Visible
Language

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Contents

Railway Rules:

Image Content Origins of Wayfinding Pictograms from the 1960s and 1970s

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Wayfinding pictograms are sometimes seen as "words" of a "visual language." This research investigates for 52 common referents in which organizations and domains these words originated. This research is on the pioneer period of wayfinding pictogram development, 1963–1974, using a set of 24 pictogram systems. The results shows that the image contents of most common pictograms that we use today were introduced in only three years' time by transport organizations. Olympic events and world exhibitions played a minor role in this process. Known designers probably focused more on improving the visual perception and consistency of a pictogram set. A comparison of image contents of pictogram systems from 1963–1974 with two more recent systems suggests there has hardly been any evolution in contents since.

K e y w o r d s
pictograms,
1960s,
evolution,
wayfinding,
image contents

Where Do the Image Contents in Wayfinding Pictograms Originate?

The Olympic Games as milestones in the history of wayfinding pictograms

The 1960s and early 1970s are seen as a pioneer period in the development of wayfinding pictograms for public space. During this time, several well-known pictogram systems for Olympic Games and world expositions were introduced. Design historical overviews emphasize the importance of these systems as an example for pictograms in general. For example, Meggs and Purvis (2011) noted that the pictograms of the Tokyo Olympics—introduced in 1964 and art directed by Masaru Katzumie—served as "a guide for universal public visual design systems and worldwide events" (p. 429). Similar remarks have been made about the system that Otl Aicher and his team designed for the 1972 Munich Olympics (Eskilson, 2007, p. 321). Design history also associates the development of pictograms with the development of a visual language, in which famous designers play a crucial role (Katzumie, 1971, p. 369). An interesting implication of bringing up the term "language" is that it suggests that these designers—and by extension, Olympic Games and world exhibitions—gave us the "words" of this language, the image contents of pictograms. But is this really true? There are reasons to doubt this.

What about pictogram standards of transport organizations?

Not much attention has been given to the parallel introduction of pictogram systems by transport and tourism organizations in the 1960s (Bakker, 2013). These systems were developed by lesser-known designers and amateur draughtsmen, aided by officials, and were often laid down in standards that found long-term use. The first of these organizations to introduce a pictogram standard was the Union Internationale des Chemins de fer (UIC), also known as the International Union of Railways, in 1963. The UIC was the leading international railway organization in the Western world, and it developed railway standards and policies. Its members were mainly national railway companies that owned both transport means and stations. They were obliged to follow the UIC standard if they wished to introduce a pictogram system. Similar systems were introduced by aviation organizations. Their longevity and general use make it likely that these more anonymous

pictogram systems exercised a larger influence over our current pictograms systems than is generally assumed in design history, especially in regard to image contents. After all, the pictograms developed for Olympic Games and world exhibitions were typically disposed of after these events were finished.

Aim of this research

This research sets out to study the introduction and evolution of image contents for the most common referents used in wayfinding pictogram systems. It aims to establish which organizations and domains—such as railways, events, aviation, or tourism—introduced these image contents, and whether these contents evolved after their introduction. Establishing this is a first step toward developing a less "designer"-oriented history of wayfinding pictograms—one that also acknowledges the role of institutions in shaping our designed environment. The introduction and evolution of image contents was researched for 24 representative pictograms systems from the period between 1963 and 1974, for 52 well-known referents. In order to do this, a new approach was developed that aimed to quantify the contribution of different domains and organizations. To verify certain aspects of this approach, two systems from 2017 were also researched. This follow-up research was also used to check whether image contents for earlier researched referents had undergone major changes since the 1970s.

Pictogram, image content, and referent

Pictograms are abstracted graphic pictorials, and are often part of a set, system, or a collection of pictograms that is designed for a specific client or purpose. They are used to indicate certain functions or desired behaviors—for example, when using products or for wayfinding. A good example of pictograms are the abstracted depictions of a male or a female to indicate toilets and their intended users. Pictograms in a set usually share a common visual style or aesthetic, which helps in identifying them as part of a specific system, and assert certain emotional or associative qualities. In this article, pictorial and non-pictorial graphic elements are referred to as the image contents of pictograms, whereas the referent of a pictogram stands for the concept or thing that the image contents refer to. For example, the "telephone" pictogram refers to the presence of a telephone, the referent, whereas the image contents of this pictogram typically consist of a telephone horn (Figure 1) (ISO/TC 145/SC 1, 2007). It should be noted that this research only looks at wayfinding pictograms for pedestrians and leaves out traffic symbols and road signs due to their specific nature and history.

Figure 1

Pictogram: telephone
The image or sign itself in all its graphical detail

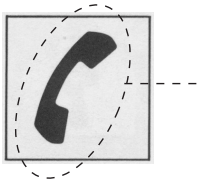


Image contents: telephone horn
The general contents of a pictogram, as it can be described in text

Referent: telephone
The object or concept that the pictogram refers too

Figure 2

Abbr.	Organisation	Year	Country	Design
ADCA	Australian Department of Civil Aviation	1972	United Kingdom	Kinneir, Calvert and Associates
ADV	German Airports Association	1968	Germany	M. Krampen and H.W. Kapitzki
ATA	Air Transport Association	1966	United States	Arnold Thompson Associates
BAA	British Airports Authority	1972	United Kingdom	Kinneir, Calvert and Tuhill
D/FW	Dallas-Fort Worth International Airport	1973	United States	Henry Dreyfuss Associates
FA	Frankfurt Airport	1971 *	Germany	Otl Aicher and staff
ICAO	International Civil Aviation Organization	1970	International	-
IATA	International Air Transport Association	1966	International	IATA
LVA	Las Vegas Airport	1972	United States	Richard Graef and John Follis
NPS	National Park Service	1970	United States	Chermayeff and Geismar Associates
NRR	Netherlands Railroads	1968 *	The Netherlands	Gert Dumbar of Tel Design Associates *
O64	Olympic Games (Tokyo)	1964	Japan	Masaru Katzumie (directed by)
O68	Olympic Games (Mexico City)	1968	Mexico	Lance Wyman and Beatrice Cole
O72	Summer Olympic Games (Munich)	1972	Germany	Otl Aicher and staff
Pg	Picto'grafics	1972	Canada	Paul Arthur and Associates
Port	Port Authority of New York and New Jersey	1971	United States	Owen Scott
S/TA	Seattle-Tacoma Airport	1971	United States	Donald J. Gerands and Richardson Associates
SP	Swedish National Parks	1972	Sweden	-
TA	Tokyo Airport	1970	Japan	Aisaku Murakoshi
TC	Transport Canada	1974	Canada	Ministry of Air Transportation Design Staf
UIC	International Railroad Union	1963	International	UIC
W072	Winter Olympic Games (Sapporo)	1972	Japan	Fukuda Shigeo
X67	Expo 67, Montreal	1967	Canada	Paul Arthur and Associates
X70	Expo 70 (Osaka)	1970	Japan	Eknan Kenji, GK Industrial Design Institute, Isozaki Arata, and Fukuda Shigeo
	Canadian National Signing System	-	Canada	Hunter Straker Templeton Ltd.
	KFAI AB (Sweden)	-	Sweden	Claes Tottie
	Mexico City Metro	1969	Mexico	Lance Wyman
	Olympic Games (Montreal)	1976	Canada	Georges Huel and Pierre-Yves Pelletier

Rail · Aviation · Events · Tourism · Part of the DOT evaluation but not used in this research · * Date or designer added by the author

Using Evaluated Pictogram Systems from the DOT Symbol Signs Reports as a Foundation

The DOT Symbol Signs reports

To investigate the historic development of image contents in wayfinding pictograms, a representative selection of pictograms and referents was needed. This selection was found in the reports that accompanied the introduction of the U.S. Department of Transportation (DOT) pictograms in the 1970s (DOT, 1974, 1979). These pictograms were intended as a general and freely available pictogram set for public spaces in the United States. Over time, it has become one of the best-known sets worldwide. It was developed by the designers Raji Cook and Don Shanosky, aided by a committee from the American Institute of Graphic Artists (AIGA), headed by designer Thomas Geismar. The AIGA committee gave the designers image content recommendations based on the results of an evaluation that it had made of 28 pictograms systems, all introduced between 1963 and 1976. As part of this evaluation, the AIGA committee matched the image contents of these systems with the referents for which the DOT needed pictograms. This resulted in the collection of circa 600 categorized pictograms, which were depicted in the DOT Symbol Signs reports that described the development of the DOT pictograms. This collection is at the heart of the research presented in this article.

How did the AIGA allocate image contents to referents?

A potential caveat in using these already-categorized pictograms was that the reports did not explain how the AIGA had allocated pictograms of the evaluated pictogram systems to the DOT referents. Was this based solely on the image contents, or were the referents (the intended meanings of the pictograms) also taken into account? Research into a sample of the collected systems suggests that a combination of referent and image contents matching was used. At the time, the typical pictogram set contained between 25 and 40 referents, with a relatively large semantic distance—a difference of meaning—between them. The same could be said for the associated image contents. Referents and image contents were tied in unique combinations. For example, the DOT referent "coffeeshop" matched with referent names such as "coffee" or "lunch room," with associated image contents being either

a coffee cup and saucer or a mug. It was hard to confuse these with the DOT referent "restaurant," which was also referred to as "diner" in some evaluated systems, and was associated with depictions of cutlery, often combined with a plate.

Representativeness of the pictogram systems and referents

The systems from which the evaluated pictograms stem are to a large degree representative for the pioneer phase of pictogram development. They include all five known and introduced pictogram systems for wayfinding up until 1967 and a large sample of 23 systems for the period immediately thereafter (Figure 2). They cover the most important countries, producing such systems such as the United States, Canada, Germany, and Japan. Apart from the latter, the development of pictograms was limited mainly to North America and Europe at the time, especially in the 1960s. The samples also cover the most important domains for which wayfinding pictograms were developed during this period: railways—hereafter referred to as rail—aviation, events, and tourism. In addition, the DOT referents represent a wide and common range of applications and domains. This was a reflection of the fact that the list of needed referents was established by a DOT committee that included representatives from the United States industry and government organizations responsible for infrastructure, transport, land use, and tourism. In summary, the DOT referents and the categorized pictograms in the DOT Symbol Signs reports are well-suited to serve as a starting point for tracing the development of image contents during the pioneer phase of pictogram development.

Adjustments made to improve representation

Nevertheless, a few adjustments were made to make system representation more balanced and useful. As a result, four systems were removed. Two of these could not be dated; one of them was the only representative for the years 1975 and 1976, and one consisted of only two symbols. In addition, the extensive pictogram system of the UIC was split into two parts, reflecting its stepped introduction and distribution in 1963 and 1965. Since it was the first pictogram system to be introduced worldwide, a correct dating was deemed particularly relevant. This resulted in a final data set of 24 selected pictogram systems, covering the period of 1963 to 1974.

Categorization of pictogram systems into four domains

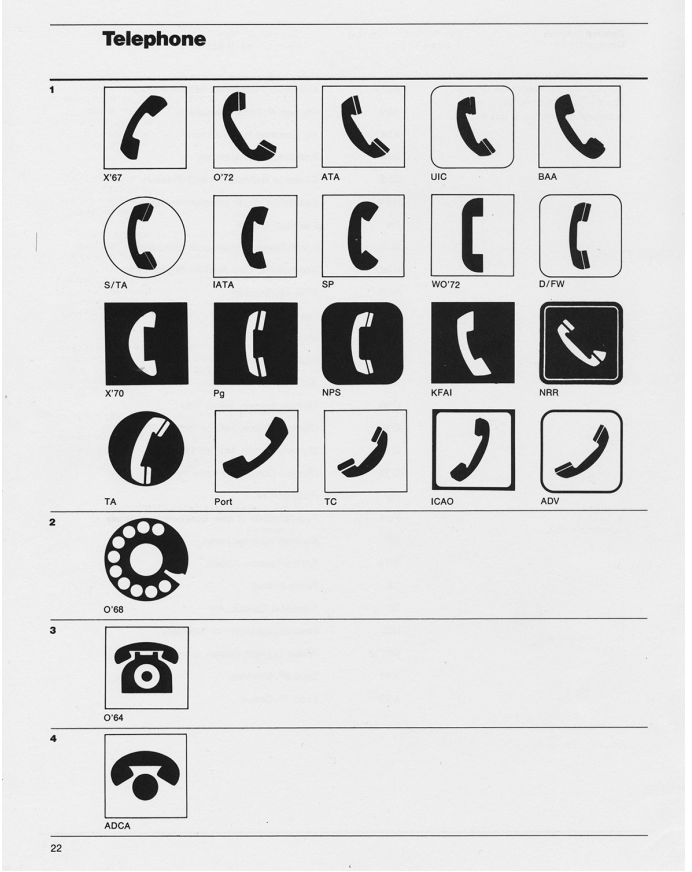
The selected systems were categorized as belonging to one of the following domains: rail, events, aviation, and tourism. Rail is represented by two systems, the main one being that of the earlier mentioned International Railway Union (UIC). Aviation is represented by 14 systems. The most important of these are the Air Transport Association of America (ATA) that represented United States airlines, and the International Aviation Transport Association (IATA), representing most Western international airlines. Both systems were introduced in 1966, and were superseded—as a standard for aviation—in 1970 by the pictogram system of the International Civil Aviation Organization (ICAO). The large number of aviation systems is a reflection of the spectacular growth of airlines and airports, and the relative lack of pictogram systems in other domains at that time. The events domain covers six systems: the Olympic Games of Tokyo (O64), Mexico City (O68), Munich (O72), and Sapporo (WO72), and the world expositions in Montreal (X67) and Osaka (X70). Finally, there is the tourism domain that numbers two systems—most notably, the one for the U.S. National Park Service (NPS) introduced in 1972. This is a relative low number, which might be attributed to a lack of pictograms in the tourism domain that matched the desired DOT referents.

Categorizing Image Contents and Tracing Their Origins on a Chart

Subcategorizing image contents for referents

Tracing the introduction and development of image contents of referents over time necessitated an organizational framework. A thorough look at the DOT report showed that the AIGA had given each referent a page where allocated pictograms were subcategorized based on similarities in image contents. These pages demonstrated that image contents of pictograms for most referents were generally similar or dissimilar, with not much intermediate image contents being available (Figure 3). That is why for this research, a

Figure 3



categorization approach was also used, which raised the following question: When should contents be identified as part of a new category? In the DOT research, it was not clear what exact categorization criteria were used. In this research, a pictogram is categorized differently when its image contents—as defined by the objects depicted in silhouette—differs from that of other pictograms for the same referent. Ignored for the purpose of categorization were (Figure 4):

1 General applicable image contents or sub-signs such as sign shapes, negations, and pointers;

2 Repeating image contents (multiples). Example: depicting two suitcases instead of one;

3 The composition of image contents within a pictogram;

4 The addition of a slightly different type of the same image contents (generalization). Example: showing different shapes of suitcases to symbolize a more inclusive category;

5 The addition of a minor clarifying element to image contents (specification). Example: attaching a small label to a suitcase. Exempted from this were referents, where detail differences in image contents of pictograms suggested major functional differences between them. A good example of this is the referent "water transportation," which included pictograms of ferries, as well as tour boats. In this case it is likely that the DOT wanted a generic referent for water transportation, where earlier, two different referents would have been used, such as ferry and touring boat.

Figure 4

Borders and negation bars: 'No Smoking'

Signs shapes and negation bars were ignored in the categorization of these 'No Smoking' pictograms. The ones with the cigarettes (4a, 4b) were catagorized differently from the one with the match (4c).

4a *4b* *4c*

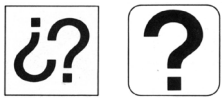
Composition and silhouette: Car Rental'

The two left 'Car rental' pictograms (4f, 4g) were categorized similarly, ignoring the position of image contents. Also ignored was the label as a minor clarifying element. The right pictogram (4h) had a different car silhouet and got its own category.

4f *4g* *4h*

Multiply: 'Information'

Repeating image contents (multiply) in these 'Information' pictograms was ignored (4d, 4e). Therefore both information pictograms were categorized similarly.



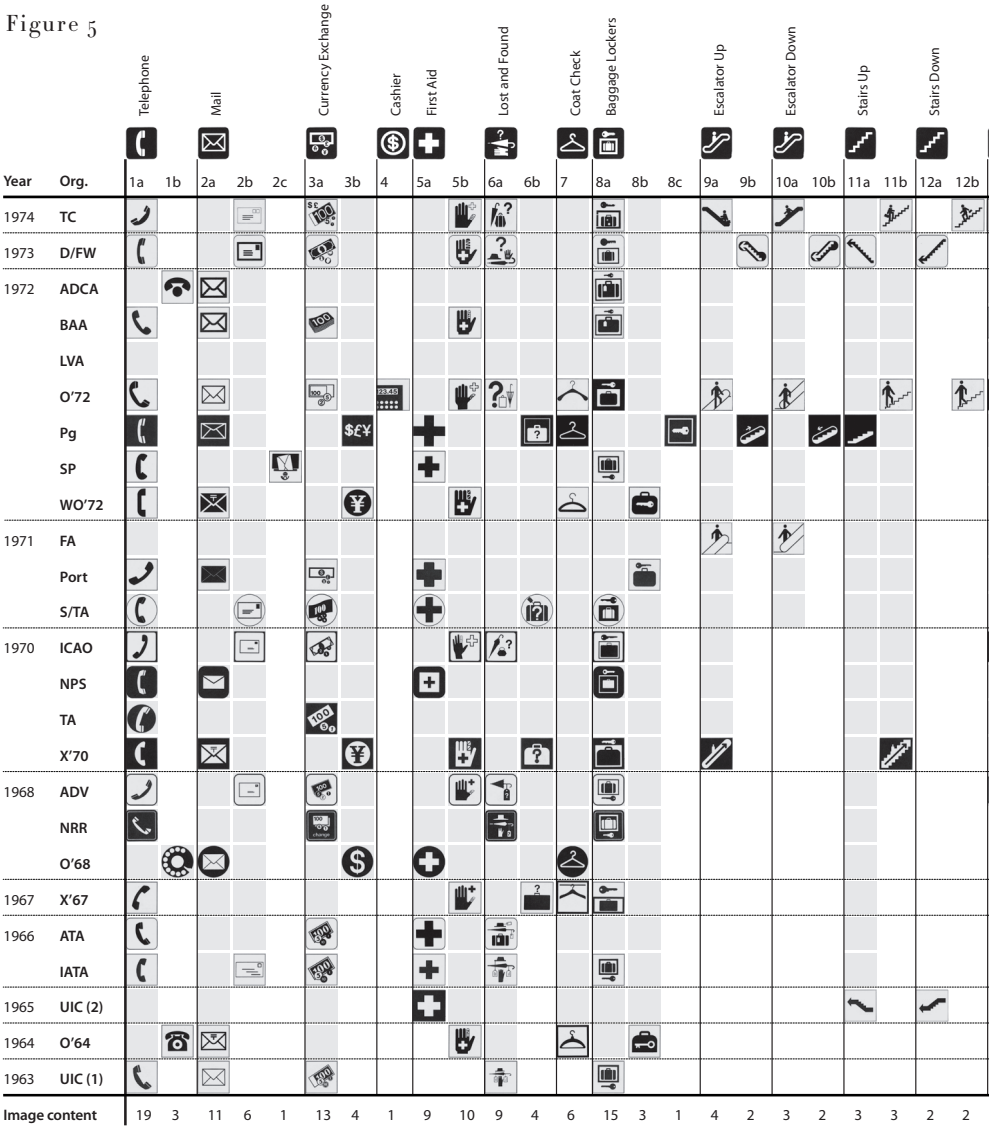
4d *4e*

Generalize and specify: 'Baggage claim'

Suitcase shapes (generalize) and minor clarifying elements like labels (specify) were ignored in these 'Baggage claim' pictograms (4i, 4j). The rollers at the right pictogram (4k) were a major new element. Therefore pictogram (4k) was catagorized differently.

4i *4j* *4k*

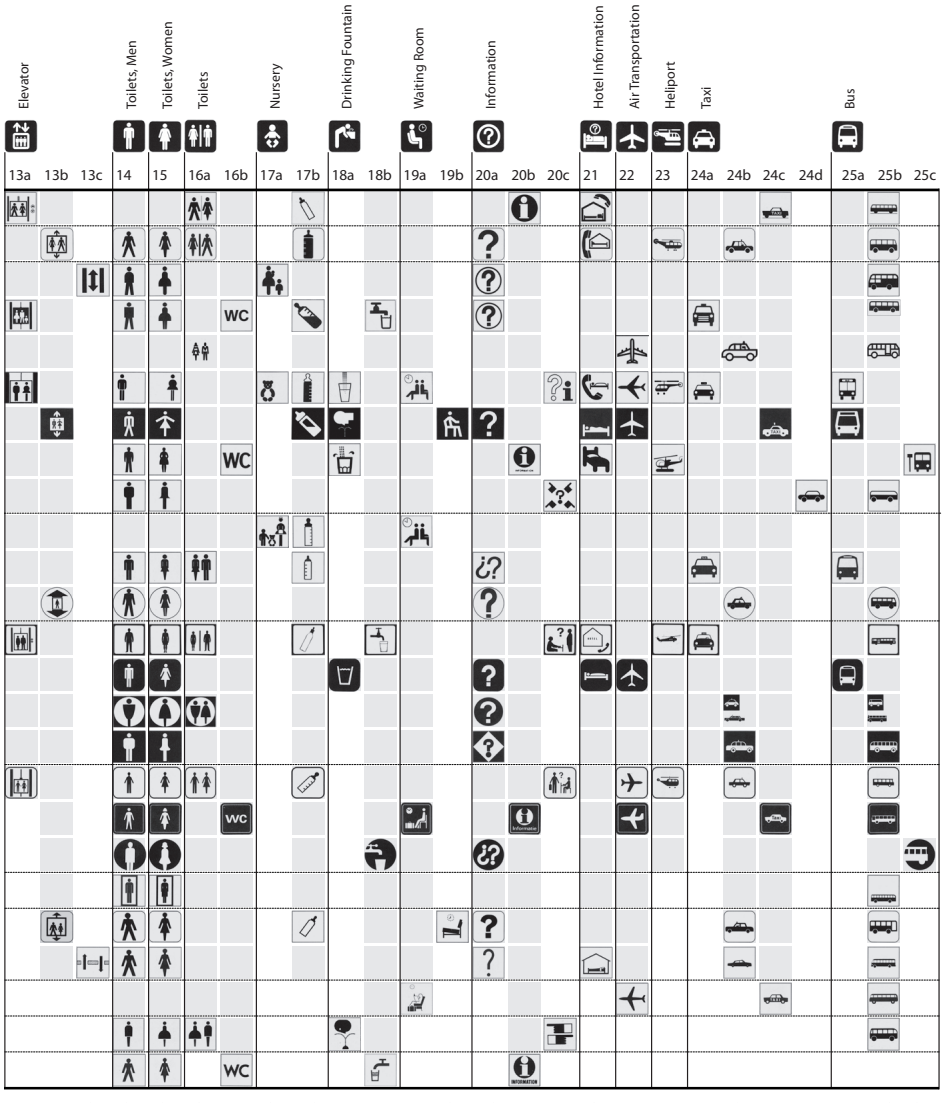
Figure 5



ADCA Australian Department of Civil Aviation
ADV German Airports Association
ATA Air Transport Association of America
BAA British Airports Authority
D/FW Dallas-Fort Worth International Airport
FA Frankfurt Airport
IATA International Air Transport Association
ICAO International Civil Aviation Organization
LVA Las Vegas Airport
NPS National Park Service
NRR Netherlands Railroads
O'64 Olympic Games, Tokyo 1964
O'68 Olympic Games, Mexico 1968
O'72 Olympic Games, Munich 1972
Pg Picto'grafics
Port Port Authority of New York & New Jersey
SP Swedish National Parks
S/TA Seattle-Tacoma Airport
TA Tokyo Airport

Understanding the categorization chart

The image contents of pictograms were categorized using a chart (Figure 5). The chart enables the reader to trace the development of pictograms for all DOT referents over time, while at the same time making it possible to visually verify the used categorization. The vertical axis of the chart shows



TC Transport Canada, Air
UIC (1) International Railroad Union
UIC (2) International Railroad Union
W0'72 Winter Olympic Games, Sapporo 1972
X'67 Expo 67, Montreal
X'70 Expo 70, Osaka

The image contents of pictograms were categorized using a chart, only half of which is reproduced here due to space limitations of the journal - ED.

the chronologically ordered pictogram systems, ranked from the most recent (top) to the oldest (bottom). The abbreviated names for each of these systems can be seen on the left side of each page. The 52 DOT referents are on the horizontal axis, following their original introduction order in the DOT Signs Symbols report. They can be seen on the top of each page and are accompanied by their matching DOT pictogram to facilitate quick reading. Underneath each referent, there are one or more numbered columns filled with pictograms with successful or unsuccessful image contents. "Successful

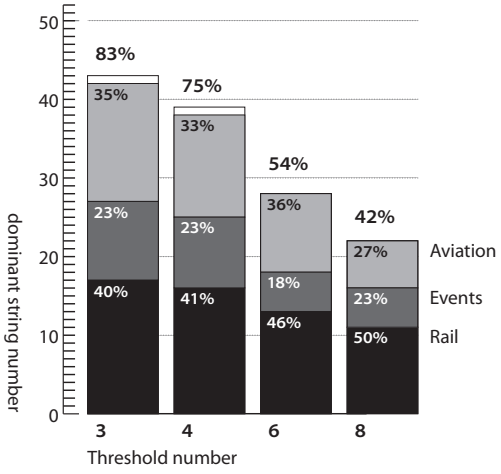
image contents" has similar image contents, that is used in at least three pictograms for the same referent. Such a succession is also referred to as a "string" in this article. "Unsuccessful image contents" is used in less than three pictograms.

