexity of the built environment, the shortcomings of the hospitals' wayshowing (wayfinding assistance), and the users' limited wayfinding abilities. No matter what cause, wayfinding problems may stress already worried patients and visitors and make them feel less welcomed. Add to this, the cost of staff using their time for wayfinding and wayshowing rather than health service and the cost of staff and facilities waiting for patients late for appointments. These hidden costs have apparently never been calculated precisely, but they may be considerable (Michael McCarthy, 2004; Per Mollerup, 2009).

Hospital settings are often large, complex, and complicated. Large hospitals provide many kinds of specialised health care in many facilities not necessarily located in some immediately understandable pattern. Patients must sometimes navigate long distances along complicated routes between facilities. Additions of new buildings and repurposing of existing buildings often lead to further complication. New buildings may be squeezed in between old buildings rather than located in the most logical position. Repurposed buildings may be configured less than ideally seen from a wayfinding viewpoint. The ideal wayfinding process where wayfinders immediately and intuitively understand where to go is not common in hospital settings.

Many patients and visitors are novices in the hospital. This together with the scale of the hospital and the unfamiliar names of facilities may stress already stressed patients and visitors further. Some wayfinders, among them elderly citizens, may have reduced sensory, cognitive, and motor abilities. If patients and visitors (from now on interchangeably called 'wayfinders') have been in the same hospital before, something may have changed since their last visit.

In spite of the hospitals' efforts, the existing wayshowing far from prevent patients and visitors from losing their way. This paper presents an innovative way of improving wayshowing in hospitals. Together with airports, hospitals feature some of the most complicated and stressful wayfinding situations thinkable. If the proposal for bespoke wayshowing developed in this paper will work in hospitals, it may also work in other, less demanding, environments.

2

Indoor wayfinding

Indoor wayfinding differs from outdoor wayfinding in at least two respects. One is that indoor wayfinding often includes vertical transport, be it by stairs, escalators, or lifts. Another difference is that several wayfinding technologies, WFTs, favour outdoor wayfinding. WFTs include any device that helps wayfinders orientate (determine where they are), and navigate (find their way) in unknown territory, and confirm that they are on the right track.

In contrast to indoor areas, useful maps to a large extent complement outdoor areas. Also, a rising number of on-board GPS, Global Positioning System, devices guide drivers visually, and often also audibly, to their specified outdoor destination. Further, several types of wearable/portable digital devices with wayshowing potential assist pedestrians' and bikers' outdoor wayfinding visually, sometimes also audibly.

Indoor signage may be of varying quality, and maps, sited or wearable/portable, cannot be taken for granted. On-board GPS devices are off limits and wearable/portable digital devices are not necessarily applicable, save effective, indoors.

In other words, the state of indoor wayshowing in hospitals raises important questions: Is the hospital planned with sufficient consideration for effective wayfinding? Can improved environmental features ease the problem? Can WFTs enable smoother orientation and navigation? Here it should be noted that reduction of the problem (making the environment more readable) of course is as valuable as, or even more valuable than, improvement of the wayshowing (wayfinding assistance), making better WFTs.

3

Wayfinding with least effort

Before discussing in some detail the potential of indoor design and WFTs, we shall take a look at the principle of least effort and codify wayfinding styles accordingly.

The principle of least effort (George Kingley Zipf, 1949) suggests that whatever humans and animals do, they try to do along the path of least effort. Several authors have applied the principle of least effort to information seeking, e.g. in libraries. The principle of least effort, however, also applies to the use of all kinds of tools (Per Mollerup, 2015). When we buy a new drilling machine many of us immediately try to get it out of the package and running without bothering about any instruction. If necessary, we shall look

for the labels on the tool: on, off, forward, reverse etc. If the labels also fail to help us, we shall, as the source of last resort, look for the user instructions, hopefully written in a comprehensible language for the model at hand. The three tiers of information give rising mental burdens to the user:

Tier	Medium	Mental workload
1	object	x
2	labels	xx
3	user instructions	xxx

Wayfinders also intuitively seek their information with the least effort. If they can 'read' the environment directly and intuitively find their way they won't worry about reading signs or consulting maps. They will just proceed through the environment. If wayfinders do need to consult wayshowing signs they prefer signs that they can spot from a distance and read and understand while moving in the right direction. This approach is almost as good as reading the environment directly. Often, however, there are so many and so complicated signs that the wayfinder cannot read, sort, and interpret the signs while walking. In this case, the wayfinder must slow down to read and, possibly, turn to the means of last resort, in other words, stop and study available descriptions, probably a site map. The same is the case if there is no signage. Applied to wayfinding, the three-tier model looks like this:

Tier	Medium	Wayfinding style	Mental workload
1	environment	walk-and-see	x
2	signage	walk-and-read	xx
3	description	stop-and-study	xxx

Walk-and-see

When Pablo Picasso allegedly claimed je ne cherche pas, je trouve, I don't search, I find, he serendipitously also described our preferred wayfinding style when navigating unknown territory. We want to advance intuitively and directly to our destination. The environment should encourage and enable seamless wayfinding. We want to walk while watching and understanding. Some building genres enable this wayfinding style.

Walk-and-read

Unfortunately, buildings of a certain size don't necessarily follow a pattern well known to the wayfinder and they are not organised in an immediately recognisable or understandable way. However, directional signs and identification signs can sometimes make up for a building's lack of self-explanation and allow wayfinders to read and understand while walking.

Stop-and-study

The walk-and-read wayfinding style may be difficult or impossible to apply in large built environments with multitudes of possible destinations. There is simply not space for all possible directional signs, and if there is, the information provided may be difficult to filter for the wayfinder. To find their way wayfinders must stop and consult maps that provide an overview not given by directional signage.

The walk-and-see and the easier part of the walk-and-read wayfinding styles involve the kind of thinking, which Nobel Laureate Daniel Kahneman labels 'System 1':

> *System 1 operates automatically and quickly, with little or no effort and no sense of voluntary control.*
> (Daniel Kahneman, 2011, p20).

The stop-and-study wayfinding style and the less easy part of the walk-and-read wayfinding-style involves the kind of thinking, which Kahneman labels 'System 2':

> *System 2 allocates attention to the effortful mental activities that demand it, including complex computations. The operatings of System 2 are often associated with the subjective experience of agency, choice, and concentration.*
> (Daniel Kahneman, 2011, p20)

Maps and verbal descriptions may be declarative or procedural. Declarative descriptions explain the lay of the land (what), while procedural descriptions (instructions) explain how to find the way. Declarative descriptions intentionally result in sense making, while procedural descriptions intentionally result in rule following. Sense making is more cognitively demanding than rule following. A site map (survey map) involves declarative knowledge, while a route map involves procedural knowledge. Another difference between site maps and route maps is that site maps are allocentric: they are neutral, while route maps are egocentric: they see the area from one wayfinder's viewpoint. In principle, route maps demand less mental effort than survey maps

Of course, distressed wayfinders may stop and ask any person nearby for help, in a hospital typically the first white coat passing. This behaviour, however, falls outside our business: assisting wayfinders in getting around on their own. Interpersonal help is not part of our inquiry.

To make wayfinders' navigation as easy as possible building owners should learn from the principle of least effort and invest in self-explanatory environments, in signage, and in description in that order. When planning signage, the goal should be to make signage usable in a way that emulates intuitive reading of the environment: letting wayfinders walk-and-see.

4

Environmental wayfinding support

The environment constitutes the core of the wayfinder's problem. The environment's inherent wayshowing qualities assist the wayfinder by reducing the wayfinding problem. User centred wayshowing includes all the characteristics that support the strategies, which wayfinders intuitively apply when navigating unknown territory. These strategies include track following, route following, educated seeking, sequential inference, screening, aiming, map reading, compassing, and social navigation (Per Mollerup, 2005, 2013).

Track following involves getting the needed wayfinding information along the route while route following means using information given before start. Route following depends on the wayfinder's ability to remember, assisted or not by written notes. Educated seeking implies using knowledge learned in other situations. Sequential inference depends on reading logical sequences of numbers or letters. Screening means scrutinising an area in full or in part. Aiming involves moving in the direction of visible destinations. Compassing uses cardinal directions without (sometimes with) the use of a compass. Finally, social navigation implies learning from what other people do.

Use of each of these strategies may benefit from one or more environmental qualities, most important of which is accessibility. It is not enough to know the position of one's destination if it is inaccessible because of a bridge-less river barring it from the wayfinder. Accessibility is paramount to wheelchair-bound users and other wayfinders with motor disorders. Transparency is a close contender to the position as the most important wayshowing quality. An environment bereft of transparency offers only few visual cues and leaves the wayfinder to rely on aural, olfactory, and other non-visual cues.