Using "strings" to determine which image contents were successful

Strings are seen as the key to understanding which systems, organizations, and domains were successful or not in introducing new image contents. A good example of a string can be seen with the telephone referent in column 1a (Figure 5). As indicated underneath the column, there are 19 pictograms with similar image contents in this string, starting with the telephone pictogram from the UIC in 1963. Strings are emphasized visually through the use of gray squares in the gaps between its constituting pictograms and the top of the chart. The string with the most pictograms for a referent is the "dominating string" for that referent. For mail, the dominating string can be found in column 2a; it has five more pictograms than the string in 2b. All dissimilar —unsuccessful—image contents for a referent are placed in a separate column, which for the telephone and the mail referents are column 1b and 2c, respectively. If strings for the same referent have the same length—which happened for the period between 1963 and 1974 only for column 11a/11b—the most recent one is considered to be dominant.

A threefold repetition of image contents for a string might seem like a relatively low threshold. It was chosen because some domains were less well-represented than others. Overlooking the negligent tourism domain (two systems), this is especially relevant for the event domain (six systems). The same could be said about the rail domain (two systems) were it not for its considerable overlap with aviation (14 systems) in regard to transport referents. Three is also the minimum number necessary to indicate a repetition of image contents, taking into account that there are two design teams—Otl Aicher's team and Jock Kinneir and Margareth Calvert's team—who each designed two systems covered in the chart, with some of these reusing the same image contents (Figure 4). Finally, a threshold of three makes it possible to cover most of the DOT referents: 83%. Using a threshold of four, six, or eight would limit the percentage of DOT referents with strings over the period between 1963 and 1974 to 75%, 54%, or 42%, respectively, lessening coverage for less popular and more domain specific pictograms (Figure 6).

Figure 6



Categorization Results

Domain and organization origins of image contents: The "big four"

The categorization of the image contents identified 65 strings during the period between 1963 and 1974, of which 43 were dominant. The railway, aviation, event, and tourism domains were responsible for 40%, 35%, 23%, and 2%, respectively, of the dominant strings, with an almost similar distribution for started strings (Figure 7). This means that 75% of the successful

Figure 7

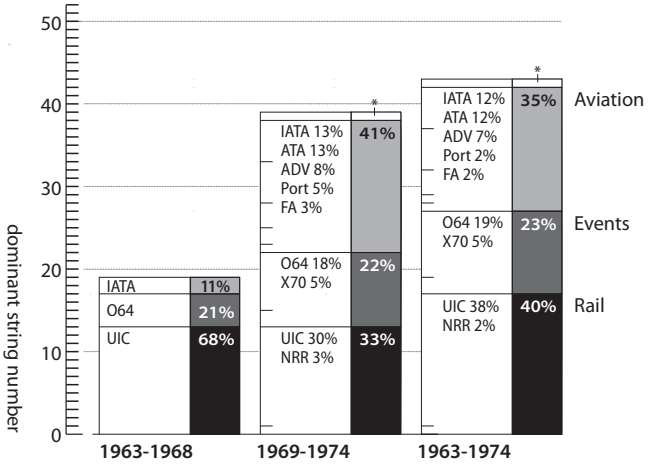
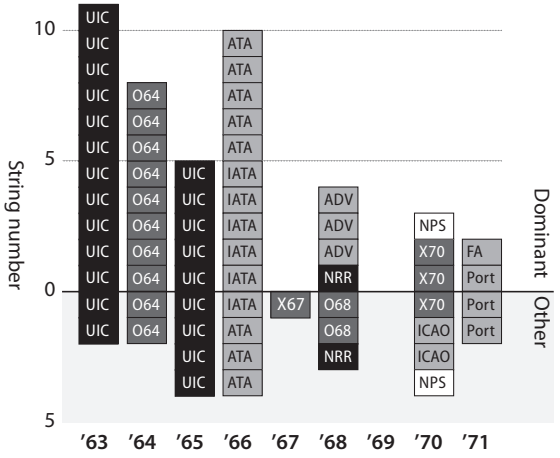


image contents originated in transport organizations. The main entities that introduced dominating strings were the International Railway Union (UIC, 38%), the 1964 Tokyo Olympics (O64, 19%), the International Air Transport

Association (IATA, 12%) and the Air Transport Association of America (ATA, 12%). Together, these "big four" delivered 81% of the image contents of the dominant strings all within the period between 1963 and 1966 (Figure 8).

Figure 8

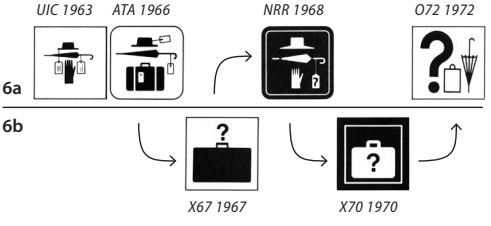


A closer look at the introduction dates of dominant strings shows a first wave originating from rail and, to a lesser degree, events from 1963 onwards, followed by a second wave from aviation from 1966 onwards. Looking at 1963–1974 as a whole, it can be surmised that image contents hardly evolved.

Strings showing evolution or using incoherent sharing

Most image contents could be categorized as clearly being similar or dissimilar. However, there were four referents: "Currency," "Lost and Found," "Hotel Information," and "Rail Transportation," with image contents that were not totally similar nor dissimilar from each other. Some showed a gradual change in image contents over time (evolution). Others shared similar image contents as a group, but each pictogram was always missing one or two elements present in most other pictograms of this group (incoherent sharing) (Figure 9). Both groups of image contents—those showing evolution

Figure 9



and incoherent sharing—have been categorized as strings because they do show a clear and linked effort to reuse image contents. To some degree, their characteristics can also be found with pictograms for other certain referents, but there it usually concerns the addition or subtraction of only one specific and minor element, rather than multiple elements. Finally, there were nine referents with no strings. Typical for these referents was the low number of pictograms, which reduced the change for establishing strings and suggests a lack of popularity of these referents at the time.

Connection between domain and image contents

The categorization also showed a slight but discernable connection between domain and the referents for which it delivered dominating strings. Rail, for example, dominates referents associated with luggage, such as "Baggage Lockers," "Baggage Check-in," and "Lost and Found," reflecting the long experience of railways —as the first mass transportation medium— with luggage. Something similar can be seen with aviation that delivered dominant strings for referents, such as "Hotel Information," "Car Rental," "Parking," "Elevators," and "Escalators." Services and installations like these were particularly relevant to airports, especially in the United States, whereas events such as Olympic Games and expos distinguished themselves more with connections to commercial activities, introducing dominant strings for referents such as "Ticket Purchase," "Coat Check," "Coffeeshop," and "Shops."

Applying the Categorization Method to Two Current Systems

Dutch Railways (NS) and Schiphol Airport

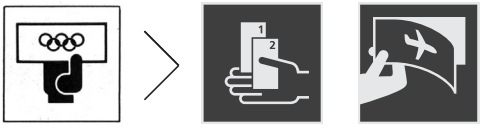
The lack of evolution in image contents between 1963 and 1974 is remarkable. One explanation might be the short time period that was researched. Therefore, it is interesting to see whether image contents have evolved since. To answer this question, the referents and image contents from the DOT evaluation were compared with those of two more recent systems. The main question is: What percentage of image contents for similar referents in these recent systems was already introduced in the pioneer period? This research question also made it possible to experiment with matching the referents and image contents of these new systems with those of the DOT evaluation. Based on only two samples, it is obvious that any results are not generally applicable. However, it is enough to obtain a quick impression.

The first of the two more recent pictogram sets being researched is of the Dutch Railways. This company is also referred to as NS, and is the main operator for railway transport in the Netherlands. An earlier incarnation of the NS set was part of the evaluated DOT pictogram sets under the abbreviation NRR. It was drastically redesigned and expanded in the late 1990s by the Dutch wayfinding specialist Mijksenaar. This agency also designed the pictogram set of Amsterdam Schiphol Airport in the early 1990s, which is the second set to be researched. Both sets have received updates since that time, and the versions being used here are from 2017. Compared with the sets used in the DOT research, those of the Dutch Railways and Schiphol Airport are very extensive, containing 121 and 280 signs and pictograms, respectively.

Matching referents and image contents becomes more challenging

In the NS set, a large number of pictograms were signs with only letters, numbers, and pointers that were used to indicate platforms. After removing these, circa 70 pictograms were left, which were relatively easy to match. Remarkable was the occurrence of a so-called joined match (j). A good example of this concerns the NS referent "Food and drinks," which was equivalent to the DOT referents "Restaurant" and "Coffee shop" together. Its opposite was the more common split match (s). In this, a DOT referent was split into several others that were equal in importance or value such as "Rail transport," which was split into the referents "Tram," "Train," and "Metro." Similar matches could also be seen with the Schiphol Airport set, for example with "Litter Disposal" and "Ticket Purchase" (Figure 10). With split matches, additional elements for image contents were acceptable as long as the main element remained the same. For the calculation of the percentage of similar image contents, split and joined referents were weighted as being equivalent to the originating DOT referents.

Figure 10



Ticket Purchase (column 36b) *Train ticket* *Ticket desk*

The Schiphol Airport pictogram set was more challenging to work with than the NS system, showing severe limitations of using a categorization approach when matching referents and image contents of a large set. After removing duplicate pictograms and signs with only letters and numbers, there were still almost 250 different Schiphol Airport pictograms left. In general there was less semantic distance between

the referents and image contents of this set. Sometimes the referents were totally new, but often it concerned variations on DOT referents that could be considered neither joined nor split matches. Problematic was also that some referents used image contents that were associated with other referents in the DOT evaluation. This made it difficult to establish clear matches, despite there being a connection with earlier pictograms.

A good example of this matching problem can be seen with the DOT referent "Baggage check-in." The Schiphol Airport set has three referents that to some degree matched this DOT referent: "Check-in," "Baggage drop-off," and "Self-service baggage drop-off." (Figure 11) The image contents for the DOT referent "Baggage check-in" was either a suitcase on a weighing scale, or much rarer, a man standing next to a suitcase on an elevation with a pointer, suggesting the suitcase was moving away. This did not match well with the image contents of the matching Schiphol referents. Instead the contents of "Check-in" were more similar to that of DOT referent "Ticket Purchase," and the contents of "Baggage drop-off," and "Self-service baggage drop-off" were more similar to that of the DOT referent "Baggage Claim." In this case, the "Self-service baggage drop-off" pictogram was chosen as the best match for the DOT referent "Baggage check-in." Since the machine was a major new element, this image contents match was weighted half. There were also six other, less challenging matchings in the NS and Schiphol sets, which were accepted and weighted half as well. A good example is the DOT referent "Rail Transport," which in the Schiphol set had a depiction of a train bending in a corner and coming toward the viewer, instead of showing only the side or the front of the train.

Figure 11

Bagage Check-in (column 37a)

Bagage Check-in (column 37b)

Check-in

Bagage drop-off

Self-service baggage drop-off

Ticket Purchase (column 36a)

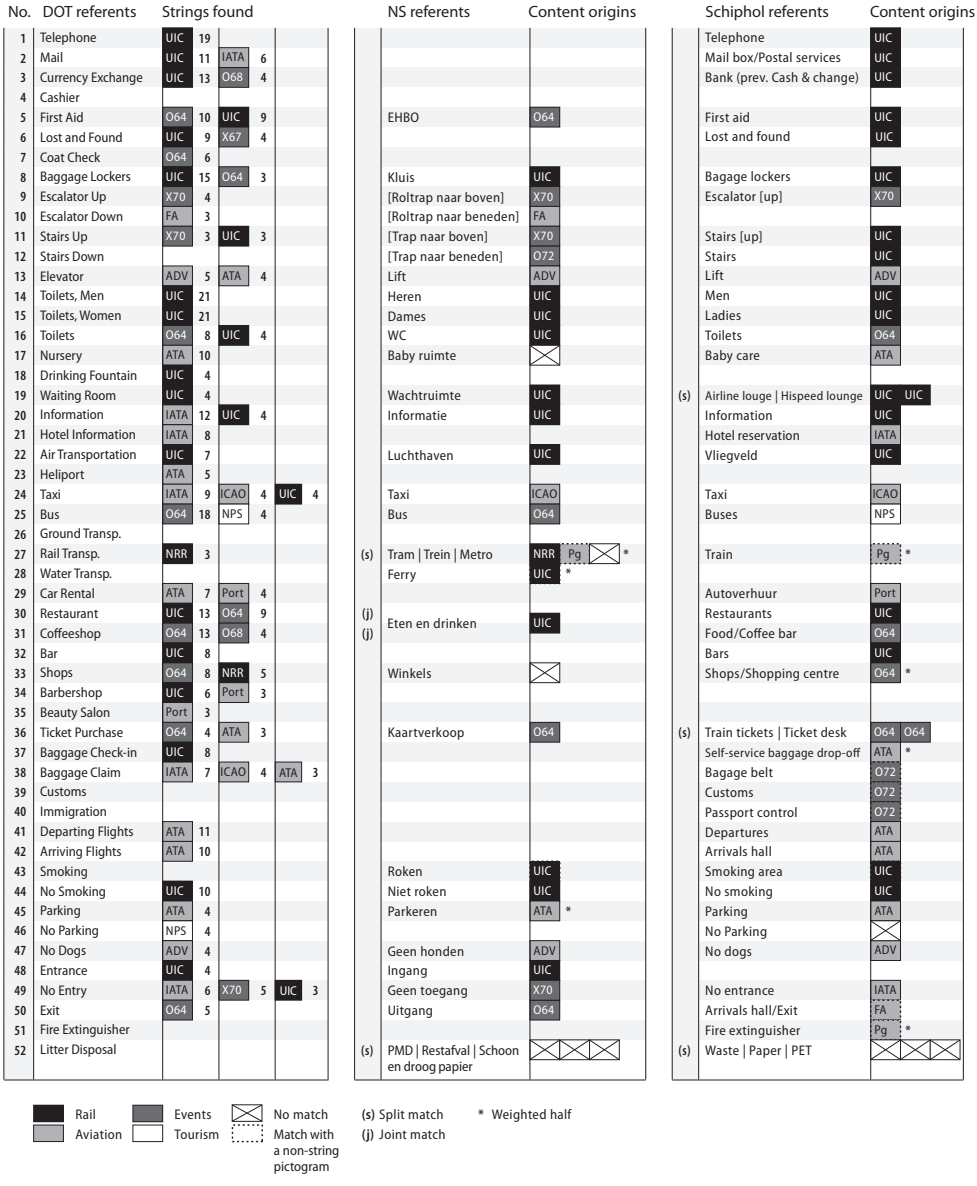
Baggage Claim (column 38b)

Baggage Claim (column 38c)

Image contents of common pictograms hardly changed during the last half century

In total, 30 NS referents and 42 Schiphol referents matched with the 52 DOT referents. For these referents, image contents matches were allowed with string and non-string image contents from the DOT research. The results showed DOT image contents matches for 83% of the NS referents (24 fully and three half matched), and 90% of the Schiphol referents (36 fully matched and four half matched) (Figure 12). This suggests that image contents of most common pictograms hardly changed during the last half century. Apart from the increasing specialization of referents, which led to a larger size of pictograms sets, changes that did happen and stand out are those associated with changed processes and behaviors. For example, in the Schiphol Airport set the DOT referent "Litter disposal" has been split into several waste disposal categories, such as "Waste," "Paper," and "PET," –the latter abbreviation indicating plastic bottles. This split suggests shifting attitudes toward waste. The subtlety of these changes can also be seen with the DOT referent for "Smoking." It was introduced in a time when "No smoking" was the exception, while currently, the situation is reversed. This is visible in the Schiphol referent "Smoking area" that emphasizes the delineated "area" for this habit in the referent name, whereas the image contents remain the same as in earlier smoking signs.

Figure 12


No. DOT referents Strings found
NS referents Content origins
Schiphol referents Content origins
1 Telephone UIC 19
2 Mail UIC 11 IATA 6
3 Currency Exchange UIC 13 O68 4
4 Cashier
5 First Aid O64 10 UIC 9
6 Lost and Found UIC 9 X67 4
7 Coat Check O64 6
8 Baggage Lockers UIC 15 O64 3
9 Escalator Up X70 4
10 Escalator Down FA 3
11 Stairs Up X70 3 UIC 3
12 Stairs Down
13 Elevator ADV 5 ATA 4
14 Toilets, Men UIC 21
15 Toilets, Women UIC 21
16 Toilets O64 8 UIC 4
17 Nursery ATA 10
18 Drinking Fountain UIC 4
19 Waiting Room UIC 4
20 Information IATA 12 UIC 4
21 Hotel Information IATA 8
22 Air Transportation UIC 7
23 Heliport ATA 5
24 Taxi IATA 9 ICAO 4 UIC 4
25 Bus O64 18 NPS 4
26 Ground Transp.
27 Rail Transp. NRR 3
28 Water Transp.
29 Car Rental ATA 7 Port 4
30 Restaurant UIC 13 O64 9
31 Coffeeshop O64 13 O68 4
32 Bar UIC 8
33 Shops O64 8 NRR 5
34 Barbershop UIC 6 Port 3
35 Beauty Salon Port 3
36 Ticket Purchase O64 4 ATA 3
37 Baggage Check-in UIC 8
38 Baggage Claim IATA 7 ICAO 4 ATA 3
39 Customs
40 Immigration
41 Departing Flights ATA 11
42 Arriving Flights ATA 10
43 Smoking
44 No Smoking UIC 10
45 Parking ATA 4
46 No Parking NPS 4
47 No Dogs ADV 4
48 Entrance UIC 4
49 No Entry IATA 6 X70 5 UIC 3
50 Exit O64 5
51 Fire Extinguisher
52 Litter Disposal
EHBO O64
Kluis UIC
[Roltrap naar boven] X70
[Roltrap naar beneden] FA
[Trap naar boven] X70
[Trap naar beneden] O72
Lift ADV
Heren UIC
Dames UIC
WC UIC
Baby ruimte
Wachtruimte UIC
Informatie UIC
Luchthaven UIC
Taxi ICAO
Bus O64
(s) Tram | Trein | Metro NRR Pg *
Ferry UIC *
(j) (j) Eten en drinken UIC
Winkels
Kaartverkoop O64
Roken UIC
Niet roken UIC
Parkeren ATA *
Geen honden ADV
Ingang UIC
Geen toegang X70
Uitgang O64
(s) PMD | Restafval | Schoon en droog papier
Telephone UIC
Mail box/Postal services UIC
Bank (prev. Cash & change) UIC
First aid UIC
Lost and found UIC
Bagage lockers UIC
Escalator [up] X70
Stairs [up] UIC
Stairs UIC
Lift ADV
Men UIC
Ladies UIC
Toilets O64
Baby care ATA
(s) Airline louge | Hispeed lounge UIC UIC
Information UIC
Hotel reservation IATA
Vliegveld UIC
Taxi ICAO
Buses NPS
Train Pg *
Autoverhuur Port
Restaurants UIC
Food/Coffee bar O64
Bars UIC
Shops/Shopping centre O64 *
(s) Train tickets | Ticket desk O64 O64
Self-service baggage drop-off ATA *
Bagage belt O72
Customs O72
Passport control O72
Departures ATA
Arrivals hall ATA
Smoking area UIC
No smoking UIC
Parking ATA
No Parking
No dogs ADV
No entrance IATA
Arrivals hall/Exit FA
Fire extinguisher Pg *
(s) Waste | Paper | PET
Rail
Aviation
Events
Tourism
No match
Match with a non-string pictogram
(s) Split match
(j) Joint match
* Weighted half

Conclusion

Most image contents of common wayfinding pictograms originated in transport organizations and hardly changed over time

Three quarters of the most used image contents for wayfinding pictograms originates in transport organizations. Particularly surprising is the pioneering role of the International Railway Union (UIC) that delivered almost 40% of the most used image contents for common pictograms during the pioneer period. This is remarkable because the railways were not known to be the most progressive domain at the time. That role was allocated to aviation, which contributed another 35% of the image contents, mainly originating from the International Aviation Transport Association (IATA) and Air Transport Association of America (ATA). Events contributed only 23% of the image contents, the majority of which came from the 1964 Tokyo Olympics. Research into two more recent sets suggests that to this day, these percentages did not change much. This also means that known designers and the international events for which they designed, such as Olympic Games and World Exhibitions, played a minor role in introducing image contents for pictogram systems during the pioneer period. It is likely that their work was more in the area of systemizing known image contents and improving their visual perception and aesthetics.

81% of the image contents of pictograms was introduced in just three years: 1963–1966. The lack of evolution in image contents thereafter suggests that the first organizations or events to introduce contents for a certain referent had an advantage in introducing image contents. This can be well observed with the pictogram systems for the UIC and the Tokyo Olympics, which were the first systems to be introduced. Their pictograms were unique in that they were developed almost simultaneously, and as a result, the strings that they started were also the ones competing the most for certain DOT referents. One explanation for the stability in image contents over time is the tendency among transport organizations in particular to follow existing standards—in other words, institutional compliance. At the same time, societies as a whole might have a tendency to stick with known image contents. There are many instances in which image contents already existed as symbols before their incorporation in a pictogram set. Typical examples are the symbols for train, glass, or fork and knife, which can be found in timetables from transport organizations from the end of the 19th century onward. Other symbols can be found in traffic signs, maps, travel guides, and visual statistics, such as Isotype.

The categorization method has limitations

This research investigated the introduction and evolution of image contents in pictogram systems during the pioneer period by developing a method for categorizing image contents and drawing meaningful conclusions from the results. Since image contents in the DOT research hardly evolved, this research was conceptualized as a "survival of the fittest" between successful image contents and not successful image contents, the former being visualized as "strings" in a chart. A major advantage of this method is that enables others to visually verify the choices made when categorizing image contents. It also introduced and successfully applied categorization rules for the pictograms sets used in the DOT research. Nevertheless, this method does have limitations. After all, this research benefited greatly from the fact that at the time, pictogram systems were relatively small, with a large semantic distance between referents, and a similarly large distance between image contents as well.

An assumption in this research was that referents would provide a stable anchor for researching the development of image contents over time. However, the follow-up research with the NS and Schiphol pictogram systems demonstrated that especially in large sets with less semantic distance between referents, as well as image contents, matching becomes more difficult. The relationship between referents and image contents can be subject to subtle change over time. This makes it difficult to use a fixed referent list like that of the DOT as a standard for measuring change. Therefore, before engaging in further research into the image contents of picograms, it is helpful to establish a theoretical framework first to inform a methodological approach that takes potential instability of both referents and image contents over time into account. It is hoped that the practical experiences from this research can contribute to developing such an approach.

References

Bakker, W. (2013). Icograda and the development of pictogram standards: 1963–1986. *Iridescent, 2*(2), pp. 38-48.

Department of Transportation. (1974). *Symbol Signs* [DOT-OS-40192]. National Technical Information Service.

Department of Transportation. (1979). *Symbol Signs 2* [DOT-OS-60510]. Technical Information Service.

Eskilson, S. J. (2007). *Graphic design: A new history*. 1st Edition. Yale University Press.

ISO/TC 145/SC 1. 2007. *ISO 7001:2007 Graphical symbols — Public information symbols.* ISO.

Katzumie, M. (1971). Aspects of the official graphic design programme of Expo '70, *Graphis* (150), 364–372.

Meggs, P. B., & Purvis, A. W. 2011. *Meggs' history of graphic design*. 5th edition. Wiley.

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Teotihuacan Writing: Where are We Now?

Christophe Helmke
Jesper Nielsen

Teotihuacan, the great metropolis of the Central Mexican highlands, has often been characterized as a state without a writing system. This paper redresses this notion and provides an overview of the city's writing system and weighs in on its state of decipherment. The corpus of texts is defined and outlined as are its media and contexts. The geographical distribution of the writing system is considered, identifying the localities that define the heartland of Teotihuacan writing and culture, as well as more distant sites and enclaves elsewhere in Mesoamerica where examples of Teotihuacan writing have been found. The temporal distribution is also appraised before going on to present the underlying graphic characteristics of the writing system, leading to an appraisal of the sign inventory, showing clear correspondences to other Mesoamerican logophonetic writing systems. A synopsis of previous work on the writing system is presented in a historical précis, before considering candidate languages of the script and features of the underlying language recorded in the writing system.

K e y w o r d s
Mesoamerica,
writing systems,
Teotihuacan,
epigraphy,
state of decipherment

No knowledgeable student of Teotihuacan art and artifacts has doubted that the Teotihuacanos had evolved a system of glyphic signs. [Yet] it has been much more difficult to sort out what rules the Teotihuacanos did observe in forming and ordering their signs, or to determine to what extent they might be said to have a writing system, compared to other Middle American peoples.
(Millon, 1973, p. 306)

Introduction

During its heyday, Teotihuacan (c. AD 0–650) was a thriving metropolis, with a population of around 150,000 (Cowgill, 2015; Smith, 2018) (Figure 1). For all its distinctive and superlative features, Teotihuacan culture shares a number of defining traits with other Mesoamerican cultures, including monumental architecture, a polytheistic pantheon, and ritual expressions involving ritual caching, scattering rituals, and human sacrifice (Headrick, 2007; Helmke & Nielsen, 2017; Sugiyama, 2005; Taube, 2006). On par with other Mesoamerican cultures, Teotihuacan also had its own writing system, and dates were recorded in an early form of the 260-day ritual calendar (better known as the *Tōnalpōwalli* from later cultures of central Mexico). Rather than a utopian enclave, Teotihuacan was the capital of a vast empire that interacted with contemporary cultures of Mesoamerica through both bellicose actions and commerce. Undoubtedly a result of these widespread interactions, a series of ethnic enclaves has been identified around the city center, demonstrating the presence of populations from the Mayan area,

Figure 1

Aerial view of Teotihuacan, showing part of the monumental epicenter with the towering Sun Pyramid (at right) and the broad Avenue of the Dead that terminates at the base of the Moon Pyramid (in the background) (photograph by Christophe Helmke).

Oaxaca, the Gulf Coast, and Michoacan. As a multiethnic city, this greatly complicates the question of language affiliation, especially as it concerns the dominant linguistic context of the city and the relationships to the majority language of the local population. This has implications for identifying the underlying language of Teotihuacan's writing system, since there are several candidate languages that are spread across several language families. Despite these difficulties, the writing system of Teotihuacan has witnessed important progress in recent decades, including the documentation of calendrical notations and the year-bearer system, as well as identifying toponyms, titles, and a selection of personal names. As a means of providing a state-of-the-art of Teotihuacan epigraphy, we consider the possible language candidates and outline the temporal and spatial distributions of the script before considering general features of the writing system and summarizing the most recent findings.

The Geographical Distribution: Teotihuacan and Beyond

In establishing the geographical distribution of the Teotihuacan writing system, the first challenge is to identify the area that can be characterized as the heartland of Teotihuacan culture. In part, this is due to the overwhelming focus on the city of Teotihuacan itself. In many ways, the archaeology of Teotihuacan is capital-centric, as though investigations of Rome were the only way to generate a picture of Roman culture. Furthermore, the continued habitation of urbanized centers of the central Mexican highlands, after the fall of Teotihuacan, means that detailed knowledge of larger settlements that once formed part of classic Teotihuacan culture is still lacking. Based on the distribution of inscribed monuments, rock art, and items of material culture bearing partial texts in Teotihuacan writing, we consider the Teotihuacan Valley (including the site itself), the wider Central Mexican Basin (including the sites of Santiago Ahuizotla and Azcapotzalco; Tozzer, 1921; von Winning, 1987) as the heartland of Teotihuacan (Figure 2). In addition, adjoining parts of the modern states of Tlaxcala, Puebla, Hidalgo, and Morelos can be said to have been well-integrated into the Teotihuacan cultural sphere (Matos Moctezuma, 2009, pp. 71–79; Cowgill, 2015, pp. 133–139, 194–203).

Figure 2

The heartland of Teotihuacan culture, showing the distribution of sites with attested Teotihuacan writing (map by Christophe Helmke).

As the Teotihuacan state prospered and expanded its influence through trade, military conquest, and networks of tributary obligations, examples of Teotihuacan writing began to appear on ceramic vessels, incense burners, and monuments outside this core region, and are now found in nearly all parts of Mesoamerica dating to the fourth to fifth centuries AD. In certain cases, Teotihuacan glyphic signs were borrowed into other scripts (e.g., at Tikal in Guatemala and Monte Alban in Oaxaca; Stuart, 2000; Taube, 2011, pp. 91–92), but in the majority of cases Teotihuacan texts, in their predictably concise format, appear alongside other characteristic expressions of Teotihuacan culture, including Teotihuacan-style iconography (Nielsen, 2003). We thus encounter Teotihuacan glyphs and texts in the Bajío-region (El Rosario, Queretaro; Nielsen et al., 2019a), and in the Mexican states of Guerrero (e.g., Acatempan and Cerro de los Monos; Nielsen et al., 2019b), Michoacan (Queréndaro; Filini, 2004; Nielsen, 2019), and Veracruz (e.g., Piedra Labrada and Soyoltepec; Taube, 2000). Further to the southeast, Teotihuacan writing appears on the Pacific coast and piedmont of Chiapas (Los Horcones and Fracción Mujular; Navarrete, 1986; Taube, 2000; García-Des Lauriers, 2005) and Guatemala (e.g., Escuintla and Tiquisate; Hellmuth, 1975; Berlo, 1984), in highland Guatemala (Kaminaljuyu and Lake Amatitlan; Kidder et al., 1946; Berlo, 1984) and across the central Mayan lowlands (e.g., Tikal and Copan; Stuart 2000, 2005). It is important to emphasize, however, that the total number of Teotihuacano texts that we have been able to document from these regions outside of Teotihuacan and its immediate hinterland is relatively small (n = 67+), and the majority of examples come from a limited number of sites in piedmont and highland Guatemala, such as Escuintla. The high incidence appears to reflect a local tradition of producing ceramics and incense burners in Teotihuacan style that is likely related to a warrior cult, possibly for use by a central Mexican enclave (Berlo, 1983, 1984). Having thus defined the spatial parameters, we provide further details concerning the number and nature of the texts from this Teotihuacan heartland, as well as the media on which they occur and their archaeological contexts.

The Corpus

Before introducing the graphic properties of signs and approaching the fundamental issue of the number of signs involved in Teotihuacan writing, we shall briefly discuss another important, but mostly ignored aspect of Teotihuacan literary culture: the number of known texts. German epigrapher Thomas Barthel did in fact call for a *Corpus Inscriptionum* of Teotihuacan texts already in 1987, but it never materialized. Crucial to this question is the criterion employed in defining what constitutes a text. Here we define a text as any written statement, however brief and/or fragmentary, on a single monument, artifact, or architectural unit, and note that in western Mesoamerica, there is a prevalence of very succinct texts, often reduced to a single calendrical date, anthroponym, title, or toponym. By this definition, a single glyphic compound, be it a calendrical date, a personal name, or a title, constitutes a text since each record is a single stative or declarative clause.[1] The same definition has been put to good use by the authors as part of other studies focused on Mayan writing and the writing system of the Epiclassic period (c. AD 650–1000), hence its applicability in the present case. In this respect, it is worth remarking that the central Mexican tradition of writing can be traced from the Classic period Teotihuacan through to the Epiclassic at sites such as Xochicalco and Cacaxtla, until Toltec and Aztec writing of the Postclassic period (Taube 2000, 2011; Helmke & Nielsen, in press a; Lacadena, 2008).

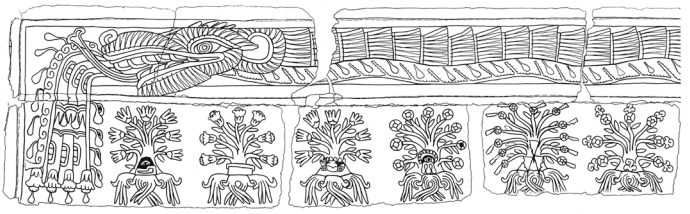
The brevity of such statements does not in itself disqualify them from being part of a phonetic writing system, and one only has to think of isolated words in present-day Western adverts, stop signs, singular toponymic indicators (road signs) or important dates highlighted on posters and banners ("9/11" or the "4th of July") (Nielsen, 2014a, p. 179; Millon, 1973, p. 307; Berlo, 1989, p. 21). When regarded in a wider Mesoamerican comparative perspective, it is worth noting that although ancient Mayan writing was often employed to compose much longer texts, there are also numerous examples of very brief texts that do not constitute full sentences, but merely stative expressions such as nametags and individual calendrical signs. Likewise, Teotihuacan texts tend to consist of one or two glyphs in a brief horizontal row, or short columns of three glyphs or so. Frequently, such rows repeat the same sign, and such repetition, as a form of calligraphic expression, may have been a specific scribal practice at Teotihuacan (Nielsen 2014a, 180). The two longest texts known from Teotihuacan are the remarkable forty-two glyphs from the Plaza de los Glifos at La Ventilla (Cabrera Castro, 1996; Nielsen & Helmke, 2011) and the

1 Barthel employed a different criterion for a text, requiring "at least two graphemes" forming a vertical continuum. Based on this he reached a provisional total number of texts of just 23 (Barthel, 1987, p. 11).

thirty-four glyphs in the series of repeated glyphs labelling flowering trees at Techinantitla (Cowgill, 1992; Pasztory, 1988a) (Figure 3). These provide tantalizing evidence that Teotihuacano scribes at times did produce more lengthy texts. Much as the text of the Plaza de los Glifos presents some evidence of the format, layout, and content of ancient codices at Teotihuacan (Nielsen & Helmke 2011, pp. 360–362), depictions of what could be codices paraded in processions of priests are also known from the murals of the great metropolis (de la Fuente 1995a, 87–91). This evidence makes it clear that the ancient city must have also had an important codical tradition— although at present, it is entirely lost.

Figure 3

Detail of the murals of Techinantitla showing a feathered serpent slithering above a series of trees qualified by glyphic compounds (drawing by Saburo Sugiyama, after Pasztory 1988a: Fig. VI.1).



In our textual survey we have relied on published sources on the murals (Miller, 1973; Berrin, 1988; de la Fuente, 1995b), ceramics (Rattray, 2001; Séjourné, 1966; von Winning, 1987), and more general works on the material and visual culture of Teotihuacan such as exhibition catalogues, monographs, and articles (Seler, 1915; Berrin & Pasztory, 1993; Robb, 2017). In the case of murals, it can be difficult to determine the number of texts when separate glyphs are set in a larger iconographic framework or occur as diminutive captions to the associated scenes. In such circumstances, such as the individual glyphic labels appearing in the murals of Portico 2 at Tepantitla, we count this as a single text, since the textual elements are confined to the single architectural unit (Browder, 2005).

Furthermore, when glyphic signs were used as semantic determinatives (marking materials and qualities of entities or objects), most commonly affixed to or infixed in speech scrolls (Nielsen, 2014a), these are not included in the count.[2] Equally, cases in which a single, isolated motif can function both as an iconographic element as well as a glyphic sign—such as a flower or a human heart—are excluded from our count. James Langley (1986, 2002) provides a number of glyph-like signs from as-yet-unpublished museum and private collections, but as these are extruded from their context, it is impossible to determine whether they are part of speech scrolls, iconographic compositions, or actual texts. Finally, unprovenanced pieces that are assumed to have come from Teotihuacan

2 Given these many parameters, we do not include the carved panels in pure Teotihuacan style found at the site of Las Parotas (located in the State of Mexico, c. 192 km southwest of Teotihuacan). For complete line drawings, iconographic analyses and reconstruction of their provenance, we point interested readers to the forthcoming study by Rivera and Valdez Bubnova (2017).

Table 1

The corpus of Teotihuacan writing according to provenance and supporting media.

or its hinterlands have been treated as a separate category in our count, to indicate their incidence in the total tally. With the above-mentioned criteria and caveats in mind, our survey has identified the following approximate (and conservative) numbers (Table 1).

Teotihuacan (site and heartland):	Frequency
Murals	52
Ceramics (incl. incense burners)	138+
Monuments	4
Minor sculptures (incl. plaques)	9
Petroglyphs and caves	4
Provenance unknown	65+
Total	**272+**

Teotihuacan (abroad):	Frequency
Murals	2
Ceramics (incl. incense burners)	45+
Monuments	15
Stuccoes	3
Mirrors	2
Total	**67+**

As can be seen, if we add the numbers of securely provenanced texts and those that are likely to originate from within Teotihuacan's heartland, we reach a total number of Teotihuacan texts below 300. We also know that many more texts written in Teotihuacan writing exist in bodegas, in museum storerooms, and in private collections, just as others await archaeological discovery. A striking observation is the high number of ceramics bearing texts, making this the most common Teotihuacan media for writing as preserved in the archaeological record. Of the 138+ identified texts, the vast majority come from the residential compounds of Tetitla (n = 35+) and Zacuala (n = 14), whereas numerous other examples are reported from Santiago Ahuizotla and Azcapotzalco (von Winning, 1987). Evidently, there is enormous potential for expanding the corpus once additional ceramics, complete as well as fragmentary, are made accessible to researchers. Another interesting, although less prominent, trend is the relatively high number of carved stone monuments with Teotihuacan-style texts that occur outside the Teotihuacan heartland (n = 15) compared to the four from within. This may reflect a local preference for other types of media for inscriptions, or could be the result of the destruction of Teotihuacan since Epiclassic times. Certainly, freestanding megalithic monuments were not common in central Mexico, which probably affects the distribution of these numbers. Something similar can be said about the smaller sculptures and other portable objects such as *almenas* and plaques, of which only seven are known from the Teotihuacan core area. It is also surprising that no inscribed mirror backings have been encountered at Teotihuacan, but appear twice outside the capital area in the Cuitzeo Basin of Michoacan (Filini, 2004, p. 69) and at Copan in Honduras (Nielsen, 2006).

Temporal Distribution

Part of the fame of Teotihuacan rightly belongs to the vibrant and bold polychromatic murals found in the some of the affluent compounds of the city. Despite the intricacy and importance of these murals, their temporal placement is, for the most part, unresolved. Instead, most art historians have dated these to sometime during the apogee of the city, which is to say during a span of about five centuries or so, between the Miccaotli and Metepec phases (Berrin, 1988; Berrin & Pasztory, 1993; Cowgill, 2015, p. 206) (Table 2). This rather long temporal span is essentially useless and provides no concrete information that can be used by iconographers and epigraphers to obtain a more fine-tuned and diachronic appreciation of the stylistic features under scrutiny. Nevertheless, a close examination of the mural corpus is beginning to reveal which stylistic features can be segregated into early and later horizons. Further, intersite comparisons are also yielding good results. Thus, based on comparisons to the murals at the site of El Rosario (located 140 km to the northwest of Teotihuacan), which have been dated to AD 200–250 by calibrated AMS dates (Fenoglio & Viramontes, 2014; Nielsen & Helmke, 2014a; Nielsen et al., 2019a, pp. 17–18), we can see that some of the murals in Portico 13 at Tetitla (Séjourné, 1969, pp. 104–105) and also the Storm God murals of Techinantitla (Millon, 1988, pp. 96–104) probably date to the same range.

Table 2

The main ceramic complexes of Teotihuacan (after Rattray 2001: Fig. 2, p. 435).

Teotihuacan Chronology	Gregorian dates
Coyotlatelco	AD 700–900
Metepec	AD 550–650+
Late Xolalpan	AD 450–550
Early Xolalpan	AD 350–450
Tlamimilolpa	AD 250–350
Miccaotli	AD 150–250
Tzacualli	AD 0–150
Patlachique	150 BC–AD 0

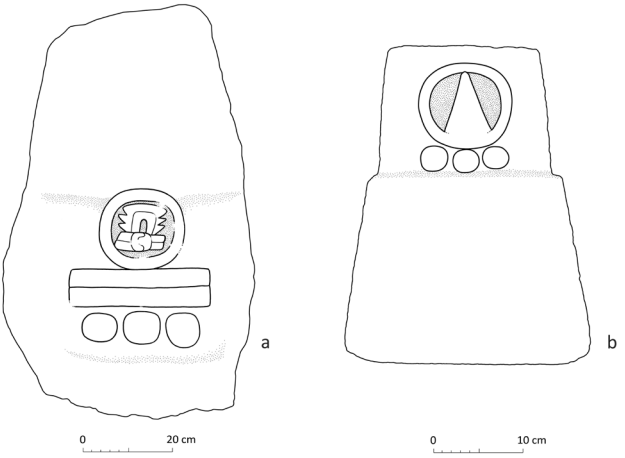
In terms of stylistic assessments, some attempts have been made to create a broad, temporally-sensitive typology of murals, arranged into periods and phases (Millon, 1972; Lombardo, 1995). Pasztory, focusing on the content and composition of the murals, suggested another sequence, with impersonality and simplicity characterizing the early history of Teotihuacan, whereas glyphs and individuals figure prominently in the late history, allegedly a sign of "a preoccupation with communication" (Pasztory, 1988b, p. 75). These attempts have, however, been met with some incredulity on the part of archaeologists since some of the categorizations run against stratigraphic evidence and ceramic-based dating, and in large measure seem to be grounded in preconceived notions about the sociopolitical trajectory of the city. Relying on paleographic features of Teotihuacan graphic conventions, we have noted that elements made of stone are

typically marked by triangular serrations as semantic determinatives, which in later examples use much duller lunate forms to denote the same material. This paleographic feature allows us to date the murals of Portico 1 of Patio 3 at Atetelco to a later phase of mural painting (Helmke & Nielsen, 2014, pp. 81–82). Furthermore, examining the paleographic features of the Mayan glyphs painted on murals in the Tetitla compound at Teotihuacan, and comparing these to well-dated monuments in the Mayan area, has allowed us to date these murals squarely to the late Xolalpan phase, or more precisely to AD 475–534 (Helmke & Nielsen, 2013a). Continued work, taking into account such paleographic features as well as available stratigraphic and ceramic data, will eventually enable researchers to produce a more informed temporal seriation of Teotihuacan murals.

Other inscribed elements are equally difficult to date, including the rock art at Chalcatzingo, in particular the painted pictographs (Apostolides, 1987, pp. 192–193), and the petroglyphs at the Cerro de la Estrella (Helmke & Montero García, 2016, pp. 69–71), Xihuingo (Galindo Trejo et al., 2002, p. 261), and Axutla (Nicolas Latsanopoulos, personal communication, 2021), although the latter include calendrical notations with highly circular cartouches. The shape of these cartouches is a paleographic feature that is temporally sensitive, with Teotihuacan day signs enclosed within circular cartouches, in squared cartouches with rounded corners in the Epiclassic, and square frames in the Postclassic (Helmke & Nielsen 2011, p. 6, in press a) (Figure 4). The shape of the circular cartouches suggests that the aforementioned examples date somewhere between the second through sixth centuries AD. These calendrical signs also compare to those incised on a finely carved statuette of a coiled snake made of *tecalli*, or travertine (Helmke, 2017a, p. 327; Taube, 2011, pp. 78–79) and to those inscribed on the monuments raised at the summit of the Cerro Xoconoch, 6.3 km southwest of Teotihuacan (Helmke et al., 2013).

Figure 4

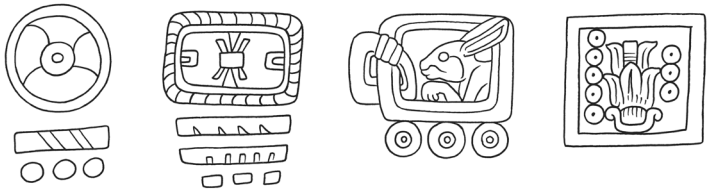
Inscribed Teotihuacan monuments: a) Monument 4 found at the summit of Cerro Xoconoch, bearing the date "13 house" (after Helmke et al. 2013: Fig. 4g) and b) Monument E104 of Frente E at the Plaza de las Columnas, inscribed with the date "3 flint" (after Carballo et al. 2017: Fig. 6.44) (drawings by Christophe Helmke).



Whereas the glyphic notations recorded in the murals, on monuments, and in rock art amount for about a quarter of the total corpus, we are on much better footing with ceramics, which together represent more than two-thirds of the entire glyphic corpus for Teotihuacan. These ceramics are embellished with modelled applique and bear post-slip incised designs or detailed polychromatic scenes painted onto a thin layer of gesso applied to the exterior of vessels. Together, these provide a rich source of evidence that can be arranged in chronological sequence given the very medium that bear these. The one vexing issue is not so much the relative sequence of ceramic complexes and their distinctive typological traits, but that disagreements persist between various research projects and individual researchers as to the absolute temporal parameters for the different complexes (Cowgill, 2015, pp. 7–11; Millon, 1976, p. 213, Fig. 1; Rattray, 2001, p. 435, Fig. 2; Sugiyama, 2005, pp. 1–2). In large part, this has to do with the dating of the collapse and near-total abandonment of the site at the end of the Metepec complex, since that date is placed to anywhere between AD 550 and 750 (Mazanilla, 2003). Despite this, there is relative agreement that the ensuing Epiclassic phase occupation is subsumed under the Coyotlatelco complex (c. AD 700–900) and that the main complexes of Classic Teotihuacan occupation range from Tzacualli (after AD 0–150), to Miccaotli (c. AD 150–250), to Tlamimilolpa (c. AD 250–350), to Xolalpan (c. AD 350–550), to Metepec (c. AD 550–650) (see Table 2).