Environments following normal patterns and logical numbering of buildings, floors, and rooms support wayfinders' use of experience from other situations. Systematic floor plans support many strategies and so do landmarks, visual anomalies such as buildings or building parts that stand out from their surroundings. Strangely, the two opposites, repetition and variation, used with moderation, both help wayfinders. Building names and other names involving cardinal directions support compassing.

Environmental qualities moderate the wayfinding problems. WFTs contribute to their solution.

5

Wayfinding technologies, WFTs

Patients' and visitors' successful wayfinding in hospitals is the hospitals' responsibility. Hospitals' wayshowing includes pre-visit information, static (non-interactive) wayshowing media, and interactive assistance at the hospital. Pre-visit information in appointment letters may describe both the way to and around in the hospital by site maps, route maps, or verbal route descriptions. Hospital websites may contain site maps. In the hospital, static media such as traditional signage, guidelines, and site maps may guide patients and visitors. Finally, digital kiosks, information desks, and voluntary guides, may provide interactive wayfinding assistance. Digital kiosks are computer terminals where wayfinders traditionally type a destination or chose it from a menu to get a route description, on- screen or printed.

Three pairs of contrasting properties characterise the wayfinding technologies used in the hospital setting:

Communal / personal wayshowing

The wayshowing media used in hospitals are as a rule communal: they address, in principle, all users. Directional signs are examples of communal wayshowing media. So are printed handout site maps. Communal wayshowing may appear economical to the hospital, but the information given may be difficult to filter for the individual user. The information relevant to the individual user is surrounded, perhaps eclipsed, by information only useful to other people.

Personal wayshowing, information addressing one person's wayfinding needs, serves the individual wayfinder better. A map showing the route from the main entrance to the urology department is an example of a personal wayshowing medium. Some kinds of personal wayshowing may involve prohibitive costs.

Wearable/portable / sited

wayshowing media

Wearable/portable devices, such as printed maps and PPDs, personal portable devices, have some advantages compared with sited wayshowing media such as wall mounted signs. Most important, wearable/portable devices are per definition always at hand. Also, wearable/portable devices are only visible to the user. One person using a PPD doesn't interfere with other people's wayfinding.

Disadvantages of PPDs to some degree outweigh the above advantages. These disadvantages concern the users' perceptive and cognitive workload. Users of PPDs must divide their attention between two places: the small wearable/portable device and the life-size surrounding environment. This shift in scale between the wearable/portable small thing and the environment may be especially stressful for wayfinders with less than perfect sight. Also, using the wearable/portable device demands mental energy. A wayfinder must turn a printed map manually or mentally when changing direction to align forward in the environment with forward on the map. PPDs make this manoeuvre redundant, but involve the keyhole problem: only a fraction of the needed information is shown at a time. The user must scroll or pan to see other parts of the total picture or zoom in and out to see a part or the total picture. These operations are time consuming and add to the mental burden. Wayfinders with mental or motor impairments may already invest some cognitive efforts in moving along and have less capacity for intricate wayfinding problems. Some wayfinders may use one hand for a walking stick, or both hands for crutches. Wheelchair users also have one or two hands occupied elsewhere.

Static / interactive wayshowing

Traditional wayshowing media work one-way, from sender to user, expecting no input from the latter. Traditional wayshowing media are static. Wall mounted signs, painted guidelines on the floor, and printed maps are examples of static wayshowing media. PPDs that tell the wayfinder in what direction to go and adjust the explanation as the wayfinder moves along, are interactive wayshowing devices, and so are digital kiosks. For the hospital, the choice between static and interactive wayshowing media is practical and economical.

Given the advantages of individual and interactive wayshowing and the drawbacks of wearable/portable devices, we would ideally prefer individual, interactive information given by sited devices: only-for-me big signs on the walls. Such devices would allow the walk-and-read wayfinding style. This solution would, however, only serve one person or several persons with the same start point and destination. Everyone bound for other destinations would not be assisted. The trick is to make the sign content a dependent variable that varies with the viewer and at the same time does not disturb other wayfinders. Information kiosks used in some hospitals and shopping centres meet these specifications.