One of the very earliest decorated ceramics, found in the tunneling excavations of the Pyramid of the Sun (Millon et al., 1965, p. 69, Fig. 95), is a small effigy cup representing an archaic form of the Storm God, the precursor to the Aztec deity *Tlālok*—the personification of rain and meteorological phenomena (Paztory, 1974; Nielsen & Helmke, 2017; Wrem Anderson & Helmke, 2013) (Figure 5a). This specimen has been dated to the Tzacualli phase and may be one of the earliest examples of these effigy vessels, which would continue to be produced well into the Epiclassic, with some neo-Classical examples produced by the Aztec in the Late Postclassic and deposited as offerings in the Templo Mayor (Carballo, 2007). The example from the Sun Pyramid shows the Storm God with bulging eyes and a large, wavy upper lip, the headdress marked with a simple knot. This knot is an integral part of the headdress in later examples and given the use of this sign in writing, may have functioned as the logogram for "headdress" (Nielsen & Helmke, 2020). In additional to modeling, some of the Tzacualli ceramics were also decorated using resist techniques, probably employing lost wax. Some of these vessels bear dots and linear configurations, but one in particular bears a feathered eye, a distinctive element of the feathered serpent (Berrin & Pasztory, 1993, p. 236), again making it clear that some of the very earliest examples of elements of writing at Teotihuacan date some time to the first or second centuries AD (Figure 5b). By Miccaotli, the decorative modes of ceramics had shifted to post-slip incisions and the application

Figure 5



The shape of day sign cartouches as a continuously evolving paleographic feature, ranging from a) circular (Early Classic Teotihuacan), to b) rectangular with rounded corners (late Teotihuacan), to c) squared with rounded corners (Epiclassic Xochicalco), to d) entirely square (Late Postclassic Aztec) (drawings by Christophe Helmke).

of additional slip to produce chromatic zones. As part of this complex, we begin to see vases with nubbin supports bearing features of what would become the so-called "four element" group (Figure 5c), which some scholars associate with the symbolism of fire and pyrolytic rituals (Langley, 1991, pp. 291–292, Fig. 15; von Winning, 1987 II, p. 79). Incising continues into Tlamimilolpa and begins to bear examples of more elaborate elements of writing, which become more commonplace by Xolalpan, including many examples of circular cartouches containing the Reptile Eye glyph, topped by a particular headdress (probably a record of a date) alternating with other motifs, including reptilian heads drawn from Mayan iconography (Taube, 2003, pp. 303–308) (Figure 5d). By Late Xolalpan, the most highly embellished ceramics are painted polychromatically on gesso underlay, displaying supernatural entities, fallen warriors, complex mythological scenes, and more. It is amidst these scenes that writing is found, naming deities and places and providing titles of warriors (Conides, 2018). Another ceramic medium where glyphs frequently appear are the theater-type censers, where especially the so-called Reptile Eye glyph (Beyer, 1921; Caso, 1961; von Winning, 1961) is commonly represented on *adornos* (Berlo, 1984, pp. 27–75). By the Metepec phase, molding had become the preferred form of decoration, either applying elements produced by stamps such as the Xi-9 Vase found cached in the Aztec Templo Mayor (López Luján et al., 2000) (Figure 5e), or as whole bowls cast in wooden molds, such as the renowned Calpulalpan bowl, and additional fragmentary specimens found at Teotihuacan and its environs (Linné, 1942, Fig. 128; Rattray, 2001, p. 587, Fig. 189; Taube, 2000, p. 12; von Winning & Gutiérrez Solana, 1996, pp. 21–27) (Figure 5f).

Graphic Characteristics

Much as with other Mesoamerican writing systems, the glyphic signs of Teotihuacan writing are highly figurative. This is to say that the pictorial qualities of the signs are drawn according to the graphic conventions—or artistic canons—of the culture in question. On par with other Mesoamerican writing systems, the glyphs of Teotihuacan writing thereby serve as referents to elements in the tangible world (Valdez Bubnova, 2012). We can

therefore readily identify signs that depict animals of the region, including the heads of raptorial birds, snakes, and coyotes, as well as seashells, including bivalves and gastropods, and plant life is represented by flowers and *pencas*—leaves of the maguey plant—as well as the ripening boles of cotton (Langley, 1991, pp. 287–289) (Figure 6). Elements drawn from the cultural world include torches, woven mats, headdresses, nose pendants, mirrors, shields, obsidian blades, and small paths marked by footprints, to name a few. Some of the signs that appear to be highly abstracted or even geometric are undoubtedly so on account of years of graphic evolution and owing to general unfamiliarity with Teotihuacan cultural conventions of graphic representations (Langley, 1986). That being said, some of the most abstracted signs, such as the aforementioned Reptile Eye glyph, exhibit some of the greatest degree of graphic diversity, owing to the prevalence of its use and its graphic evolution over the centuries, from at least the Early Classic to the Epiclassic (Helmke & Nielsen 2011, p. 16, in press a). As such, this is one of the signs that deserves a more thorough paleographic study to disambiguate and better attribute temporal spans to its many variants (Peñafiel, 1890, p. 186; von Winning, 1961; Langley, 1991, Fig. 14). As with any hieroglyphic writing system, the degree of figurativeness conveys nothing as to the function of signs, and cannot be used to distinguish logograms from phonograms, for instance.

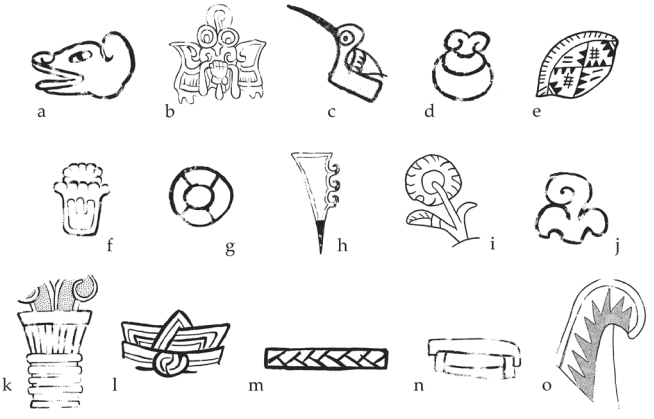
Figure 6

Teotihuacan ceramics from successive phases that exhibit elements of writing. a) Tzacualli Storm God effigy vessel (after Berrin and Pasztory 1993: 241, n. 117), b) Feathered Serpent eye rendered in resist technique on a Tzacualli vase (after Berrin and Pasztory 1993: 236, n. 108b), c) Miccaotli vase with nubbin feet with "four element" group (after Sugiura 2008: 51), d) Xolalpan stuccoed tripod vase recording a title and place name (photograph © Los Angeles County Museum of Art), e) The Fine Orange Xi-9 Vase found cached in the Aztec Templo Mayor (after Cowgill 2008: 26), f) the mold-made Calpulalpan bowl of the Metepec phase, showing a procession of high-ranking dignitaries, each named by accompanying glyphs (after Robb 2017: 212, n. 7).

Based on comparisons to other Mesoamerican writing systems, such as that of the Mayan and Aztec, we can see that glyphs can be rendered according to three basic variants, which we designate as geometric, head variants, and full-figure glyphs (Helmke & Nielsen, 2013b; Zender, 1999, pp. 47–48). This means that signs can be rendered in any three of these forms, depending on context, without change in function or meaning, ranging from more compact and stylized forms to highly figurative renditions that in large measure take on attributes of iconographic scenes. It is thereby necessary to isolate discrete signs in order to parse more complex scenes and identify the constituent glyphic elements. It is largely in part from the use of full-figure glyphs that Teotihuacan writing has been deemed as "emblematic" (Langley, 1986, 1991), especially since comparisons to the graphic properties of other writing systems have been lacking.

Thus, a common title for warrior-priests at Teotihuacan is written as a human heart that is being bitten, eaten, or is at least clenched within the mouth or maw of an entity. In its full-figure form, for instance, we see coyotes and so-called reticulated felines in the murals of Atetelco devouring human hearts, oozing blood rendered as stylized drops below (Figure 7a). As a head-variant, we see the same title represented on a stuccoed tripod vessel, where a feline bites into a bleeding heart (Figure 7b). And finally, in what may be the most conventionalized representation at Tetitla, we see a juxtaposition between a grinning mouth, replete with speech scrolls, besides a stylized heart (Figure 7c). Clear survivals from Teotihuacan, the same title is also represented in the Epiclassic, in the murals of Cacaxtla, on the frieze decorating the *tablero* of the Temple of the Feathered Serpents at Xochicalco, and on incense pouches of warrior-priests at Palenque (Helmke & Nielsen, 2011, pp. 26–27). The heart-devouring eagles rendered on the panels of the much later (c. AD 950–1150) Structure B at Tula probably express comparable "heart-eater" titles (de la Fuente et

Figure 7



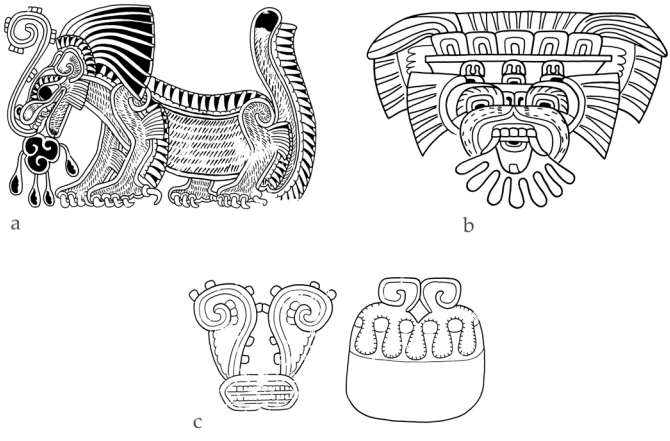
Figurativeness of glyphs used in Teotihuacan writing. Glyphs drawn from the animal world: a) head of a canine, b) a butterfly with additional qualifying elements, c) a hummingbird, d) a bivalve seashell, and e) a marine gastropod (possibly *Oliva porphyria*). The realm of plants: f) lateral flower, g) four-petalled flower, h) *penca de maguey*—maguey leaf, i) waterlily and its bud, j) cotton boll. From the human realm: k) lit torch, l) year-sign headdress, m) woven mat or *petate*, n) *tlapechtli*—bench or platform, o) obsidian blade (drawings by Christophe Helmke).

al., 1988, pp. 138–149, lám. 92-95a; Helmke & Nielsen, 2013b). This graphic diversity has generally been overlooked, and we can now recognize it as a fundamental feature of Teotihuacan writing—one shared with other writing systems of Mesoamerica, both contemporaries and descendants.

One of the most widespread graphic principles of Mesoamerica is that of *pars pro toto*, wherein any larger entity or object can be referred to by its most diagnostic feature. Thus, at La Ventilla in Teotihuacan, we see a reference to deer through its antlers (Nielsen & Helmke, 2011, 355–357) (Figure 8a). In the supernatural realm, the highly distinctive "goggles" of the Storm God serve as its identifying elements (Figure 8b), and the feathered serpent is identified by its distinctive feather-rimmed eye (Figure 8c), whereas the netting characterizing the reticulated felines from Tetitla and Atetelco can be reduced to a single pair of woven strands (Figure 8d).[3] From the cultural realm, we can see a house abbreviated to a single *almena*—a distinctive decorative merlon of typical flat central Mexican rooves (Nielsen & Helmke, 2014b) (Figure 8e). Necklaces in particular, and jewelry in general, are simplified to a single strung bead (Taube, 2000, pp. 19–20, 2011, pp. 84–85) (Figure 8f). A lone footprint may equally designate a more substantive path of travel, or roadway (Taube, 2000, p. 30; von Winning, 1987 II, pp. 41-46) (Figure 8g). Concerning headdresses, their depictions in writing serve, by metonymy, to embody commensurate social stations and ranks, and their constituent parts thereby point not only to whole headdresses, but also to corresponding titles. Thus, a distinctive tassel of the eponymous Tassel Headdress designates the title of that office (Millon 1988) (Figure 8h), whereas elongated knots—quite possibly a logogram for "headdress"—served to name particular headdresses in writing (Nielsen & Helmke, 2020).

Figure 8

The "heart-eater" title in Teotihuacan writing, written in a) full-figure form, b) as a head-variant, and c) in geometric form (drawings by Christophe Helmke).



3 The woven strands on the body of the "Net Jaguar" may well serve as semantic determinatives, qualifying these creatures as having certain abilities indicated by the interlaced woven lines.

This brings us to the question of glyph blocks and sign combinations. Unlike Eastern Mesoamerican writing systems (such as Mayan and Isthmian) where glyphic elements are preferentially presented in squared forms called glyph blocks, in Western Mesoamerican writing systems, sign compounds are generally freer. This is to say that these are both unbounded and that the internal reading order, or sequencing of the grouping, is non-linear—much as with Aztec writing, as well as earlier Toltec and Epiclassic writing. The result is that the constituent parts have to be identified on first perusal and potential combinations evaluated introspectively, before the reader opts for the most plausible solution and/or intended coda. The combination of signs is also partly motivated by the manner in which these may fit together, and thereby qualifying items can be placed beside, atop, or below that which is being modified (Taube, 200, Fig. 23; Colas, 2011; Nielsen, 2014a). For instance, the glyphic label to a figure represented in the murals of Techinantitla includes a single tassel above the head of a coyote, yet the reading order is unclear (Figure 9a). Should it be read from bottom to top, and as such with a syntactic order of *name* followed by *title*, or the reverse? In this case, resolution requires knowledge of the underlying syntax and basic word order of the language recorded in the glyphs.
In other instances, combinations can be made by placing signs within the syntactic head by infixing it within the main sign. This is what is seen in a series of different toponyms, naming particular mountains and their qualifiers infixed within, including a *nopal* cactus for "nopal-mountain," a howling coyote for "coyote-mountain," or a star for "star-mountain" (Helmke & Nielsen, 2014). Another interesting feature of Teotihuacan writing is that groupings of glyphs are often repeated across murals, as though the combinations of signs together constitute decorative elements (Figure 9b), adhering to what may be described as heraldic aesthetics (see Langley 1986). This is a feature shared by Cotzumalhuapan writing along the Pacific piedmont of Guatemala (Chinchilla, 2011), which suggests to us that the latter may be derived from the former.

Figure 9

Examples of the use of the *pars pro toto* principle in Teotihuacan writing, wherein the most distinctive element is used to represent a larger entity (drawings by Christophe Helmke).

Much of our ongoing work involves identifying the signs used in Teotihuacan writing, and ascribing them provisional semantic values is based on knowledge of the culture and sign usage in other Mesoamerican writing systems. At times, however, we have been able to benefit from rare biscripts, functioning essentially as the famed Rosetta Stone of Egypt, wherein parallel entries are made in two different writing systems, each recording their own language. One fascinating instance are the stucco friezes on the lower terraces of Structure 2 (the Temple of the Cormorants) at the Mayan site of Dzibanche in modern Quintana Roo, where large Teotihuacan-style mountains are represented, that enclose a series of qualifying elements drawn from Teotihuacan writing. Yet in addition to the elements of writing from Teotihuacan, the Classic Mayan glyph *witz* "mountain" has also been added, making the semantic equivalence clear and confirming the identification of the sign in Teotihuacan writing (Helmke & Nielsen, in press b).

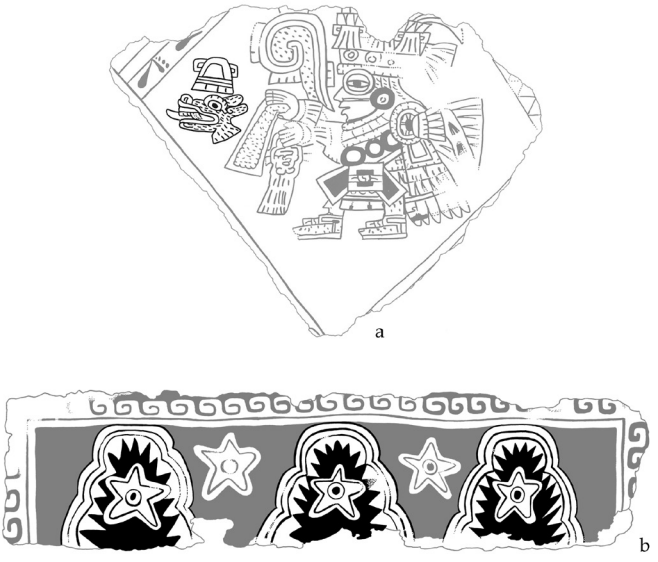
Regarding calendrical notations, these have also been identified at Teotihuacan, and these provide calendrical signs of the 260-day religious calendar, the precursor of the *Tōnalpōwalli* or "count of days" of the Aztec. In that system, twenty named days are distinguished from all the other signs in the writing system by enclosing these off in circular cartouches, to indicate their calendrical function. The underlying parameters of this calendar is a set of twenty individually named days, which occur in a fixed sequence, and combine with thirteen numerical coefficients. It is this pairing of named days and coefficients that produces a greater sequence of 260 uniquely named days, before the cycle begins anew. Despite decades of research, only 8 of the days' signs have been identified for Teotihuacan (Helmke & Nielsen, 2013b; Urcid, 2012, p. 857) (Figures 10a–h).

Interestingly, the numerical coefficients in Teotihuacan writing are systematically placed below the named day, a pattern that may be linguistically significant. The numerals at Early Classic Teotihuacan employ a combination of dots (for units) and bars (for groups of five), which could be paired together to yield higher numerals, up to 14. Outside of the more formal contexts of writing, painted cursive forms are documented wherein units are marked with dashes and fives as striped, elongated rectangles (Arreola, 1922) (Figure 10i). Based on the mechanics of the calendars, the first named day of the *Tōnalpōwalli*, at the start of the solar year, can only be one of four evenly spaced days. These are known as the Year Bearers and theoretically form one of five different sets (Broda de Casas, 1969, pp. 27–29; Caso, 1967, pp. 40–41; Helmke & Nielsen, 2011, pp. 12–20). Based on patterns of ubiquity, the days most often named in the glyphic inscriptions are those that refer to named years, and thereby give an indication of the set of Year Bearers recognized in a particular culture. Based on these features, we find that there is good evidence to suggest that the dominant set of Year Bearers in Central Mexico went unchanged from

at least the Early Classic to the Late Postclassic, and involved the four days named "house" (3), "rabbit" (8), "reed" (13), and "flint" (18) (Helmke & Montero García, 2016, pp. 66, 73; Helmke & Nielsen, 2011, p. 15; Helmke et al., 2013). That one of these days was named using the Reptile Eye sign is also highly significant for inferring the narrow lexeme that this sign cues, with "reed" emerging as the most plausible (Helmke & Nielsen, 2011, pp. 11–12). This also accounts for the fact that the sign functions in a toponymic capacity to designate Teotihuacan (Stuart, 2000, pp. 501–506), and abroad, such as in the corpus from Escuintla, serves in an emblematic function (Hellmuth, 1975; Berlo, 1984).

Figure 10

The question of sign combination and reading order: a) Mural fragment of Techinantitla showing an individual bearing a tassel headdress, named in the accompanying glyphic caption by a singular tassel and the head of a coyote with a lolling tongue (drawing by Saburo Sugiyama, after Millon 1988: Fig. V.2). b) The toponym "Star Mountain," written as a repetitive sequence in the murals of Zona 5A (drawing by Christophe Helmke, after Helmke and Nielsen 2014: Fig. 7a).

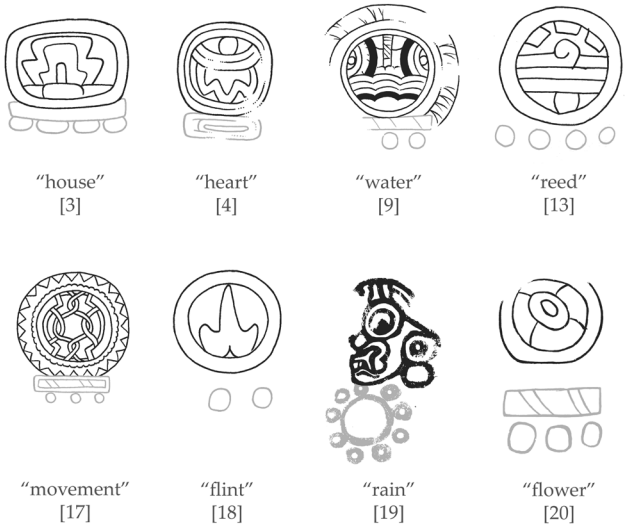


Glyphic notations at Teotihuacan writing are generally quite terse, being reduced to a single glyph block and providing a single date, toponym, or caption to a person depicted. As such, one can say that the verbal complex is greatly deemphasized in Teotihuacan writing as long glyphic sentences are essentially unknown. This is an inherent feature of western Mesoamerican writing systems, where weight is placed on logographic spellings (as for instance with the Tenochtitlan school of Aztec writing; Lacadena, 2008, 2019). When verbs are recorded, these appear as logograms, as uninflected verbal roots, often serving as captions that qualify the iconographic scenes that these accompany. Thus in the texts of Tetitla, we see a procession of priestly figures in the murals around Patio 1, performing scattering rituals with the glyphic notations that qualify the scene spread across various murals (Figure 11). These glyphs provide a toponym (possibly naming the site of the pilgrimage), as well as what may be the names of historical individual and the action itself is recorded as a pair of disembodied

hands that scatter, thereby recording the verb of the action depicted in the iconography (Helmke & Nielsen, 2014, pp. 91–94; Taube, 2000, pp. 23–24). With this more holistic understanding of these murals, we can see that the predicate and its main arguments are recorded in writing, although their spatial dispersal across the mural has stymied the efforts of earlier scholars. The combination of these scattering hands with an element referred to as an "enclosure sign" suggests that the latter may specifically function in verbal contexts, and distributional patterns in the writing of Teotihuacan, and the ensuing Epiclassic, support this observation (Helmke & Nielsen, 2011, pp. 34, 45–46; Helmke et al., 2017, pp. 100–101).

Figure 11

The calendrical signs of the Teotihuacano 260-day calendar, with approximate glosses and day sign number in square brackets (drawing by Christophe Helmke).



At times when a sequence of glyph blocks does occur in a linear sequence, a small space is introduced between them to separate parts of speech. This is seen, for instance, in the glyphic notations on the floor of La Ventilla. At the southern end of the courtyard is a combination of nine signs arranged in three columns, and given the regularity of the sign sequencing, we have been able to propose that these ought to be read in boustrophedon, which is to say sinuously in alternating directions by column (Nielsen & Helmke, 2011, p. 363) (Figure 14). Interestingly, boustrophedon is a feature of early writing systems and appears to speak of a more experimental phase, particularly before more standard reading orders were devised and established for a given writing system (see, for instance, the place of boustrophedon in early Greek, Etruscan, and Latin texts [Bonfante, 1996; Woodard, 2008]). Nevertheless, precisely the same type of boustrophedon is also known for Aztec codices, such as the Codex Boturini (Nielsen & Helmke, 2011, pp. 361–363), suggesting some continuity in this practice within the codical tradition.

Sign Inventory

The first attempt to produce a complete signatory for Teotihuacan writing took place as part of the doctoral work of epigrapher James Langley. This was eventually published in 1986 and appeared as a compendium of what he termed "notational signs," in which he included 193 "confirmed and probable signs," with an additional 36 "problematic signs" (Langley, 1986, pp. 223–228). In 2002, Langley published a revised version containing only 95 signs. The relatively high number of the initial signatory was induced by the inclusion of iconographic elements, such as feather arrays and fringes, but mostly due to his separation of signs that were obvious variants of the same sign (e.g., the "shell" sign that was presented as eight distinctive entries). There are still some examples of this in his much-reduced list, for example sign no. 232 that he identifies as a "frond"—although it probably represents an antler (no. 234)—or when he segregates a "butterfly" (no. 36), from a "butterfly head" (no. 109) and a "butterfly wing" (no. 228) into three separate signs. In the latter case, we analyze all the constituent signs, including the head and wing as *pars pro toto* variants of the greater butterfly logogram.

For the present study, we have prepared a new sign count, based on the textual corpus described above (not including signs from later periods that emulate Teotihuacan writing, such as the inscription from Temple 26 at Copan; Stuart, 2005). In so doing, and making conservative estimates by grouping possible variants of a sign together, we have obtained a total count of circa 116 signs. Examples that may turn out to be discrete signs are those involving footprints and hands. From Mayan and Aztec writing, we know that specific hand and finger positions, as well as alternate orientations, can cue completely different words and/or sounds, and we can expect similar conventions for Teotihuacan writing. In our count we also group head variants and full-figure variants of the same sign, as for instance felines represented in full-figure vs. head variants, and examples of *pars pro toto* where a diagnostic feature stands in for the complete sign. It is equally possible that some of the identified signs are polyvalent, functioning as logograms and phonetic signs depending on their context, although these differences cannot be adequately established at present.