The table below codifies WFTs according to the three pairs of contrasting qualities: communal/personal, static/interactive, and wearable/sited:

Wayfinding technologies typology		
	Wearable/portable	Sited
Communal	**Static:** Site maps (paper)	**Static:** Directional signs Marking signs
Individual	**Static:** Route maps (paper) **Interactive:** PPDs	**Interactive:** Kiosks

The weak point of existing wayshowing kiosks is that wayfinders to get a route description must specify their destination, e.g. Department of Gastroenterology and Clinical Nutrition, either by typing it or by choosing it from a menu with a large number of other destinations, some of them perhaps with similar names. This can be a time consuming and cognitively demanding task, especially to users who are not accustomed to typing and computing and to users who suffer from sensory, cognitive, or reading disorders. Also, this time-consuming characteristic reduces the kiosk's capacity. Several kiosks may be needed to reduce waiting time in crowded areas. Also, long waiting time and long processing time may both induce potential users to abandon the kiosk and approach the next passing white coat for wayfinding advice.

While the idea behind wayshowing kiosks is basically sound, identification of the wayfinder's destination is a weak point to be negotiated. Before dealing with this problem, we shall discuss the principle behind communal media that give bespoke assistance: mass-customisation.

6

Mass-customised wayshowing

'Mass-customisation' is a contraction of 'mass production' and 'customisation'. It stands for a happy marriage between mass-production's low unit

costs and adaption to individual needs and wants. The automotive industry has long since discarded Henry Ford's narrow view on car colours; they mass-customise to meet the wants of the individual buyers. Together with several other features including motor size, trimmings, and electronic equipment car manufacturers vary colour to give buyers their special car at mass production price. Mass-customisation is also applicable outside manufacturing, in the service sector for instance. Charter flight passengers finding their own accommodation at the destination combine cheap mass-transportation economy with individual lodging preferences.

James H. Gilmore and Joseph Pine II (1997) identified and named four distinct approaches to mass-customisation, each with its distinctive characteristics: collaborative, adaptive, cosmetic, and transparent mass-customisation. Collaborative customisation implies a dialogue to identify the offering that will satisfy the customer. Adaptive customisation means that the customers can themselves adjust the product to fulfil their needs. Cosmetic customisation deals with the presentation of the product. Finally, transparent customisation implies that the provider learns from the customer and adjusts the product without the customer knowing it.

Adaptive customisation suits our purpose:

Each customer independently derives his or her own value from the product because the company has designed multiple permutations into a standard, but customisable, offering. It is the product itself, rather than the provider, that interacts with customers.

(James Gilmore and Jospeh Pine II, 1997, p13)

In adaptively customised wayshowing, each wayfinder derives with minimal effort his or her individual route description from a digital kiosk designed for communal use. All registered users can use the kiosk to get an individual explanation. It is bespoke wayshowing.

7 Bespoke wayshowing

In bespoke wayshowing, kiosks, called touchpoints, present the preferable route from the touchpoint's position to any destination in the hospital to registered wayfinders. If relevant, the touchpoints can present special routes for wheelchair bound wayfinders.

Patients' destinations are as a rule determined by the hospital. When informing the patient about an appointment, the hospital also delivers a code, which, when presented to a touchpoint, calls the relevant route description from this touchpoint to the destination. All relevant hospital staff can assign a wayfinder with a new destination. The information triggered by the code includes the wayfinder's name, destination, and route.

Codes can be carried by NFC, Near Field Communication, tags in the shape of a patient card, or they can be QR codes printed on an appointment letter or a patient card. When a patient card with NFC code or QR code or an appointment letter with a QR code is presented to a touchpoint, the touchpoint will show the user's name, destination, and a route description. The route suggested may lead directly to the final destination, or - if the route to the final destination is long and/or complicated - to another touchpoint.

Iris, face, or fingerprint recognition could be part of a more advanced solution, where the touchpoint recognises the patient directly and pairs this information with information about patients' destination (and possible use of wheelchair). This would demand a previous registration of the patient's identifying features.

The bespoke wayshowing touchpoints are vertical, wall mounted (or free-standing) computer terminals, conspicuous enough to attract attention, large enough to present route descriptions in readable size, and small enough to provide some privacy. When not in use, the touchpoints announce their presence and availability with a default message, readable from a distance, such as: FIND YOUR WAY - PRESENT YOUR CODE HERE. The touchpoint should also be visible, when in use.

The touchpoints should be placed strategically, importantly at decision points, places where wayfinders must make a choice: continue, turn, or go to level x. Important decision points are typically entrances, lift banks, and crossing corridors. Generous deployment of touchpoints makes bespoke wayshowing forgiving. Wayfinders having lost their way can always get back on the right track at the nearest touchpoint. At important positions, more than one touchpoint should be available. Perhaps with adjustable height, touchpoints should be positioned with a view to walking as well as wheelchair bound wayfinders.

Bespoke wayshowing includes an element of ball parking: Bespoke wayshowing takes the wayfinder to the right destination area, e.g. the right ward. When being there the wayfinder must find the wanted room by watching identification signs. As wayfinding strategy, screening or sequential inference will replace track following and route following.

8 Route description

Route descriptions are critical to the success of bespoke wayshowing, and to the costs involved. Costs considered here include production of route descriptions and procurement and instalment of touchpoints. The main consideration is that the route descriptions should be readable, understandable, and memorisable. Simplicity resulting in clarity is the core quality.

The touchpoint computer terminal will clearly indicate if a suggested route takes the wayfinder directly to the intended final destination, or to a new touchpoint.

The route description given by the touchpoint will use one of two formats: map+text, or text+arrow. Production wise a screen picture showing a map+text costs more than a screen picture with text+arrow. This study will present some initial tests concerning the efficiency of map+text vs. text+arrow.

How many route elements a route description should comprise is the planner's judgement call. The length of the route descriptions influences the wayfinding challenge as well as the need for touchpoints:

- Short route descriptions - with relatively few elements - are easier to read and remember, but the wayfinder may need more touchpoint visits before reaching the destination because the total route is divided into more legs.
- Long route descriptions - with relatively many elements - are less easy to read and remember, but the user may need fewer touchpoint visits before reaching the destination because the total route is divided into fewer legs.

The length of route descriptions influence the bespoke wayshowing costs:

Short and long route descriptions compared			
Route description	Easy to follow	Visits needed	Hardware costs
Simple	very	many	high
Complex	less	few	low

All destinations and touchpoints as well as turning points must be visually identifiable from a distance, by appearance, e.g. stairs, or by clear identification signs, e.g. UROLOGY.

Route maps

Route maps should show the present position (YOU-ARE-HERE) and the destination or intermediate destination marked verbally or by a pictogram.

Maps should comply with the principles of structure matching and orientation (Marvin Levine, 1982). Map orientation should always be forward-up, meaning that the maps will always be aligned with the wayfinder's position: left on the map means left to the wayfinder studying the touchpoint. Other possible map orientation principles such as north-up, entrance-lowermost, and all-maps-same- orientation should give way to forward-up. This will free the wayfinder from struggling with mental rotation.

Route maps should be designed with great care seeking a fine balance between clarity and detail. Simplification of shapes, colour, and text should be weighed against usability. Most route maps will benefit from a short text that confirms the route.

The position of the touchpoint and the position and direction of the wayfinder while studying the touchpoint, the destination or intermediate destination, and the route with route markers should be marked. Route markers are visual elements along the route that contribute to make the route distinctive and memorisable. Route markers can be any visual element found along the route that is easily noticed and is narratable, easy to describe in text or in picture, and easy to identify in situ. Route markers can be hospital facilities or landmarks. Eligible hospital facilities have fairly easy designations, for instance CAFETERIA, PHARMACY, or LABORATORY.

Landmarks are visual anomalies, something that sticks out and is visible from a distance, and is narratable. A three-meter high teapot is a better landmark than a delicate oil painting of Asclepius, the god of medicine. The teapot sticks out, can be seen from a distance, and is easy to talk about, understand, and remember. The nature of landmarks and their importance in wayfinding are described by numerous researchers, notably K. F. Richter and S. Winter (2014).

On the map, hospital facilities should be represented by their name, while landmarks should be represented by simple, easily understandable, pictures: naturalistic, but simple, drawings. Understandability and memorability are the relevant criteria. Designers' idées fixes should never take control.

Verbal route descriptions

Verbal route descriptions should be short. The vocabulary should be basic. Hospitals with users with different languages may consider bespoke wayshowing with language options. The text should whenever possible be supported by an arrow that confirms the route.

While several researchers have investigated route maps, researchers seem to have ignored verbal route descriptions. Why? Because they are not 'design' solutions? What if pure text messages are as good as, or superior to, maps?