Regardless, the count of signs is highly conservative and speaks of a general unity with other Mesoamerican writing systems, especially considering the other commonalities outlined above. These features together suggest that Teotihuacan writing had essentially the same workings and functioned in much the same way as any other Mesoamerican writing system. The 116 signs of Teotihuacan writing can be compared to the writing system of the ensuing Epiclassic which used c. 200 signs (Helmke & Nielsen, 2011, p. 1), to Mayan writing, which used anywhere between 300 and 400 signs in any given century (Knorozov, 1958, p. 289; Mathews & Bíró, 2008), and to Aztec writing, which most commonly used c. 450 signs (Cases

Martín & Lacadena García-Gallo, 2013). As the number of signs in a script says something of the type of writing system (i.e., whether it is logographic, syllabic or alphabetic) (Coe, 1992, pp. 32–43; Daniels & Bright, 1996, pp. 142–143, 155), and acknowledging that both Mayan and Aztec scripts are mixed logo-phonetic writing systems, it stands to reason that likewise, Teotihuacan writing (and the intervening writing of the Epiclassic) were equally logo-phonetic. The caveat must evidently be made that a greater emphasis is placed on logograms and logographic spellings in Western Mesoamerica, since that is a characteristic feature of the writing systems in that part of the world. Nevertheless, these are important conclusions to reach, which we hope will continue to guide future investigations. Turning to a retrospective, we will now provide a précis of previous research before concluding about the current state of decipherment.

Previous Research and State of Decipherment

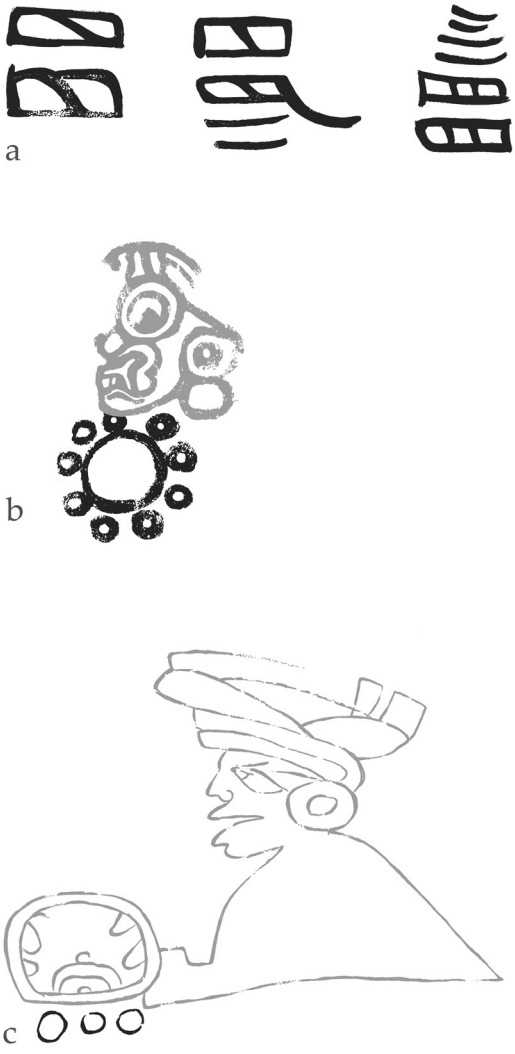
Given that Teotihuacan writing has only recently been identified as such, the state of decipherment is evidently still in its infancy. In short, the writing system of Teotihuacan has yet to succumb to a complete decipherment, but important progress has been made in identifying features of the writing system, especially with the growing realization that this script shares many features with other Mesoamerican writing systems (Taube, 2000, 2011; King & Gómez Chávez, 2004; Nielsen, 2004; Nielsen & Helmke, 2008, 2011, 2014b, 2020; Helmke & Nielsen, 2013b, 2014, in press b; Urcid, 2012). Among these are the advances made in identifying calendrical signs, anthroponyms, titles, and toponyms, even though these results have yet to be embraced in broader syntheses of Teotihuacan culture, most of which have been published by archaeologists and art historians. Cowgill's (2015) recent introduction to Teotihuacan, for instance, gives the impression that there was no real writing, and the script is compared to what he erroneously describes as the "pictographic signs" of the later Aztec (pp. 213–217). Similarly, Robb's (2017) substantial catalogue for a major Teotihuacan exhibition is strangely silent on the topic of writing.

Looking back into the research history of the field, the current situation is hard to understand, as scholars had already recognized the basic features of the writing systems by the early twentieth century. Thus, early work by Arreola (1922) and Beyer (1922) discussed examples of writing at Teotihuacan, and in the following decades Caso (1937, 1959, 1961, 1966, 1967) was, with his characteristic pan-Mesoamerican and comparative approach to the material, the great catalyst in presenting evidence

for writing and the calendar at the ancient metropolis (Figure 12). In a time where Mayan writing had yet to be proven to be logophonetic, Caso (1966) understandably classified the writing of Teotihuacan as "ideographic" (p. 249). From the 1940s and onwards, von Winning (1947, 1948, 1961, 1979, 1987) published numerous and invaluable studies on Teotihuacan iconography and "signs," although von Winning himself appears to have been somewhat ambivalent on the subject of writing.

Figure 12

The graphic variation and placement of numerals in Teotihucan writing: a) numerals painted on slate slabs found in the Templo de Tláloc (after Arreola 1922: Fig. 97). b) Single digit embellished with small peripheral dots, painted floor Plaza de los Glifos, La Ventilla. c) Numeral "three" below the so-called Reptile Eye sign, here used in its calendrical capacity (drawings by Christophe Helmke).



In 1973, Millon published a seminal paper in *American Antiquity* where she insightfully concluded that "the writing system of the Teotihuacanos may not have been so completely different from other Middle American writing systems, as superficially it appears to be" (p. 311). Millon (1988) would later pick up on some of these initial observations in a study of the Tassel Headdress. In two brief and largely overlooked papers, epigrapher Barthel (1982, 1987) insisted on the phonetic quality of some of glyphs at Teotihuacan, pointed out the existence of texts, and called for a more systematic approach, involving a sign inventory and a corpus of texts. Barthel (1987, p. 10) also emphasized the relationship between the script and a single language, stating that:

> A wholly "visual approach" tempts one to conceive of the graphemes as interculturally understandable signals. Clearly the next step leads to postulate that the signs of the Teotihuacanos formed a corpus of signals intelligible to all Mesoamericans—"airport pictograms," as it were, or "religious propaganda" for arriving pilgrims in a multi-ethnic metropolis. In contradiction to this, I take the view that the total stock of signs (as used by the "senders" and as understood be the "receivers") by necessity was firmly rooted into the *lingua franca* of Teotihuacan.

In Barthel's view, the language of the texts were most likely to be "Proto-Nahua." Nawatl was also favored by Cowgill (1992) in his interpretation of the Techinantitla texts. Likewise, King and Gómez Chávez (2004) have proposed readings of the text from La Ventilla, suggesting linguistic affiliations to proto-Nawatl-Pochutek, which have been recently taken up by Whittaker (2012, 2019). Their suggested readings are not, however, based so much on script internal evidence, but consist mostly of applying Nawatl lexemes to the glyphs, most of which appear to be logograms. For example, the "arm" glyph at La Ventilla and in the murals of Techinantitla are attributed the value **AKOL** given its resemblance to the Aztec logogram for "shoulder, arm" (King & Gómez Chávez, 2004, pp. 218–219; Whittaker, 2019). Yet, matching lexemes to the graphic appearances of signs is not the proper method for positing a phonetic decipherment, as in the absence of additional evidence, it is an exercise that could be undertaken on the basis of any other Mesoamerican language. The similarities of the logograms are such that one can indeed posit a continuity in the inventory of logograms from Classic to Postclassic times, but it does not necessarily imply a continuity in the encoded language. Despite our caveats, an early form of a Southern Yuto-Nawan language, remains a valid candidate for the language recorded in Teotihuacan writing (Nielsen & Helmke, 2011, pp. 345–349; Pharao Hansen, 2021)—something we return to below.

As already mentioned, Langley had published his valuable compendium of so-called "notational signs" in 1986 (followed by additional articles in 1992, 1993 and 2002), which for the first time provided a large collection of Teotihuacan glyphs to the scholarly community, and approached the subject in a consistent and systematic manner. Langley did less in terms of decipherment and did not attempt to group the signs into semantic categories. A few years later, however, in 1989, Berlo greatly contributed to the field with a seminal study that demonstrated that writing in central Mexico can be traced all the way back to Teotihuacan and that the later Epiclassic and Late Postclassic scripts were inheritors of the same "basic principles," thereby convincingly demonstrating how several signs were in use for at least ten centuries. In 2000, Taube (2000a) published *The Writing System of Ancient Teotihuacan*, which initiated a new period of research and kick-started our own interest in the topic. Having worked on Teotihuacan iconography for nearly two decades (Taube, 1983, 1986, 1992a–b), and accounting for his familiarity of other Mesoamerican writing systems, Taube's approach was inexorably comparative. This productive approach allowed him to outline different semantic categories of signs (calendrical signs, names, titles and toponyms), just as he pointed out substitutional patterns and the occurrence of several Teotihuacan-style texts outside Teotihuacan itself. In 2011, Taube followed up on his seminal study with a chapter in which he added more examples and once more emphasized the role Teotihuacan had had in developing a script tradition in central Mexico.

The past two decades have seen an increase in publications related to Teotihuacan writing, including several of the above-mentioned sources. Others include de Guerrero's (2005, 2014) two flawed publications purporting to provide a partial sign catalogue, which have added little or nothing new to the existing literature—not least of which since the later publication is a duplicate of the former. Of much greater merit was careful examination by Colas (2011) of Teotihuacan speech scrolls and their affixed and infixed glyphic signs. In addition to identifying logographic signs, Colas (2011) also suggested that some of the signs were examples of "semasiographic writing," a proposal that runs counter to most recent suggestions (for a critique, see Nielsen, 2014a, pp. 177–182). In 2012, Urcid presented a new and welcome attempt to relate Teotihuacan writing to other central Mexican and western Mesoamerican writing systems. Importantly, following Berlo and others, Urcid (2012) emphasized the historical content of the texts, thereby distancing his work from the continued tendency to regard Teotihuacan as an impersonal and ahistorical "utopia" in Mesoamerica. Most recently, a surprisingly lucid study of Teotihuacan writing has appeared by Italian archaeologist Domenici (2017), drawing on the continuities between the Late Postclassic writing of the Aztec to further our understanding of particular textual compositions and glyphic combinations. It is hoped that further studies of this kind will appear in the future, further refining our

understanding of Teotihuacan writing and the complex interplay between text and imagery.

Surprisingly, Mexican scholarship has not been much concerned with writing at Teotihuacan, possibly a result of the notion of "pictographic writing" that has come to dominate the field and given the reluctance to regard central Mexican scripts as actual writing. Nevertheless, it is hoped that recent work by Valdez Bubnova (2008, 2012), who has focused on the glyphs and text from La Ventilla, Teopancazco, and Zacuala and shows how the glyphs are representations of cultural entities inherent to Teotihuacan culture, will inspire a renewed effort among Mexican scholars to intensify research on Teotihuacan writing. An all-important step in this process will be the increased availability of Teotihuacan ceramics housed in storerooms and bodegas across the world. As our survey of texts clearly shows, this appears to have been the preferred media for writing, and further progress in the decipherment requires access and integration of this dataset.

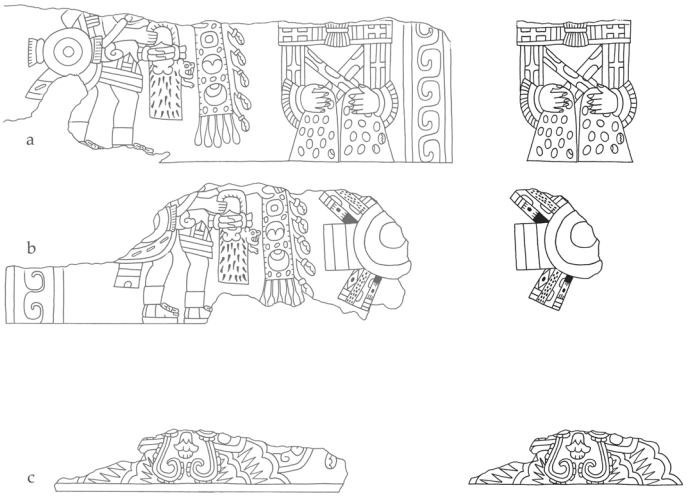
Candidate Languages

The question of language at Teotihuacan is inevitably a highly thorny and contentious issue. This is due to the fact that Teotihuacan was a large multi-ethnic metropolis, as has been demonstrated by excavations since the 1920s revealing evidence of ethnic enclaves or barrios ("neighborhoods") along the perimeter of the monumental city center. These include the Oaxacan enclave to the west, with evidence of Zapotecan funerary urns and burial practices, Oaxacan grey ceramics, and a stela bearing a Zapotec date (Millon, 1973, pp. 41–42, Figs. 60a–b; Ortega Cabrera & Archer Velasco, 2014; Ortega Cabrera et al., 2016; Rattray, 1993); a Mayan enclave in the east in what is usually known as the merchant's barrio, with polychromatic ceramics from the Mayan lowlands and circular residential structures typical of northern Veracruz (Clayton 2005; Rattray 1987); a Western Mexican enclave, adjacent to the Oaxaca barrio, with ceramics and figurines and burials typical of Michoacan (Gómez Chávez & Absaolo Hernández, 2011). Based on such overwhelming evidence, it is clear that Teotihuacan was a multi-ethnic metropolis where many different languages were spoken in antiquity (Figure 13). Yet, the question remains as to what language the local population spoke, and whether this served as the primary *lingua franca* of the site for administrative, commercial, and religious activities. In this view, can we speak of Teotihuacan as having one dominant and highly codified H (high) language used by the ruling elite and functionaries of the state versus other vernacular and foreign languages considered as L (low) languages? The alternative would be to posit a multilingual continuum of exoglossic

languages or a situation of polyglossia. Regardless of these models, what language did Teotihuacan writing record? Given the multi-linguistic situation, is it not most likely that Teotihuacan writing recorded the dominant H language of the site, in much the same way that Latin was the dominant language of Rome?

Figure 13

Murals of Patio 1 at Tetitla showing a pilgrimage of priestly figures accompanied by a series of glyphic captions (highlighted in the column to the right). Together these glyphs comprise a larger clause: a) Portico 1, Mural 1, with the scattering verb referring to the action depicted in the imagery, b) Portico 1, Mural 3, with what may be an anthroponym and c) Portico 2, Mural 1, with the toponym where the pilgrimage is thought to have culminated (drawings by Christophe Helmke).



Faced with these uncertainties and the comparatively little corpus of texts that are terse and fragmentary in the extreme, it is understandable that the writing system of Teotihuacan has not attracted the attention of many scholars. Some have also chosen to abandon attempts altogether and have instead labeled all decipherment efforts as "adventurous" (Valdez Bubnova, 2014). Given the evident importance of Teotihuacan and the uniqueness of its culture and place in Mesoamerican culture-history, other researchers have turned their backs on the manifest monumental architecture (Murakami, 2010; Trigger, 1990) and have begun to weave highly unusual and as-yet-undocumented social structures, imagining Teotihuacan as a type of utopia where governance was by deliberative assembly or quadrumvirate or the like (Manzanilla, 2007; Pasztory, 1997; for a critique see Nielsen, 2014b; Nielsen & Helmke 2020; Smith, 2017). In this atmosphere, some are now suggesting that Teotihuacan writing did not record language after all, but was instead designed from the onset to convey extra-linguistic messages to a multi-ethnic population without making any recourse to language (Pasztory, 1997, pp. 192–194); or as, Houston (2004, pp. 275–276) formulated it, an "open" script that could "probably be understood across language boundaries".[4] Whereas these ideas may be attractive to some, finding their social dreams in an imagined prehistory, none of these are met with correspondences in attested early civilizations (Trigger, 2003).

4 In contrast to the "closed" writing systems, like Mayan writing, that were characterized by a "fuller commitment to linguistic transparency" (Houston, 2004, 275).

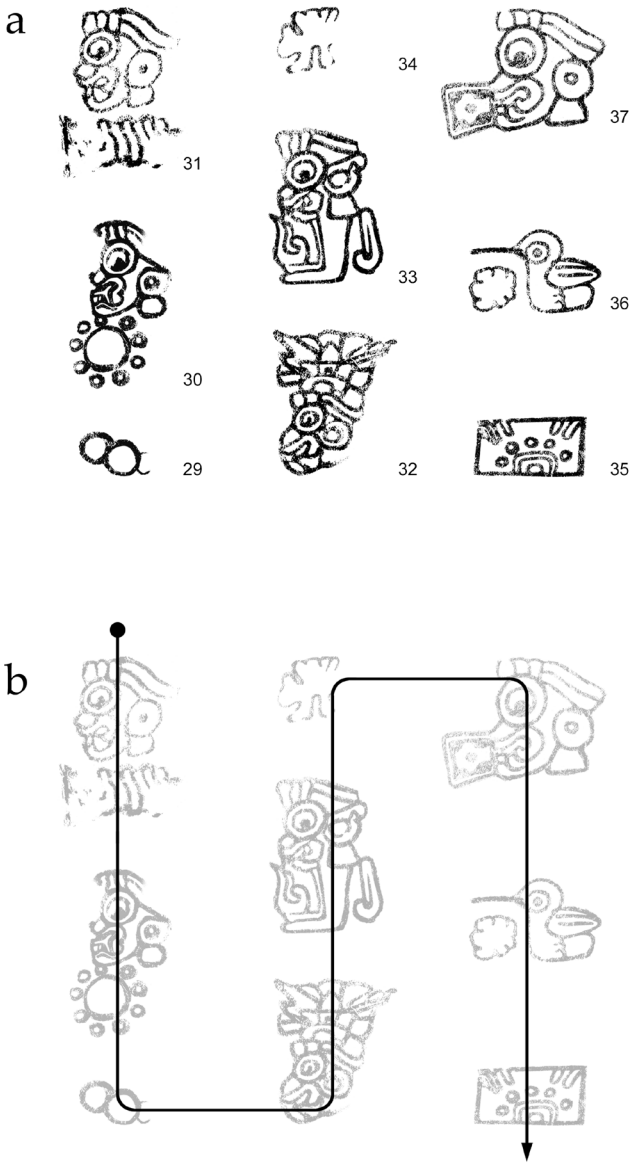
Other researchers have instead made clear attempts to identify elements in Teotihuacan writing and to pair these to Native American languages, known from the region around the time of the Spanish conquest. The one language that has consistently been highlighted in this regard is Nawatl, the language of the Aztec, with the assumption that an early stratum of this language may have been present in Central Mexico from at least the Early Classic onwards. These suggestions have been met with staunch criticism from linguists, especially Kaufman (2001, pp. 6–7, 28–29), who proposes that Nawatl arrived late to Mesoamerica, no earlier than the collapse of Teotihuacan. Nevertheless, one of the early suggestions posits that Teotihuacan writing was closely linked to one language, proto-Nawatl in this case, as suggested by Barthel (1987, p. 10), who went on to propose readings on the basis of this hypothesis (Barthel, 1987, pp. 16–17). Taube (2000), in his seminal paper on Teotihuacan writing, did not make any claims as to language affiliation, although in an endnote one can see an attempt to parse the so-called "twisted root" sign by analogy to Nawatl (pp. 9, 51). As we have touched upon above, King and Gómez Chávez (2004) as well as Whittaker (2012, 2019) have also attempted to read combinations of signs in Nawatl at La Ventilla and Tetitla, in both cases suggesting that these record ancient toponyms of the area.

Considering script-internal evidence, we can reflect on the constituent order of clauses and the order of modifiers in a noun phrase. The numerical coefficient in calendrical contexts is interesting in this regard, since it is systematically placed below day signs in Teotihuacan writing, a pattern also found in the Otomanguean writing systems of Oaxaca (Zapotec and Ñuiñe) (Prem, 1973) and in the Epiclassic writing system of central Mexico (Helmke & Nielsen, in press a). This scribal convention may codify a feature of basic word order, demonstrating affiliation to a distinct language family, as numerals in Classic Mayan texts as well as Isthmian writing are preferentially set before, or atop of the signs that they qualify, in keeping with the syntax of the languages recorded in these writing systems (i.e., Mayan and Mije-Sokean, respectively). The conclusion is that the positioning of the numerals may signal affiliation to an Otomanguean language. Likewise, examination of the linear sequence of text at La Ventilla suggests that each of the three segments exhibits a syntactic head (each naming a particular aspect of the Storm God) followed by two qualifying elements (Figure 14. This suggests a syntactical order wherein these clauses are subject-initial, and qualifiers close the noun phrase. These are underlying features that should be accounted for when evaluating the language candidates against one another.

Linguists have also advanced their own theories, which for the most part espouse language families other than Yuto-Nawan. These include Lyle Campbell, who has suggested that Totonakan played a key role in the founding of this metropolis (Campbell, 1997, p. 161); whereas

Figure 14

Example of boustrophedon writing in the glyphic texts of the Plaza de los Glifos at La Ventilla: a) reflecting original disposition and b) with proposed reading order superimposed (drawing by Christophe Helmke, after Nielsen and Helmke 2011: Fig. 16).



Kaufman and Justeson (2008, p. 65) have suggested that the dominant language at Teotihuacan was a now-extinct branch of a Mije-Sokean language. At present, these linguistic proposals have to be considered as highly tentative. More cautiously, Nielsen and Helmke (2011, pp. 345–349), have attempted to outline the various language candidates that are most likely for Teotihuacan and have used epigraphic evidence to assess their respective merits. Whereas the matter is far from resolved, we can only urge researchers to keep an open mind and to consider the probable role and presence of early Otomanguean languages, especially that of proto-Otomi-Masawa (or even a later western branch Oto-Pamean), since that language family has not been conclusively evaluated for its potential with regards to language candidates. At present, none of the languages listed above should be discarded, and all should be treated as viable candidates, in spite of the clear preference that scholars have given to Nawatl.