9

Route map vs. verbal route description

Which route description, map or verbal, is best for the user? Some wayfinders love maps, others hate maps. What is easiest for most people? We are not sure, but have done some testing. We have compared how efficiently people

follow a route in a university setting described by a route map and by a verbal route description.

Instead of mounting a great number of touchpoints and testing route maps vs verbal route descriptions in a hospital setting we, for practical reasons, tested the two modalities by using paperboards emulating screens in a university setting: Swinburne University of Technology, Melbourne.

Research design

In a between-subjects experimental design we asked different groups of people to find four targets in a specific order, 1) assisted by route maps, and 2) assisted by verbal route descriptions.

Participants

48 people, 24 aged 19-32 years and 24 aged 50-68 years were recruited outside Swinburne University of Technology and had no knowledge of the buildings concerned. They were all proficient in English. They were rewarded a coupon worth 40 Australian dollars equalling 30 US dollars redeemable in a local department store or supermarket chain. Had a participant left without completing the wayfinding task he/she would also get the reward.

Test site

The test site was a cluster of four interrelated buildings on the Hawthorn Campus of Swinburne University of Technology. The four selected buildings named TA, TB, TC, and TD are generally considered complicated to navigate. They provide space for class rooms, laboratories, and lounges. They have four levels connected by several staircases and lifts. Buildings TA/TD and TB/TC are pairwise directly connected on level 2 and level 3: You can walk directly from one building into the other. TA/ TB and TC/ TD are pairwise connected by bridges on level 2 and level 3. All suggested routes were restricted to and involved level 1, 2, and 3.

Materials

Route maps, verbal descriptions, and target markings were given on A4 portrait paper boards in size similar to a 14" monitor.

Map+text:

The route maps used by participants were designed with great simplicity. Only essential information was shown: Surrounding building parts, YOU-ARE-HERE symbol, route, destination, supporting text (see *figure 1*).