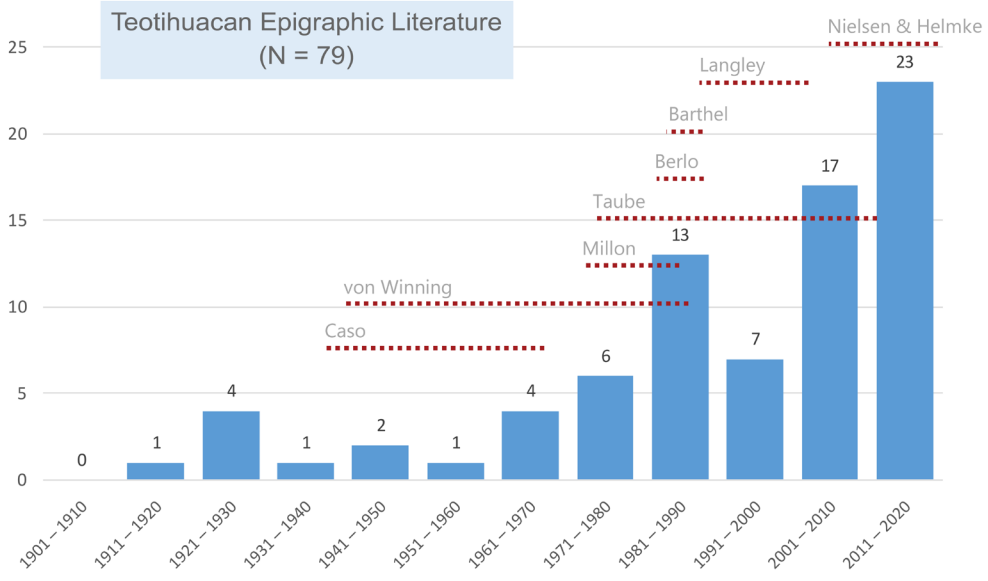
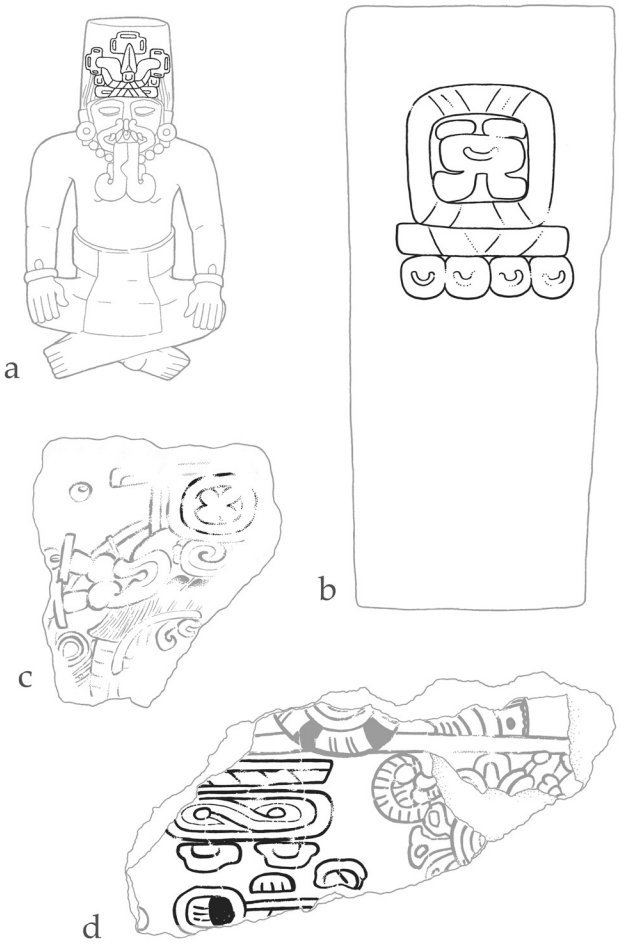


Figure 15:

Chart showing the number of publications on Teotihuacan writing that have appeared over the last century, arranged by decade, with the publication spans of major researchers also presented (chart by Christophe Helmke).

Figure 16:

Samples of foreign writing at Teotihuacan, including: a) Zapotec ceramic urn (drawing by Allen Sellen, after Sellen 2005: MNA 9-4878), and b) the Zapotec stela, both found in Tlailotlacan, the Oaxacan barrio. c) Maya-style mural fragment found at the Plaza de las Columnas (after Sugiyama et al. 2016: 8), and d) partial Maya text on a mural fragment found at Tetitla (after Helmke 2017b: Fig. 1a) (drawings by Christophe Helmke).



Conclusion

In the overview of Teotihuacan writing provided above, we can see that the system was in use at least during the apogee of the great metropolis (between the first and seventh centuries AD), although antecedents can perhaps be traced back to the incipient writing documented at sites such as Tlatilco and Tlapacoya in the Middle Preclassic (Coe, 1965, p. 33; Paradis, 2017, pp. 120–139). Likewise, the writing system of Teotihuacan subsisted and was inherited by the city-states that arose during the Epiclassic, where the script maintained in use and continued its development (Berlo, 1989; Helmke & Nielsen 2011, in press a). Although the writing system was used predominantly at the great capital and also within the central Mexican heartland of Teotihuacan cultures, the same script was also used within the farther reaches of the realm under Teotihuacan influence and remarkably so within what may have been a Teotihuacano enclave on the Pacific piedmont of Chiapas and Guatemala.

The graphic features of Teotihuacan wholly agree with analogous traits of other Mesoamerican writing systems, perhaps most noteworthy being the high degree of figurativeness. Other graphic features, such as logography, graphic variation between "geometric" head-variants and full-figure forms, the recourse made to *pars pro toto*, compounding, and infixation, are among the features shared between the Mesoamerican scripts. The number of signs identified as part of this research are also wholly in keeping with the known mixed logo-phonetic writing systems of Mesoamerica. Despite the relative terseness of texts and the relatively small size of the glyphic corpus, we have a few key examples wherein linear texts are written in columnar format, in keeping with contemporary Early Classic scribal practices across Mesoamerica. Likewise, the use of bars and dots at Teotihuacan is a shared Mesoamerican feature of the Classic period, much as the use of an early form of the *Tōnalpōwalli*, although the particulars of the calendar were specific to Teotihuacan culture.

To briefly summarize, despite some hearty disagreements and decades of definitional confusion, there is again a growing consensus among epigraphers and other scholars that Teotihuacan developed a writing system (or at least inherited it from the as-yet poorly understood scripts of earlier Preclassic forebears at Tlatilco and Tlapacoya). At present, it is difficult to distinguish between logograms (which are plainly overrepresented) and phonetic signs (which are at least grossly underrepresented). In our own work (Nielsen, 2004; Nielsen & Helmke, 2008, 2011, 2014b, 2020; Helmke & Nielsen, 2014), we have opted for semantic rather than phonetic decipherments, and believe this is the best way to proceed, until the issue of language affiliation has been resolved and the provisional readings can be tested.

Future studies of individual signs should ideally include all known occurrences and variants across time, and should carefully evaluate their context (other signs as well as any accompanying iconography). At the present stage of decipherment, careful and comprehensive documentation and comparison must have higher priority than premature and highly tentative phonetic readings. What also remains is continued work in producing a revised and more formalized sign catalogue or signatory that is both based on, and builds upon, that initially produced by Langley (1986, 2002). Given the enormous importance of decorated ceramics as a medium for recording writing in Teotihuacan cultures, their documentation needs to be systematized to prepare a corpus that is accessible to the academic community so that researchers may scrutinize these and the advances made. Examining sign compounds, we should note patterns of presence and absence to identify which signs appear to be optative, as this identifies signs as potential phonetic complements. Working with historical linguistics, prospective rebus usage of a selection of signs should be tested against candidate languages. This is an essential approach, as rebuses can only be resolved in a single language, given the demands of the semantics coded by the figurative features of a particular logographic sign, and the meaning of the homophony of the resultant utterance. Although it remains within the purview of hypothesis, it is hoped that the results of these tests may bundle together to a single language family, thereby enabling us to identity the most promising language candidate. In so doing, great progress may at last be made in the study of ancient Teotihuacan writing.

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References

Apostolides, A. (1987). Chalcatzingo painted art. In D. C. Grove (Ed.), *Ancient Chalcatzingo* (pp. 171–199). University of Texas Press.

Arreola, J. M. (1992). Caracteres alfabéticos o numéricos. In M Gamio (Ed.), *La población del Valle de Teotihuacán*, (Vol. 2, pp. 273–293). Mexico, D.F.: Instituto Nacional Indigenista.

Barthel, T. A. (1982). Veritable "texts" in Teotihuacan art? *The Masterkey 56*(1): 4–11.

— (1987). Deciphering Teotihuacan writing. *Indiana, 11*: 9–18.

Berlo, J. C. (1983). The warrior and the butterfly: Central Mexican ideologies of sacred warfare and Teotihuacan iconography. In J. C. Berlo (Ed.), *Text and image in Pre-Columbian art: Essays on the interrelationship of the verbal and visual arts* (pp. 79–117). Oxford: BAR International Series 180.

— (1984). *Teotihuacan art abroad: A study of metropolitan style and provincial transformation in incensario workshops, Vols. I–II.* Oxford: BAR International Series 199.

— (1989). Early writing in Central Mexico: *In Tlilli, In Tlapalli* before A.D. 1000. In R. A. Diehl & J. C. Berlo (Eds.), *Mesoamerica after the decline of Teotihuacan A.D. 700* (pp. 19–47). Washington, D.C.: Dumbarton Oaks Research Library and Collections.

Berrin, K. (Ed.) (1988). *Feathered serpents and flowering trees: Reconstructing the murals of Teotihuacan.* San Francisco: The Fine Arts Museum of San Francisco.

Berrin, K., & Pasztory, E. (Eds.) (1993). *Teotihuacan: Art from the City of the Gods.* San Francisco: The Fine Art Museum of San Francisco / London: Thames & Hudson.

Beyer, H. (1921). Algunos datos nuevos sobre el calendario azteca. *El Mexico Antiguo* 10: 261–265.

— (1922). Relaciones entre la civilización teotihuacana y la Azteca. In M. Gamio (Ed.), *La población del Valle de Teotihuacán*, (Vol. 2, pp. 273–293). Mexico, D.F.: Instituto Nacional Indigenista.

Bonfante, L. (1996). The scripts of Italy. In P. T. Daniels & W. Bright (Eds.), *The world's writing systems* (pp. 297–311). Oxford: Oxford University Press.

Broda de Casas, J. (1969). *The Mexican calendar as compared to other Mesoamerican systems.* Vienna: Acta Ethnologica et Linguistica, Nr. 15, Series Americana 4.

Browder, J. (2005). *Place of the high painted walls: The Tepantitla murals and the Teotihuacan writing system.* [Doctoral dissertation.] Riverside: University of California.

Campbell, L. (1997). *American Indian languages: The historical linguistics of Native America*. Oxford Studies in Anthropological Linguistics. Oxford: Oxford University Press.

Cabrera Castro, R. (1996). Caracteres glíficos teotihuacanos en un piso de La Ventilla. In B. de la Fuente (Ed.), *La Pintura Mural Prehispánica en México, I: Teotihuacan, Tomo II* (pp. 401–427). Mexico, D.F.: Universidad Nacional Autónoma de México.

Carballo, D. (2007). Effigy vessels, religious integration, and the origins of the Central Mexican pantheon. *Ancient Mesoamerica*, *18*(1): 53–67.

Carballo, D. M., Hernández Sariñana, D., Buckley, G., del Rocío Vera Flores, M., Codlin, M., & Sánchez y Tehua Osnaya, A. (2017). Frente E. In V. Ortega, S. Sugiyama, N. Sugiyama, N. Sugiyama, W. Fash, & D. M. Caraballo (Eds.) *Informe de la Segunda Temporada del Proyecto Complejo Plaza de las Columnas, Teotihuacan* (pp. 1–79). Mexico City: Technical report on file at the Consejo de Arqueología, Instituto Nacional de Antropología e Historia.

Cases Martín, J. I., & Lacadena García-Gallo, A.. (2013). Una aplicación de semiótica computacional y hermeneumática a la escritura náhuatl. Paper presented at *La gramatología y los sistemas de escritura mesoamericanos*. Tlatelolco: Centro Cultural Universitario Tlatelolco, Nov. 25th.

Caso, A. (1937). Tenían los teotihuacanos conocimiento del tonalpohualli? *El México Antiguo, 4*(3–4): 131–143.

— (1959). Glifos Teotihuacanos. *Revista Mexicana de Estudios Antropológicos*, *15*: 51–70.

— (1961). El glifo "ojo de reptil." *Ethnos, 26*(4): 167–171.

— (1966). Dioses y signos teotihuacanos. *Teotihuacan—Onceava Mesa Redonda* (pp. 249–279). Mexico, D.F.: Sociedad Mexicana de Antropología.

— (1967). *Los calendarios prehispánicos.* Mexico, D.F.: Universidad Nacional Autónoma de México.

— (2011). The flowering glyphs: Animation in Cotzumalhuapa writing. In E. H. Boone & G. Urton (Eds.), *Their way of writing: Scripts, signs, and pictographies in pre-Columbian America* (pp. 43–75). Washington, D.C.: Dumbarton Oaks Research Library and Collections.

Clayton, S. C. (2005). Interregional relationships in Mesoamerica: Interpreting Maya ceramics at Teotihuacan. *Latin American Antiquity*, *16*(4): 427–448.

Coe, M. D. (1965). *The jaguar's children: Pre-classic Central Mexico.* New York: The Museum of Primitive Art.

— (1992). *Breaking the Maya Code.* London: Thames and Hudson.

Colas, P. R. (2011). Writing in space: Glottographic and semasiographic notation at Teotihuacan. *Ancient Mesoamerica, 22*: 13–25.

Conides, C. (2018). *Made to order: Painted ceramics of ancient Teotihuacan*. Norman: University of Oklahoma Press.

Cowgill, G. L. (1992). Teotihuacan glyphs and imagery in the light of some early colonial texts. In J. C. Berlo (Ed.), *Art, ideology, and the city of Teotihuacan* (pp. 231–246). Washington, D.C.: Dumbarton Oaks Research Library and Collections.

— (2015). *Ancient Teotihuacan: Early urbanism in Central Mexico.* Cambridge: Cambridge University Press.

Daniels, P. T. & Bright, W. (Eds.) (1996). *The world's writing systems*. Oxford: University of Oxford.

de Guerrero, J. M. (2005). *Is there pre-Columbian writing at Teotihuacan?* New York: iUniverse, Inc.

— (2014). *A sign catalog: Glyphs in selected text-like layouts at Teotihuacan.* BAR International Series 2670. Oxford: Archaeopress.

de la Fuente, B. (1995a). Zona 3. Plataformas 14, 15 y 15A. In B. de la Fuente (Ed.), *La pintura mural prehispánica en México, I: Teotihuacan, Tomo I* (pp. 87–91). Mexico, D.F.: Universidad Nacional Autónoma de México.

— (1995b). *La pintura mural prehispánica en México, I: Teotihuacan, Tomo I*. Mexico, D.F.: Universidad Nacional Autónoma de México.

de la Fuente, B., Trejo, S., & Gutiérrez Solana, N. (1988). *Escultura en piedra de Tula: Catálogo*. Mexico, D.F.: Instituto de Investigaciones Estéticas, Universidad Nacional Autónoma de México.

Domenici, D. (2017). Place names and political identities in the Teotihuacán mural paintings. In M. Paxton & L. Staines Cicero (Eds.), *Constructing power and place in Mesoamerica: Pre-Hispanic paintings from three regions* (pp. 53–75). Albuquerque: University of New Mexico Press.

Fenoglio, F. & Viramontes, C. (2014). The polychrome murals of El Rosario, Querétaro: An example of Teotihuacan mural paintings at the Center-North of Mesoamerica. Paper presented at *The Archaeology and Iconography of El Rosario (Queretaro, Mexico)*. Copenhagen: University of Copenhagen, October 8th.

Filini, A. (2004). *The presence of Teotihuacan in the Cuitzeo Basin, Michoacán, Mexico: A world-system pPerspective.* Oxford: BAR International Series 1279.

Galindo Trejo, J., Wallrath Boller, M., & Rangel Ruiz, A. (2002). Marcadores punteados como manifestación de la ideología Teotihuacana respecto al cielo: El caso de Xihuingo. In M. E. Ruiz Gallut (Ed.), *Ideología y política a través de materiales, imágenes y símbolos. Memoria de la Primera Mesa Redonda de Teotihuacan* (pp. 255–271). Mexico, D.F.: Universidad Nacional Autónoma de México / Instituto Nacional de Antropología e Historia.

García-Des Lauriers, C. (2005). La iconografía y simbolismo de la escultura de Cerro Bernal, Chiapas. *Utz'ib 1*(5): 1–16.

Gómez Chávez, S., & Abasolo Hernández, R. (2011). Repensando la migración: etnicidad y etnogénesis en las comunidades foráneas en la antigua ciudad de Teotihuacán. Paper presented at the *Quinta Mesa Redonda de Teotihuacan*. San Juan Teotihuacán: Instituto Nacional de Antropología e Historia and CONACULTA.

Headrick, A. (2007). *The Teotihuacan trinity: The sociopolitical structure of an ancient Mesoamerican city*. Austin: University of Texas Press.

Hellmuth, N. M. (1975). The Escuintla hoards: Teotihuacan art in Guatemala. *F.L.A.A.R. Progress Reports, 1*(2): 5–58.

Helmke, C. (2017a). Serpent sculpture, 350. In M. H. Robb (Ed.), *City of water, city of fire* (p. 327). San Francisco: Fine Arts Museums of San Francisco, de Young Museum & Mexico City: Instituto Nacional de Antropología e Historia.

— (2017b). El pasado es un país lejano: Un análisis epigráfico de los textos mayas de Tetitla, Teotihuacan. In L. Staines Cicero & C. Helmke (Eds.), *Las Pinturas Realistas de Tetitla, Teotihuacan. Estudios a través de la obra de Agustín Villagra Caleti* (pp. 101–134). Mexico, City: Secretaría de Cultura, Instituto Nacional de Antropología e Historia & Instituto de Investigaciones Estéticas, Universidad Nacional Autónoma de México.

Helmke, C., & Montero García, I. A. (2016). Caves and new fire ceremonies in the Central Mexican Highlands: The case of the Cerro de la Estrella, Iztapalapa, Mexico. *Contributions in New World Archaeology*, *10*, 55–100.

Helmke, C., & Nielsen, J. (2011). *The writing system of Cacaxtla, Tlaxcala, Mexico*. Ancient America, Special Publication, No. 2. Barnardsville: Boundary End Archaeology Research Center.

— (2013a). The writing on the wall: A paleographic analysis of the Maya texts of Tetitla, Teotihuacan. In J. Nielsen & C. Helmke (Eds.), *The Maya in a Mesoamerican context: Comparative approaches to Maya studies* (pp. 123–166). Acta Mesoamericana, Vol. 26. Markt Schwaben: Verlag Anton Saurwein.

— (2013b). Los sistemas de escritura del Altiplano Mexicano: De Teotihuacán a los Mexica. Workshop taught at *La gramatología y los sistemas de escritura mesoamericanos*. Tlatelolco: Centro Cultural Universitario Tlatelolco, Nov 27–29th.

— (2014). If mountains could speak: Ancient toponyms recorded at Teotihuacan, Mexico. *Contributions in New World Archaeology*, *7*: 73–112.

— (2017). Of gods and rituals: The religion of Teotihuacan. In M. H. Robb (Ed.), *City of water, city of fire* (pp. 130-137). San Francisco: Fine Arts Museums of San Francisco, de Young Museum & Mexico City: Instituto Nacional de Antropología e Historia.

— (in press a). La escritura jeroglífica epiclásica. In E. Velásquez García (Ed.), *Imágenes figurativas verbales. Aproximaciones a los sistemas de escritura de Mesoamérica*. Mexico City: Instituto de Investigaciones Estéticas, Universidad Nacional Autónoma de México.

— (in press b). Los orónimos en la escritura teotihuacana y su vinculación con la escritura nahua. In E. Velásquez García (Ed.), *Imágenes figurativas verbales. Aproximaciones a los sistemas de escritura de Mesoamérica*. Mexico City: Instituto de Investigaciones Estéticas, Universidad Nacional Autónoma de México.

Helmke, C., Nielsen, J., Leni, C., & Navarrete Campos, A.. (2013). The carved monuments of Cerro Xoconoch, Teotihuacan Valley, Mexico. *Mexicon*, *35* (4): 90–95.

Helmke, C., Nielsen, J., and Rivera Guzmán, Á. I. (2017). Tras las huellas de la tradición cartográfica en el altiplano central de México. *Estudios de Cultura Náhuatl*, *54*: 79–133.

Houston, S. D. (2004). Writing in early Mesoamerica. In. S. D. Houston (Ed.), *First writing: Script invention as history and process* (pp. 274–309). Cambridge: Cambridge University Press.

Kaufman, T. (2001). The history of the Nawa language group from the earliest times to the sixteenth century: Some initial results. Manuscript on file. Pittsburgh: Institute for the Documentation of the Languages of Meso-America, University of Pittsburgh.

Kaufman, T., & Justeson, J. (2008). The Epi-Olmec language and its neighbors. In P. J. Arnold & C. A. Pool (Eds.), *Classic period cultural currents in southern and central Veracruz* (pp. 55–83). Washington, D.C.: Dumbarton Oaks.

Kidder, A. M., Jennings, J. D., & Shook, E. M. (1946). *Excavations at Kaminaljuyú, Guatemala.* Washington, D.C.: Carnegie Institution of Washington, Publ. 576.

King, T., & Gómez Chávez, S. (2004). Avances en el desciframiento de la escritura jeroglífica de Teotihuacan. In M. E. Ruiz Gallut & A. P. de Soto (Eds.), *La costa del Golfo en tiempos teotihuacanos: Propuestas y perspectivas. Memoria de la Segunda Mesa Redonda de Teotihuacan* (pp. 201–244). Mexico, D.F.: Instituto Nacional de Antropología e Historia.

Lacadena, A. (2008). Regional scribal traditions: Methodological implications for the decipherment of Nahuatl writing. *The PARI Journal*, *8*(4): 1–22.

— (2019). New research on the Aztec script: A true writing system. In H. Kettunen, V. A. Vázquez López, F. Kupprat, C. Vidal Lorenzo, G. Muñoz Cosme, & M. J. Iglesias Ponce de Leon (Eds.), *Tiempo detenido, tiempo suficiente. Ensayos y narraciones mesoamericanistas en homenaje a Alfonso Lacadena García-Gallo* (pp. 143–161). Wayeb Publication 1.

Langley, J. C. (1986). *Symbolic notation of Teotihuacan: Elements of writing in a mesoamerican culture of the classic period.* Oxford: BAR International Series 313.

— (1991). The forms and usage of notation at Teotihuacan. *Ancient Mesoamerica*, *2*(2): 285–298.

— (2002). Teotihuacan notation in a mesoamerican context: Likeness, concept and metaphor. In M. E. Ruiz Gallut (Ed.), *Ideología y política a través de materiales, imágenes y símbolos. Memoria de la Primera Mesa Redonda de Teotihuacan* (pp. 275–301). Mexico, D.F.: Universidad Nacional Autónoma de México / Instituto Nacional de Antropología e Historia.

López Luján, L., Neff, H., & Sugiyama, S. (2000). The *9-Xi* vase: A classic thin orange vessel found at Tenochtitlan. In D. Carrasco, L. Jones, & Scott Sessions (Eds.), *Mesoamerica's Classic Heritage—From Teotihuacan to the Aztecs* (pp. 219–249). Boulder: University Press of Colorado.

Manzanilla, L. R. (2003). The abandonment of Teotihuacan. In T. Inomata & R. W. Webb (Eds.), *The archaeology of settlement abandonment in Middle America* (pp. 91–101). Salt Lake City: University of Utah Press.

— (2007). Las "casas" nobles de los barrios de Teotihuacan: esctructuras exclusionistas en un entorno corporativo. *Memoria 2007 de El Colegio Nacional, México*: 453–470.

Matos Moctezuma, E. (2009). *Teotihuacan.* Fondo de Cultura Económica/El Colegio de México.

Miller, A. G. (1973). *The mural paintings of Teotihuacán.* Washington, D.C.: Dumbarton Oaks.

Millon, C. (1972). The history of mural art at Teotihuacan. In *Teotihuacan—XI Mesa Redonda* (pp. 1–16). Mexico, D.F.: Sociedad Mexicana de Antropología.

— (1973). Painting, writing, and polity in Teotihuacan. *American Antiquity, 38*: 294–314.

— (1988). A Reexamination of the Teotihuacan tassel headdress insignia. In K. Berrin, *Feathered Serpents and Flowering Trees: Reconstructing the Murals of Teotihuacan* (pp. 114–134). San Francisco: The Fine Arts Museum of San Francisco.

Millon, R. (1973). *Urbanization at Teotihuacán, Mexico. Volume 1. The Teotihuacán Map. Part One: Text.* Austin: University of Texas Press.

— (1988). Where *do* they all come from? The provenance of the Wagner murals from Teotihuacan. In K. Berrin, *Feathered serpents and flowering trees: Reconstructing the murals of Teotihuacan* (pp. 78–113). San Francisco: Fine Arts Museums of San Francisco.

Millon, R., Drewitt, B., & Bennyhoff, J. A. (1965). *The pyramid of the sun at Teotihuacán: 1959 Investigations.* Transactions of the American Philosophical Society, New Series, Vol. 55, Part 6. Philadelphia: The American Philosophical Society.

Murakami, T. (2010). *Power relations and urban landscape formation: A study of construction labor and resources at Teotihuacan, Mexico.* [Doctoral dissertation.] Tempe: Arizona State University.

Navarrete, C. (1986). The sculptural complex at Cerro Bernal on the coast of Chiapas. *Notes of the New World Archaeological Foundation, 1*: 1–28.

Nielsen, J. (2003). *Art of the empire: Teotihuacan iconography and style in early classic Maya society (A.D. 380-500)* [Doctoral dissertation]. Copenhagen: University of Copenhagen.

— (2004). The coyote and the tasseled shield: A possible titular glyph on a late Xolalpan Teotihuacan tripod. *Mexicon, 25*(3): 61–64.

— (2006). The queen's mirrors: Interpreting the iconography of two Teotihuacan mirrors from the Early Classic Margarita Tomb, Copan. *The PARI Journal*, *6*(4): 1–8.

— (2014a). "To sing arrows": Observations on the representation of sound in the writing and iconography of Teotihuacan. In C. Helmke & F. Sachse (Eds.), *A Celebration of the Life and Work of Pierre Robert Colas* (pp. 175–191). Munich: Verlag Anton Saurwein.

— (2014b). Where kings once ruled? Considerations on palaces and rulership at Teotihuacan. In J. Nehammer Knub, C. Helmke & J. Nielsen (Eds.), *Palaces and courtly culture in ancient Mesoamerica* (pp. 1–16). Oxford: Archaeopress pre-Columbian Archaeology 4.

— (2019). Hearts and torches: Possible Teotihuacan military *entradas* in north-central and western Mesoamerica. In S. G. Morton & M. M. Peuramaki-Brown (Eds.), *Seeking Conflict in Mesoamerica* (pp. 152-211). Boulder: University Press of Colorado.

Nielsen, J., & Helmke, C. (2008). Spearthrower owl hill: A toponym at Atetelco, Teotihuacan. *Latin American Antiquity*, *19*(4): 459–474.

— (2011). Reinterpreting the Plaza de los Glifos, La Ventilla, Teotihuacan. *Ancient Mesoamerica, 22*: 345–370.

— (2014a). In the shadow of the war serpent: Teotihuacan power and imagery in Mesoamerica. Paper presented at *The Archaeology and Iconography of El Rosario (Queretaro, Mexico)*. Copenhagen: University of Copenhagen, October 8th.

— (2014b). House of the serpent mat, house of fire: The names of buildings in Teotihuacan writing. *Contributions in New World Archaeology*, *7*: 113–139.

— (2017). The storm god: Lord of rain and ravage. In M. H. Robb (Ed.), *City of water, city of fire*, pp. 138–143. San Francisco: Fine Arts Museums of San Francisco, de Young Museum & Mexico City: Instituto Nacional de Antropología e Historia.

— (2020). Crowning rulers and years: Interpreting the year sign headdress at Teotihuacan. *Ancient Mesoamerica*, *31*(2): 319–334.

Nielsen, J., Helmke, C., Fenoglio, F., & Saint-Charles Zetina, J. C. (2019a). The early classic murals of El Rosario, Queretaro, Mexico: Description and iconographic analysis. *Ancient America, 14*: 1–75.

Nielsen, J., Jiménez García, E., & Rivera Guzmán, Á. I. (2019b). Across the hills, toward the ocean: Teotihuacan-style monuments in Guerrero, Mexico. In J. D. Englehardt & M. D. Carrasco (Eds.), *Interregional Interaction in Ancient Mesoamerica* (pp. 176–209). Louisville: University of Colorado Press.

Ortega Cabrera, V., & Archer Velasco, J. N. (2014). Pasado y presente de la presencia oaxaqueña en Teotihuacán, México. *Cuicuilco*, *61*: 137–164.

Ortega Cabrera, V., Díaz Ávila, E., & Vargas López, M. Á. (2016). La cerámica oaxaqueña de Tlailotlacan, Teotihuacán. *Arqueología*, *51*: 94–115.

Paradis, L. I. (2017). Early horizon materials in the greater basin of Mexico and Guerrero. In J. P. Blomster & D. Cheetham, *The early Olmec and Mesoamerica: The material evidence* (pp. 119–147). Cambridge: Cambridge University Press.

Pasztory, E. (1974). *The iconography of the Teotihuacan Tlaloc*. Studies in pre-Columbian art and archaeology, No. 15. Washington, D.C.: Dumbarton Oaks.

— (1988a). Feathered serpents and flowering trees with glyphs. In K. Berrin (Ed.), *Feathered serpents and flowering trees: Reconstructing the murals of Teotihuacan* (pp. 137–161). San Francisco: The Fine Arts Museum of San Francisco.

— (1988b). A Reinterpretation of Teotihuacan and its mural painting tradition. In K. Berrin (Ed.), *Feathered serpents and flowering trees: Reconstructing the murals of Teotihuacan* (pp. 45–77). San Francisco: The Fine Arts Museum of San Francisco.

— (1997). *Teotihuacan: An experiment in living*. Norman: University of Oklahoma Press.

Peñafiel, A. (1890). *Monumentos del arte mexicano antiguo: ornamentación, mitología, tributos y monumentos, tomo II*. A. Berlin: Asher & Co.

Pharao Hansen, M. (2021). Ears of Nopal: Reading the name of a Teotihuacán Fertility Goddess. *Nawatl Scholar*: http://nahuatlstudies.blogspot.com/2021/02/ears-of-nopal-reading-name-of.html [March 17th, 2021]

Prem, H. J. (1973). A tentative classification of non-Maya writing systems in Mesoamerica. *Indiana* I: 29–58.

Rattray, E. C. (1987). Los barrios foráneos de Teotihuacan. In E. McClung de Tapia & E. C. Rattray (Eds.), *Teotihuacan: Nuevos Datos, Nuevas Síntesis, Nuevos Problemas*, pp. 243–273. Mexico, D.F.: Universidad Nacional Autónoma de México.

— (1993). *The Oaxaca Barrio at Teotihuacán*. Monografías Mesoamericanas, No. 1. Puebla: Universidad de las Americas.

— (2001). *Teotihuacan: Cerámica, cronología y tendencias culturales/Ceramics, chronology and cultural trends.* Mexico, D.F.: Instituto Nacional de Antropología e Historia / Pittsburgh: University of Pittsburgh.

Robb, M. (Ed.) (2017). *Teotihuacan: City of water, city of fire.* Oakland: Fine Arts Museums of San Francisco/de Young & Los Angeles County Museum of Art, University of California Press.

Séjourné, L. (1966). *Arqueología de Teotihuacan: La cerámica.* Mexico, D.F.: Fondo de Cultura Económica.

— (1969). *Teotihuacan, métropole de l'Amérique*. Paris: François Maspero.

Seler, E. (1915). Die Teotihuacan-Kultur des Hochlands von México. In *Gesammelte Abhandlungen zur Amerikanischen Sprach- und Alterthumskunde* (pp. 405–585). Berlin: Behrend & Co.

Sellen, A. T. (2005). Catalogue of Zapotec effigy vessels. *Foundation for the advancement of Mesoamerican studies, inc.*: http://research.famsi.org/zapotec/zapotec.html [June 29th, 2019]

Smith, M. E. (2017). The Teotihuacan anomaly: The historical trajectory of urban design in ancient central Mexico. *Open Archaeology*, *3*: 175–193.

— (2018). Life in the city of Teotihuacan: New results from old data. Paper presented at *Archaeology, Language and History in Ancient Central Mexico.* Copenhagen: University of Copenhagen, April 26th.

Stuart, D. (2000). "The Arrival of Strangers": Teotihuacan and Tollan in classic Maya history. In D. Carrasco, L. Jones, & S. Sessions (Eds.), *Mesoamerica's classic heritage: From Teotihuacan to the Aztecs* (pp. 465–513). Boulder: University Press of Colorado.

— (2005). A foreign past: The writing and representation of history on a royal ancestral shrine at Copan. In E. Wyllys Andrews & W. L. Fash (Eds.), *Copán: The History of an Ancient Maya Kingdom* (pp. 373–394). Santa Fe: School of American Research Press / Oxford: James Currey.

Sugiura, Y. (2008). Técnicas alfareras. In M. del Villar (Ed.), *Cerámica de Teotihuacán* (pp. 42-51). Mexico, D.F.: Artes de México.

Sugiyama, S. (2005). *Human sacrifice, militarism and rulership: Materialization of state ideology at the feathered serpent pyramid, Teotihuacan*. Cambridge: Cambridge University Press.

Sugiyama, N., Sugiyama, S., Ortega, V., & Fash, W. (2016). ¿Artistas mayas en Teotihuacan? *Arqueología Mexicana*, *24*(142): 8.

Taube, K. A. (1983). The Teotihuacan spider woman. *Journal of Latin American Lore, 9*(2): 107–189.

— (1986). The Teotihuacan cave of origin: The iconography of architecture of emergence mythology in Mesoamerica and the American Southwest. *RES, 12*: 51–86.

— (1992a). The iconography of mirrors at Teotihuacan. In J. C. Berlo (Ed.), *Art, ideology, and the city of Teotihuacan* (pp. 169–204). Washington, D.C.: Dumbarton Oaks Research Library and Collections.

— (1992b). The temple of Quetzalcoatl and the cult of Sacred War at Teotihuacan. *RES*, *21*: 53–87.

— (2000). The writing system of ancient Teotihuacan. *Ancient America*, *1*: 1–56.

— (2003). Tetitla and the Maya presence at Teotihuacan. In G. E. Braswell (Ed.), *The Maya and Teotihuacan: Reinterpreting early classic interaction* (pp. 273–314). Austin: University of Texas Press.

— (2006). Climbing Flower Mountain: Concepts of resurrection and the afterlife at Teotihuacan. In L. López Luján, D. Carrasco, & L. Cué, (Eds.), *Arqueología e historia del Centro de México. Homenaje a Eduardo Matos Moctezuma* (pp. 153–170). Mexico, D.F.: Instituto Nacional de Antropología e Historia.

— (2011). Teotihuacan and development of writing in early classic central Mexico. In E. H. Boone & G. Urton (Eds.), *Their way of writing: Scripts, signs, and pictographies in pre-Columbian America* (pp. 77–109). Washington, D.C.: Dumbarton Oaks Research Library and Collections.

Tozzer, A. M. (1921). *Excavations of a site at Santiago Ahuizotla, D.F. Mexico.* Washington, D.C.: Smithsonian Institution, the Bureau of American Ethnology Bulletin 74.

Trigger, B. G. (1990). Monumental architecture: A thermodynamic explanation of symbolic behaviour. *World Archaeology*, *22*(2): 119–132.

— (2003). *Understanding early civilizations: A comparative study*. Cambridge University Press.

Urcid, J. (2012). Scribal traditions from Highland Mesoamerica (300-1000 AD). In D. L. Nichols & C. A. Pool (Eds.), *The Oxford Handbook of Mesoamerican Archaeology* (pp. 855–868). Oxford: Oxford University Press.

Valdez Bubnova, T. (2008). El valor en la imagen gráfica teotihuacana: Reflexiones desde La Ventilla. *Anales del Instituto de Investigaciones Estéticas*, *30*(92): 5–47.

— (2012). Los grafemas teotihuacanos. Relaciones entre nombres proprios y contextos entre los años 250 y 600 d.C. Teopancazco y La Ventilla. [Doctoral dissertation]. Mexico, D.F.: Estudios Mesoamericanos, Universidad Nacional Autónoma de México.

— (2014). Problemas en torno a la escritura Teotihuacana. *Sistemas de escritura Mesoamericanos: Estado de la cuestión y problemas actuales*. Mexico, D.F.: Instituto de Investigaciones Estéticas, Universidad Nacional Autónoma de México, Dec. 2nd.

von Winning, H. (1947). Representations of temple buildings as decorative patterns on Teotihuacan pottery and figurines. *Carnegie Institution of Washington Notes, 83*: 170–177.

— (1948). The Teotihuacan owl-and-weapon symbol and its association with "Serpent Head X" at Kaminaljuyú. *American Antiquity, 14* (2): 120–132.

— (1961). Teotihuacan symbols: The reptile's eye glyph. *Ethnos*, *26*(3): 121–166.

— (1979). The "Binding of the Years" and the "New Fire" in Teotihuacan. *Indiana, 5*: (15–32)

— (1987). *La iconografía de Teotihuacan. Los dioses y los signos.* 2 vols. Mexico, D.F.: Universidad Nacional Autónoma de México.

Whittaker, G. (2012). The names of Teotihuacan. *Mexicon, 34*(3): 55–58.

— (2019). Central Mexican writing from the Teotihua to the Aztecs. Paper presented at *The Future of the Study of Mesoamerican Writing Systems*. Bonn: University of Bonn, June 14th.

Woodard, R. D. (Ed.) (2008). *The ancient languages of Europe*. Cambridge: Cambridge University Press.

Wrem Anderson, K., & Helmke, C. (2013). The personifications of celestial water: The many guises of the storm god in the pantheon and cosmology of Teotihuacan. *Contributions in New World Archaeology*, *5*: 165–196.

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Factors Affecting Interpretation of Diagnostic Images as a Decision Process: Ecological Psychology, Visual Heuristics, and Design

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This article presents an empirical investigation into interpreters' decision-making criteria, personality characteristics, and emotion-laden experiences as factors affecting interpretation of images that were created for diagnostic assessment. Specifically, it seeks to examine (1) heuristic strategies as interpretive tools, which are both cognitive and experience-based, (2) the relationship between the decision criteria and accuracy of the judgments, and (3) the relationship between interpreters' experiences of abuse as victims and the judgments about the meaning of images. The study used a sample of 196 self-representational drawings created by college students and 60 independent interpreters who were asked to identify drawings that were created by individuals who experienced interpersonal abuse.

This study identified six visual heuristics that were reported independently by 60 percent of the interpreters and were associated with marginally higher accuracy of the interpretive judgments. Thirty-eight percent of participants reported making judgments about the meaning of drawings based on direct or secondhand experiences with interpersonal abuse. The study found that the trauma of interpersonal abuse can profoundly bias interpretive judgments. This result has been particularly robust among female interpreters. Women who self-identified as survivors of abuse saw indicators of abuse up to 90 percent of the time, whereas male interpreters who have been abused saw indicators of abuse up to 65 percent of the time, whether or not those purported indicators were correct. Implications of the findings for design are discussed.

An overarching goal of this article is to address interpretation of images as a decision process. The study situated the factors affecting interpretation of images within the framework of the naturalistic/ecological psychology (Brunswik, 1952, 1955) and the fast and frugal heuristic model of decision-making (Gigerenzer, 2007) vis-à-vis a model of conscious and nonconscious information processing. This study also recognized that certain personality characteristics and emotion-laden experiences can influence the quality of interpretive judgments. The frameworks, methods, and findings from psychology have been used with an intent to inform future research and practice of image construction and interpretation in visual studies and design.

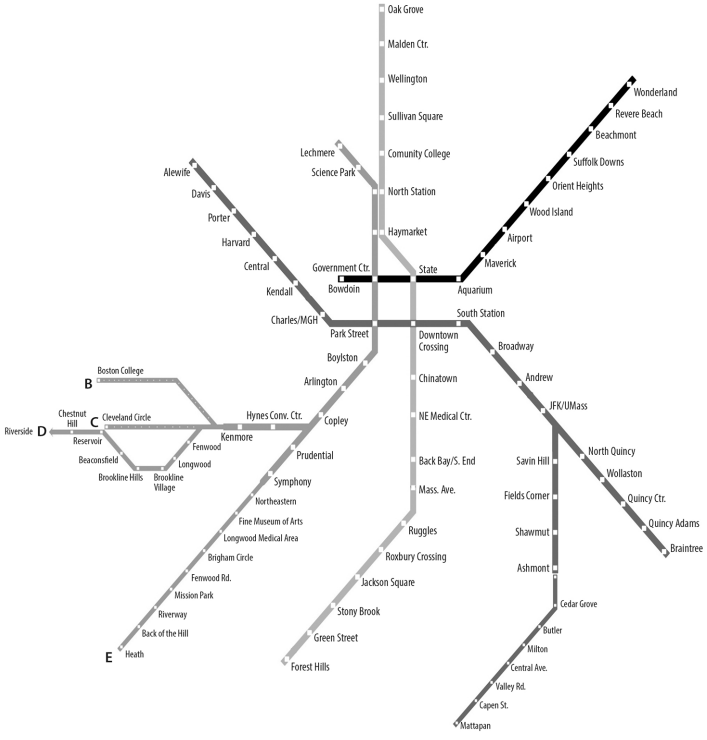
One limitation of this study is that it relied on participants' introspection and reflection on the decision process. There is a risk, then, that interpreters' explanations of how they arrived with judgments were translations rather than representations of the decision process. Even though this study has not cracked the black box of meaning-making inside the mind, it offers an analytical framework for studies of visual interpretation as a decision process that combines cognitive, personality, and experiential factors as influencing the quality of interpretations. The article translates the findings of the study into practical guidelines for applications in visual communication design and human-centered design research and practice.

Introduction

The fundamental expectation of visual communication design is to construct artifacts that different users can interpret as having the same meaning or function. The reliability of visual communications in evoking replicable interpretations is particularly important in risk-laden information domains such as way-finding, severe weather warning systems, complex machinery operations, medical disciplines, and so forth. In such high-stakes situations, interpretation is not the end goal but an essential means to guide judgments, decisions, and actions (Dreyfus, 1980; Frutiger, 1978; Neurath, 1936; Patton et al., 2015). Subway information systems are a prime example of such use in information design (see Figure 1).

Figure 1

Boston subway map based on map by Urban Rail from 2006 (E. Kazmierczak & P. Storkerson).



Clinical psychologists and counselors use diagnostic images in their practice to make interpretations and predictions about patients' social-emotional states and behaviors. Radiologists interpret findings in radiological images to make judgments about the state of patients' body parts—that is, whether they are within or outside the norm for healthy individuals. In those disciplines, images are used because they can provide information that cannot be obtained through other means.

Radiological images are mechanically derived. In clinical practice and counseling, images are generated by hand for the purpose of assessment through such techniques as drawing, painting, and collaging. In design, free-hand drawings are often used for ideation, and the communication and development of ideas. Again here, images are not the end goal, but the means for guiding decisions and actions.

In some areas, domain-specific expertise is necessary to generate reliable judgments about the meanings of images. Only experts in radiology, for example, can dependably inspect, interpret, and classify findings in radiological images. Despite the specialized training, however, the error rate in radiology has been reported as 33 percent, and efforts to reduce it have been hindered by the lack of adequate knowledge about the mechanisms of perceptual expertise (Waite et al., 2019). With respect to diagnostic drawings in clinical practice, studies have shown that domain-specific expert knowledge is not a necessary condition for making reliable interpretations. Laypersons have been shown to perform as well as clinicians who had been trained in the interpretation of diagnostic drawing tests (Albee & Hamlin, 1949; Handler, 1985; Levy & Ulman, 1967; Schmidt & McGowan, 1959). Hiler and Nesvig (1965) demonstrated that expert clinicians accurately assessed 65 percent of such drawings, whereas non-psychologists accurately assessed 64 percent of them. Like in radiology, efforts to reduce the error rate for diagnostic drawing tests have been unsuccessful in part due to the lack of knowledge about the mechanisms that guide the development of perceptual expertise and in part due to the misguided attempts to formalize the drawing process.

Studies of expertise in varied disciplines indicate that reproducible and reliable expertise cannot be developed through the accumulation of knowledge alone. It requires an acquisition of criteria and methods that enable monitoring of one's performance (Almendra & Christiaans, 2009; Ericsson, 2005). In other words, a combination of exposure to numerous exemplar cases, along with an awareness of the criteria that can yield successful evaluations, has been indicated as a factor in developing perceptual expertise.

There is a caveat here. To advance and empirically study perceptual competencies and subsequent decisions requires an interpretive lens that affords a way of understanding both cognition-based and culture-based regularities and differences. This article introduces such a lens by presenting a study that combines theoretical frameworks, findings, and methodology from psychology to investigate how interpreters' decision criteria, personality characteristics, and emotion-laden experiences can affect what they see in images when they are asked to make judgments about the makers of the images.

Several reasons led to this methodological move. First, it simulates a condition of a high-stakes decision environment, in

which interpretive judgments determine the subsequent course of action. Second, psychology has a rich history of systematic research devoted to finding reliable methods of interpretation of images that have been created for the purpose of evaluation of social-emotional states and the prediction of behaviors. Third, the accuracy of such interpretations can be objectively evaluated based on a specific criterion or criteria. In the case of the study presented in this article, the criterion was the self-reported abuse status of the individuals who created the stimulus drawings and of the interpreters who judged the drawings. Fourth, the results can be translated into immediate practical applications. Last, the results can inform research and practice in visual studies and visual communication design, especially in the area of human-centered design.

Conceptual Framework

First, the study presented in this article assumes a naturalistic or ecological lens and methodology as best suited to investigations into the perceptual judgments that underlie interpretation of images. Second, this methodology conceptualizes interpretation as a decision process and extends the ecological lens through Gigerenzer's (2007) theory of fast and frugal heuristic judgments. Third, the framework situates the decision process within the model of the mind as a complex system that processes information on a continuum between conscious and nonconscious levels (Damasio, 2012). This move accounts for the complexity of design thinking as a decision process. Fourth, the framework addresses personality and emotion-laden experiences as factors that influence interpretation of images. This move brings us closer to a model of interpretation that focuses on interpreters and subjective factors that have been shown to affect judgment of images.

An ecological or naturalistic framework and methodology have been developed by psychologist Egon Brunswik. Brunswik (1955) criticized the traditional psychological experiments that test one or two variables at a time in highly controlled experimental conditions. His ecological lens called for experiments that simulate natural world environments in which people make decisions. Brunswik's (1952) model takes into account the complexity of the environment and assumes both a selective nature of perception and that people have the skills and knowledge to make sense of the world. Hence, this methodology investigates many selected variables simultaneously to study people's perceptual judgments in experimental conditions that simulate the natural world conditions (Kirlik and Storkerson, 2010; Storkerson, 2001, 2003, 2009, 2010).

Gigerenzer's (2007) studies of judgment in naturalistic or ecological settings build upon Brunswik's (1952) model of perceptual

judgments and theory of the inherent complexity and equivocality of naturalistic environments. In Gigerenzer's (2007) model, naturalistic environments can be understood neither by increasing information nor by reductive elimination of variables in laboratory experiments. A key assumption in the naturalistic model of decision-making is that professionals are not the only experts; laypersons, too, are highly competent in the decision process. Laypersons are recognized as "capable decision-makers" (Keller et al., 2010, p. 258). Humans are perfectly adapted to navigate through complex environments, so according to Keller and his colleagues (2010), "Laypeople can also be well attuned to the environments through which they interact" (p. 258). Specifically, the fast and frugal heuristic decision model is concerned with decisions in taxing natural environments rather than with highly domain-specific expert decisions. Gigerenzer (2007) has shown that people make decisions spontaneously by developing ad hoc, experience-based heuristics—that is, rules of thumb—which ease mental effort and speed up the process of making satisfactory decisions. The study presented in this article has tested Gigerenzer's stronger claim that heuristics can improve accuracy (Gigerenzer & Brighton, 2009; Gigerenzer & Gaissmaier, 201; Gigerenzer, Todd, & the ABC Research Group, 1999).

There is a caveat here. Neither the naturalistic perceptual judgment model nor the fast and frugal decision model can adequately explain the complexity of the decision process in interpretation of images and in the design practice. To account for the judgments that involve both heuristic decisions and deliberate decisions, as is the case in design, this study situates the decision process within a model of the mind as a complex system that processes information on a continuum between conscious and nonconscious levels (Damasio, 2012). Moreover, to account for genetic predispositions and experiential factors that affect interpretation of images, the study has expanded the framework to include (1) research on personality characteristics that have been shown to influence judgments about the meaning of diagnostic drawings in psychotherapy, and (2) trauma literature that indicates that emotion-laden experiences can permanently affect worldviews, which in turn can influence subsequent judgments.