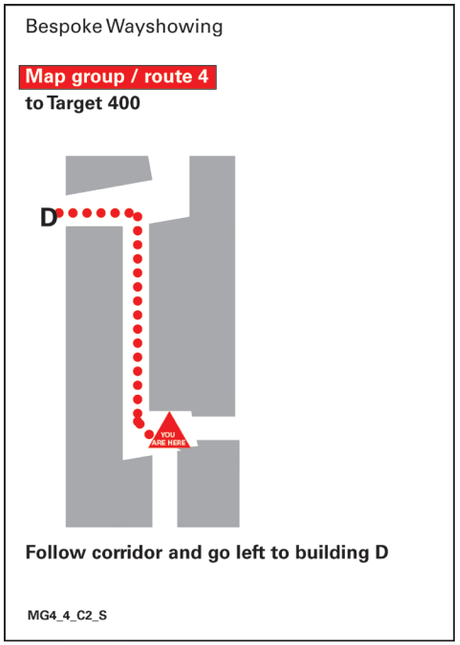

Figure 1

Map+text

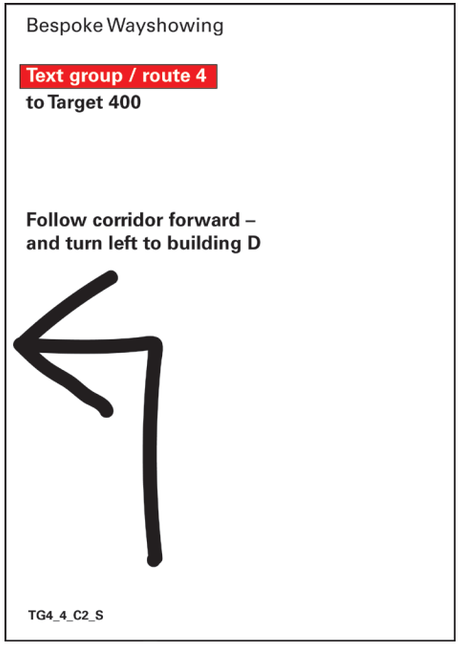

Figure 2

Text+arrow

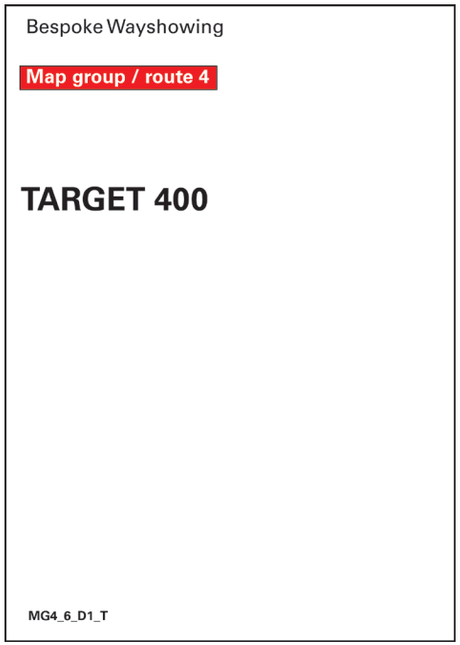

Figure 3

Text+arrow

Text+arrow:
The verbal route descriptions used by participants were written with as simple - yet unambiguous - language as possible. An arrow complemented the text when appropriate (see *figures 2 and 3*).
The targets were marked with TARGET + target number.

Procedure

The map+text and the text+arrow group participants were individually met by the research assistant, instructed, and taken to the first touchpoint 'screen' on the first route. After reading the route description, participants would follow the indicated route to the next 'screen', and so on. After five or six 'screens', they would arrive at their target. The wayshowing followed the progressive disclosure principle. The four routes followed each other in a relay pattern. The target destination of route 1 was the starting point of route 2, and so on. The researcher would follow each participant, take the time, and note hesitations and errors.

Results

The results show no significant difference in the efficiency of maps+text and text+arrow route explanations:
We first tested 24 participants 9-32 years. 12 participants (6 male, 6 female) walked four routes assisted by map+text and 12 participants (6 male, 6 female) followed the same four routes assisted by text+arrow. The text+arrow group performed slightly better M=737.17 sec than the map+text group M=760,17 sec. The difference 23.00 BCa [-36.96, 84.84] was not significant $t(22) = 0.724$, $p = .476$.
To see if this result was age related we did the same exercise with participants 50-68 years old. 12 participants (7 male, 5 female) text+arrow participants performed better M=780.75 sec than 12 participants (6 male, 6 female) map+text participants M=793.83 sec. The difference 13.083 BCa [-52.749, 78.040] was not significant $t(22) = 0.371$, $p = .714$.
The similarity between map+text and text+arrow results is remarkable. If simple verbal route descriptions work as well as, or better than, simple route maps a lot of time consuming map design can be avoided.
Future research should include more tests map+text vs. text+arrow including older participants. Also, great efforts should be taken to develop simple ways of route maps and verbal route descriptions. Could other more efficient maps be designed?

10 Total wayshowing solution

Bespoke wayshowing will not make traditional wayshowing in the hospital obsolete. Bespoke wayshowing will assist wayfinders who would otherwise look for a map or ask staff for wayfinding help.
After introduction of bespoke wayshowing, traditional wayshowing media will still provide the bulk of wayshowing in the hospital. Those who can will intuitively understand where to go or read the signs and walk.
Wayfinders who have consulted one or more touchpoints to find a ward will when having arrived in the intended destination area consult door signs or other signs to find the right room. Excellent identification signage is paramount.
Also, patients and visitors looking for the exit will be guided by traditional signage. To signpost the way to exits is a considerably easier wayshowing task for the hospital than to show the way to hundred different facilities.
Bespoke wayshowing will probably be of greatest interest to hospitals but may also be interesting to exhibition centres, airports, and shopping centres.

11 Summing up

The hospital will automatically issue all wayfinding patients with a personal identification code. Visitors can require a code. A code is related to a destination. Codes can be in NFC or QR format.
When a code is presented to a touchpoint, the touchpoint will confirm the wayfinder's name and destination and suggest a route to the wayfinder's destination. The route description may in simple cases cover the full route. In less simple cases, the route description will cover the first leg of the journey. After this the wayfinder must consult a new touchpoint.
The touchpoints are connected in a system with centralised storage and updating. The system can be expanded to suggest special routes for wheelchair bound wayfinders and wayfinders preferring an alternative language. Staff at the destinations and elsewhere can change the destination related to a code or issue a new code.

12 Future development

The future development of bespoke wayshowing will include five parts before presentation to the market:

1 (Continued) international search of academic papers and commercial kiosk solutions
2 (Continued) research on route description modality (map or text) and efficiency (simplicity vs. complexity)
3 Development of route descriptions for a hospital test
4 Development of technical working model
5 Tests of the working model

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