Design Thinking and Naturalistic Decision Process

Design thinking is different from thinking in other fields. It operates between sciences and humanities because design starts and ends with problems and possibilities in the everyday, natural world. In sum, design thinking consists of three phases: naturalistic, analytic or deliberate, and naturalistic again. That is because designers are called when people have problems and opportunities that they wish to solve or take advantage of and do not know how to do it. Hence, designers' tasks are to understand the nature of these problems or opportunities and imagine how

they can be handled so that problems are fixed and opportunities can be created. This stage of design thinking is naturalistic. It is a phase of perceptual judgments, abductive reasoning,[1] and creativity. The view of design thinking as dependent on abductive reasoning is not new; it has been postulated by Almendra and Christiaans (2009) in an insightful study on decision-making in product design.

Then, designers apply formal analyses and deliberate decisions, which are based on rules, technical specifications, and established procedures, rather than on abductions and heuristics, to competently realize final design solutions. At the end of this process, the goal is a design solution that works. When the design is finalized, it functions in the natural world of users. Good design thinking is based on an understanding of how people think and use things that fit the natural world.[2] Hence, useful insights can be derived from the research about how people make decisions when they interpret images and utilize them to make subsequent judgments.

Conscious and Nonconscious Judgments

There is a broad agreement in varied branches of psychology that people make judgments and decisions by relying on two integrated processing systems that are often labeled *intuitive* (or *tacit*) and *deliberate* (or *analytic* or *formal*) (Hogarth, 2002). Neuroscientist Antonio Damasio (2012) refers to those systems as *unconscious* and *conscious cognition*, respectively. Intuitive cognition—or in his words, "cognitive unconscious"—is a system to which the conscious mind delegates functions that initially have been acquired through repetition and deliberate learning. After the rules of execution, planning, reasoning, and evaluation of high levels of performance have been internalized, they are executed without involvement of consciously deliberate decisions. Once acquired and internalized, nonconscious judgments appear effortlessly, as though intuitively. In Damasio's (2012) words, "There is an important reasoning process going on nonconsciously, in the subterranean mind, and the reasoning produces results without intervening steps ever being known" (p. 293).

Designers know this process all too well; they make decisions and solve problems competently but often do not know why or how they have arrived at their decisions. That is not to say that self-awareness of one's thinking cannot be achieved. According to Damasio (2012) and others, nonconscious judgments can be subject to review by the

1 Abduction or abductive reasoning, according to Peirce (1903), is a mode of reasoning inference by which one studies facts and devises a theory, that is, a hypothesis or an insight to explain them. "Its only justification is that, if we are ever to understand things at all, it must be in that way" (1903, CP 5.144–45). This process can be both intuitive/unconscious and analytical. ***Dictionary of Philosophy of Mind*** defines "abduction" as inferences to the best explanation (Eliasmith, 2004).

2 P. Storkerson, personal communication, May 1, 2010.

conscious cognition (Hogarth, 2002). This view of the mind and the decision process as a reciprocal communication between nonconscious and conscious cognition provide a neurologically based framework for studies that utilize methods of verbal protocol analysis, such as the think-aloud method or introspection, among others.

Personality Factors and the Decision Process

Experimental studies of the naturalistic interpretation of diagnostic drawings in psychotherapy have found that some people are consistently better than others at making accurate inferences from drawings, regardless of their professional affiliations. Those studies indicated that positive attitudes toward the self and others and positive attitudes toward nondiscursive experiences were associated with higher diagnostic accuracy. Specifically, better interpreters had in common the following personality characteristics regarding the self and others: self-acceptance, empathy, openness toward others, a nonjudgmental approach to others, and interest in others. In respect to nondiscursive experiences, they shared creativity, intuition, self-reflection, and introspection (Burley & Handler, 1997; Hiler & Nesvig, 1965; Scribner, 1989).

The studies of personality factors in relation to psychodiagnostic skills have also revealed a positive association between certain aspects of interpreters' personalities and the frequency with which indicators of those aspects of personality occur in the drawings (Scribner & Handler, 1987). Hammer and Piotrowski (1997) discovered positive correlations between higher levels of hostility in interpreters and a higher number of signs of hostility or aggression they found in one type of drawing test in comparison with interpreters with lower levels of hostility. The study presented in this article examined attitudes toward the self and others through the measures of the diversity of professional involvement, special skills, and volunteer work.

Emotion-Laden Experiences and the Decision Process

Trauma literature and the findings that indicate a correspondence between higher levels of hostility in interpreters and higher frequency with which interpreters saw indicators of hostility in the drawings have motivated an inclusion of emotion-laden experiences as factors that can affect what people see in images. It is well accepted in psychological sciences that memories, decisions, and choices can be biased by emotions. Tacit or nonconscious processes are especially prone to emotional bias (Damasio, 2012; Hogarth, 2002). Trauma literature indicates that emotion-laden experiences, such as the trauma of abuse, can permanently affect

worldviews, which in turn can influence subsequent judgments. Victims of abuse are robbed of the sense of safety and see the outside world as a hostile and dangerous place that calls for vigilance (Figley, 1985; Finkelhor & Browne, 1985; Herman, 1992).

Thus, it was hypothesized for this study that interpreters who had experienced abuse as victims would be sensitized to those issues and would classify more drawings as created by abused drawers than would interpreters who did not experience abuse as victims.

Purpose and Research Questions

The process of visual interpretation depends, on the one hand, on the types and quality of the images and the state of mind of the drawers. On the other hand, it depends on who is doing the interpreting and how. The study presented in this article is concerned with the interpreters' side of the equation and with interpretation as a decision process. It does so by querying the interpreters' decision criteria, the accuracy of their judgments, and their emotion-laden experiences as applied to the identification of interpersonal abuse from self-representational drawings that were created by adults who were nonartists. The research questions guiding the study presented in this paper were these: What classification criteria and heuristics can be identified on the basis of interpreters' reports? Can heuristics improve the accuracy of judgments? And how do the interpreters' emotion-laden experiences relate to the quality of interpretive judgments? Considering the specifics of the study, the last question has been customized: How does the interpreters' self-reported abuse status relate to the quality of interpretive judgments?

Method

Design

The study deployed an experimental design that was *ecological* and *representative* of real-life situations. It utilized mixed methods (quantitative and qualitative) of data collection and analysis (Greene, Caracelli, and Graham 1989). Methods and the timing of the implementation of the methods were sequenced so that the results from the quantitative data analyses informed the qualitative analyses and, in turn, served the quantitative analyses that followed. Although the timing sequence of the implementation of each method indicated the linearity of the design, the reasoning process was not linear and involved going back and forth between the quantitative and

qualitative data and results to advance the integration of the findings from both phases and from researchers' progressive understanding of the subject.

Recruitment and Participants

Theory-based, stratified purposeful sampling techniques[3] (Miles & Huberman, 1994) were used to recruit sixty participants who were nonexperts in the interpretation of drawings and were from varied student and nonstudent populations. The process was guided by the goal of recruiting participants representing diverse social worlds and experiences concerning gender, ethnicity, age, known abuse histories, education level, and professional and occupational expertise. Participants from varied disciplines were sought because no previous study had evaluated performance of individuals other than trained interpreters of drawing tests, clinical psychologists, students of psychology, professional artists, and secretaries at the clinics in which the studies were conducted.

Before the recruitment, approval from the Institutional Review Board was obtained. Recruiting materials introduced this research as a study of the identification of abuse from self-representational drawings. The methods of recruitment included in-person invitations and general calls for participation with snowball sampling[4] permitted. Targeted invitations were issued to individuals in the local community and to groups with known abuse histories and professional expertise. Calls for participation were sent to local and out-of-state domestic violence shelters and sexual assault service agencies. Calls that were disseminated through the mailing lists of a large midwestern university were focused on groups that were potentially interested in the results of the study. The lists included academic advisors; those interested in women's studies; those involved in the women's resources center; students in education, art and design students; and a student organization with an interest in the healing aspect of visual arts. The participants were recruited in waves until at least five participants were recruited for each known category of professional expertise and saturation was achieved in the qualitative interview data. Saturation was a

3 Theory-based sampling is the process selecting "incidents, slices of life, time periods, or people on the basis of their potential manifestation or representation of important theoretical constructs" (Patton, 1990, p. 238). Stratified purposeful sampling is the process of selecting particular cases that vary according to key dimensions (strata). The purpose "is to capture major variations rather than to identify a common core" (p. 174). This type of sampling is used when enough information is known to identify characteristics that may influence how the phenomenon is manifested—for example, with respect to educational background, gender, life experiences, and exposure to abuse.

4 Snowball or chain sampling is a purposeful method of participant selection where research participants recruit other participants for a study. It is used for locating information-rich key participants. It is called "snowball" because "by asking a number of people who else to talk with, the snowball gets bigger and bigger as you accumulate new information-rich cases" (Patton, 1990, p. 176).

stage at which the qualitative data did not provide any new information that would help to clarify the interpretive process.

Participants of the study are referred to here as "interpreters" to emphasize the focus of their role in the study. The study's objective was to access interpreters' naïve (unbiased by the training) beliefs about the relationships between psycho-emotional states and visual characteristics of drawings. Individuals with professional training in interpretation of drawings were excluded because theoretical frameworks they acquired during their training could influence their beliefs about how psychological states are manifested in drawings.

Ages of the participants ranged from 20 to 69 years; the mean age was 34.82 years (standard deviation = 13.01). The interpreters were mostly women (78 percent). Among all participants, 39 (65 percent) reported having been abused in interpersonal relationships. Fifty percent of the interpreters were White, and nonWhites were ethnically diverse: Black (23 percent), Hispanic (10 percent), Indian/South Asian (9 percent), East Asian (5 percent), and biracial (3 percent). Most interpreters had earned or pursued college-level degrees (87 percent). Among all interpreters, 52 percent were nonstudents, working in their professions or vocations, with an exception of six interpreters who were unemployed at the time of the study.

Overall, interpreters were well educated and diverse in respect to professional disciplines: social sciences (32 percent); education as teaching, administration, research, or policy (28 percent); mental health services (23 percent); visual arts and dance (25 percent); humanities (20 percent); natural sciences and technology (15 percent); and vocations, including hairdressing, sales, clerical, and caregiving (13 percent). These proportions do not add up to 100 percent because they are not mutually exclusive; 45 percent of interpreters reported having had formal training and professional experiences in more than one discipline and have worked across multiple disciplines throughout their lifespans. This situation indicated that attempting to categorize interpreters according to professional categories as if they were separate from each other was not as straightforward as it was initially envisioned. These co-occurrences reflected that interpreters had a wealth of professional experiences. The examined characteristics of the interpreters lend support to the ecological approach, which argues against analyzing individual aspects of human experience without considering the totality of experiences for any given individual.

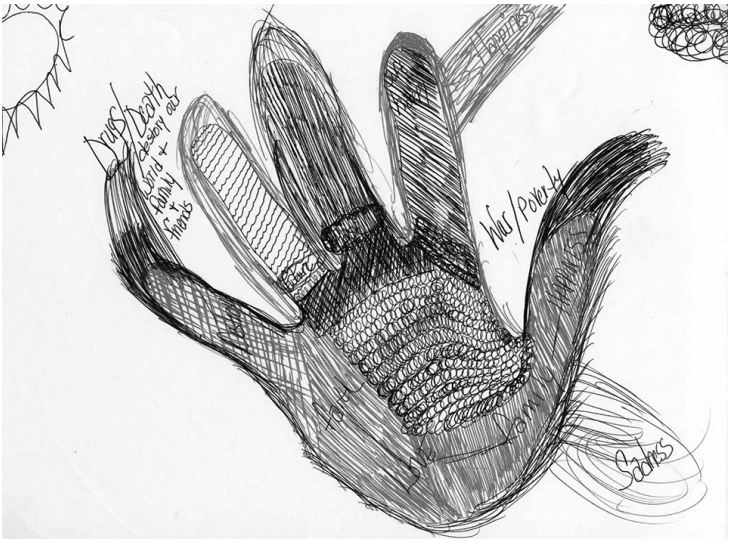
Stimulus Drawings

In research, stimulus materials augment traditional interviewing techniques by prompting the respondents through visual, auditory, or written means. They enable respondents to engage on a more direct level with

the material and elicit discussion about the researched topic.[5] In this study, the original drawings, titled "Inside Me–Outside Me," depicted drawers' self-perceptions and worldviews and were created by undergraduate students at a large public university under controlled conditions for another study (Dollinger, Kazmierczak, & Storkerson, 2011). Students were given a 50-minute time slot to create unrestricted representations of themselves in relation to others by tracing the palm of their hand or their foot onto a sheet of white, legal-size paper. The area inside the tracing designated the inner self, and the area outside the tracing designated the external world. Students populated those areas with rich representations of how they felt about themselves and the world around them. Formal aspects of the drawings included graphic marks, designs, symbols, and words in abstract, realistic, or expressionistic styles. In the current study, 196 of those drawings were sorted and interpreted by independent interpreters. Figure 2 shows an "Inside Me–Outside Me" drawing that is representative of images created by female survivors of abuse. Figure 3 shows a drawing that is representative of images created by non-abused males.

Figure 2

"Inside Me–Outside Me" drawing created by a female survivor of abuse.



5 Based on a definition from the website The Language Factory: Translation Made Simple, accessed August 8, 2018, https://thelanguagefactory.co.uk/stimulus-materials-2/.

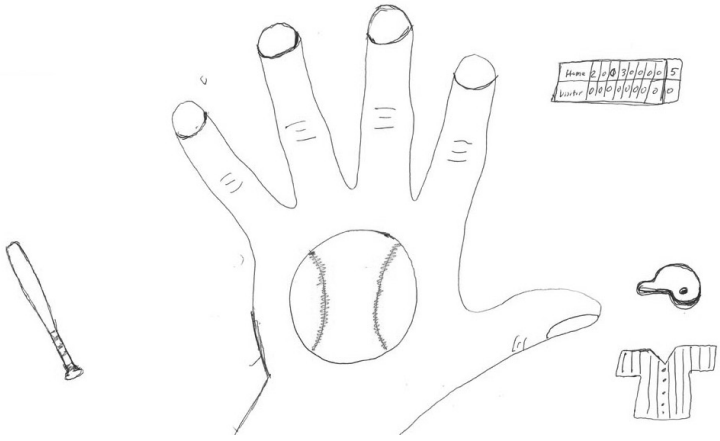


Figure 3

"Inside Me–Outside Me" drawing created by a non-abused male.

The stimulus drawings utilize imagery from Western vernacular iconography, stereotypical representations from popular culture, and imagery that has been acquired at a grade level. Hence, it is assumed that people familiar with Western culture are "capable decision-makers" about the meaning of such images and understand that those images relate to the real-life problems that can affect anybody.

Since previous diagnostic drawing tests in psychology have been interpreted by trained professionals who were actually only on par with laypersons, this study has focused on interpreters with varied skills, talents, and backgrounds to understand their decision process in judging the drawings, which do not require special training to be interpreted. A query into the layperson's decision process about images that draw from a general culture is a step toward building systematic research into interpretation of images as a decision process that can be applied both to general studies of images and to image design in particular

Procedure

The study sessions took place at semiprivate, quiet locations that were designated by the participants, including study rooms, conference rooms, participants' offices, and libraries. Each of the participants sorted and interpreted a set of 196 stimulus drawings. Some of those drawings (37 percent) were created by drawers who reported having been abused. Participants were asked to sort drawings into two piles: a pile with drawings that interpreters believed had been created by drawers who experienced interpersonal abuse, and a pile with drawings that they thought were created by non-abused drawers. Interpreters were provided with a definition of abuse and a list of 18 characteristics describing psychological attributes that can be found among victims of abuse concerning self-perceptions and perceptions of others. Those characteristics had been compiled from trauma literature and included perception of the world as a dangerous place, anxiety, self-blame, guilt, a dominant self-critical voice, and depression (Figley, 1985; Finkelhor & Browne, 1985; Herman, 1992).

The sequence of drawings was randomly changed at every 15th interpreter to counter the biasing influence of a given order. Interpreters were given technical instructions about how to perform the task, but no information was given about how abuse is manifested visually. Following the naturalistic approach, participants were asked to classify the drawings as they would any task in everyday life: devising their decision strategies and relying on their intuition. Upon the completion of the judging task, each interpreter was interviewed according to the qualitative semi-structured questionnaire, which included questions about demographic background and questions about the sorting process, such as, "Do you think that your experiences guided your interpretation of the drawings? Specify, which ones?" After the participants responded to the questionnaire, they were asked, during the interview, "What experiences, thoughts, or methods helped you classify the drawings?" and "What can you say about your interpretive process?" One goal was to avoid implying any criteria that might not be related to experiences that judges indicated in the questionnaire up to that point. Combined, the questions were designed to elicit rich descriptions of the criteria, the process, and the beliefs about how abuse is manifested visually. All interviews were recorded, and the recordings were used to validate the notes, which were taken by the researcher during the interviews. During the sorting procedure, the researcher sat across the table from the interpreters and recorded their responses on a scoring sheet that was constructed for this study. Figure 4 shows the setup of a table during the sorting procedure.

Figure 4

A table setup for the sorting procedure.

Data Analysis

The study sought to find out whether participants could identify criteria by which they sorted the drawings. The interview responses were examined in depth to provide answers to the question, "Did the interpreters develop any sorting criteria and/or heuristics?" Audio recordings were reviewed and analyzed against the researcher's notes that were taken during the interviews to make an initial list of the sorting criteria. For each interpreter, statements—indicating sorting criteria, heuristics, and intuitive beliefs about how abuse and abuse-free worldviews are manifested visually—were transcribed verbatim, that is, exactly the way they were spoken. For interpreters who indicated more than one criterion, the order in which the interpreters indicated the criteria was recorded.

Verbatim transcripts of statements about sorting criteria, heuristics, and meanings were copied from a Word file into an Excel file to accommodate different sorting approaches, searching for repetitive words, phrases, and statements. For the interpreters who provided lengthy and loquacious descriptions, two or three sentences that best represented sorting criteria, heuristics, and meanings were selected. The statements were inspected visually and clustered together in various ways—using the keyword search option—so that the same or similar statements were grouped together. For example, the frequently cited word "dark" was entered to cluster and further analyze statements that included that word for similarities and differences among them and to determine whether they revealed new information. The statements were analyzed line by line within and across varied clusters to discern dominant statements, themes, and their variations (Miles & Huberman, 1994).

To stay close to the data, the transcribed statements were preserved in their original form. Hence, no labeling, no paraphrasing, and no teasing out the possible meanings of the transcribed statements were applied. The original statements about sorting criteria, heuristics, and meanings included entire sentences, phrases, and individual words. They were grouped together if they shared keywords or phrases. For example, the phrase "when I don't like something" was entered as a keyword and counted as an instantiation of a heuristic that will be discussed in the results. Only minor modifications were made to the original statements. For example, "what dominates" was changed during the naming of heuristics into "dominant mood." A straightforward content analytic method was applied and *manifest* content, rather than latent, was analyzed and counted. This approach reduced a need for multiple coders working independently on the same data (Patton, 1990, pp. 382–83).

Statements about sorting criteria, heuristics, and meanings were quantified and entered as categorical variables in

regression analyses and chi-square tests of independence to evaluate whether sorting criteria were related to the accuracy of the judgments and, if so, what the direction and the magnitude of the association for each significant criterion were.

The abuse status of the drawers and the interpreters was recorded as a self-reported measure of abuse (explanatory variable), which included emotional, physical, and sexual abuse. Abuse was defined as "a form of victimization, mistreatment, violation, or treatment of someone so as to cause damage or harm (knowingly or unknowingly) to gain unfair advantage." A general measure has been applied because the study sought to understand the process of interpretation rather than to differentiate among specific forms of abuse (Figley, 1985; Finkelhor & Browne, 1985; Herman, 1992). At the end of the sorting task and after the drawing session, interpreters and drawers respectively were asked, "Have you personally experienced any form of abuse? If yes, specify." They recorded their responses in the semi-structured questionnaires. "Yes" responses were dummy-coded as 1, and "no" responses were coded as 0. The codes were entered into the analysis as a general variable for the self-reported abuse status of each interpreter. The *self-reported* abuse status of the drawers served as the criterion for the *judged* abuse status of the drawers and their drawings.

Results

The length of the sorting task ranged from 15 minutes to 420 minutes, with a mean time of 82 minutes (standard deviation = 64 minutes). The majority (83 percent) of the judging and interviewing were performed in one sitting, whereas ten interpreters (17 percent) completed the task in two or three sittings. Those interpreters asked for breaks to combat fatigue and maintain the ability to perform attentively throughout the entire sample.

Research Question 1: What classification criteria and heuristics can be identified on the basis of interpreters' reports?

Two overall approaches emerged from the analysis of the statements about sorting criteria, heuristics, and meanings. These approaches differed with respect to their specificity, that is, whether they allowed the identification of heuristics and specific visual cues that guided interpreters' judgments about the meaning of the drawings. The two methods consisted of broad decision criteria with which interpreters approached

the sorting task. One group of interpreters sought specific visual cues in the drawings and did so according to specific criteria. The other group of interpreters turned their attention inward and indicated recollecting their life experiences as criteria for the sorting. Hence, these approaches were labeled as "drawing-centered" criteria and "non-drawing-centered" criteria, respectively. The drawing-centered reports supplied ample information about interpreters' decision processes, including operational formulas (heuristics) that interpreters devised to perform the task. In contrast, non-drawing-centered reports were formulated in more general terms and lacked specificity needed for the identification of heuristics. Table 1 summarizes both approaches, with selected examples of interpreters' statements illustrating each approach.

Sixty percent of the reports ($n = 36$) were found in the drawing-centered group, and 38 percent ($n = 23$) were found in the non-drawing-centered group. Comparative analyses of the data were performed to identify specific decision criteria with which interpreters sorted the drawings. The criteria ranged from specific examples of visual cues that interpreters considered indicative of abuse or emotional distress to the gut reactions to what they saw in the drawings. Specific visual cues that interpreters believed indicated abuse included "issues of power" or "dramatic world and fire or blood." Gut reactions to the purported indicators of abuse were represented by statements like, "Anything odd that feels wrong" and "Anything I did not like."

As shown in Table 1, among the non-drawing-centered reports, 18 interpreters referred to familiarity with interpersonal abuse as their experiential knowledge base. That included interpreters' experiences as victims of physical, psychological, or sexual abuse and interpreters who knew about the effects of abuse on mental health directly from individuals who were abused or through learning about interpersonal abuse during their professional training. Three interpreters in that group referred to life experiences in general, including current and past interactions with others and the practice of self-reflection as the basis for the judgments. These criteria were expressed through the following statements: "Past experiences influence the viewing," "Where I am is the basis," and "Maybe my self-reflective work was helpful."

Two interpreters reported using a list of characteristics of a survivor of abuse—presented by the researcher at the beginning of the sorting session as a potential sorting aid—to guide the sorting task. It was included in the non-drawing-centered group because the list specified emotional states without indicating any visual cues. Also, one report fell outside the two categories and was coded as "did not specify," because the interpreter did not provide any information about the decision criteria.

Table 1

Sorting criteria and illustrative statements derived from the interpreters' reports.

Sorting criteria and the illustrative statements	% of the interpreters
Drawing-centered criteria (36 interpreters): • "If it looks happy, not troubled, balanced, then non-abused." • "I look for issues of power, abuse is about power." • "I wanted to be surprised." • "Dramatic, fire or blood." • "What I would draw." • "Negative words." • "Division into before and after." • "Painful memories, past hurt, drugs mean abuse." • "Mad, sad, words related to fear, pain, unlove, uncertainty, harsh, heavy 'dark' lines, even in 'pretty' pictures." • "Anything odd that feels wrong." • "When I don't like something, it means abuse, religion means abuse.	60%
Non-drawing-centered criteria (23 interpreters): 1. **Interpreter's exposure to interpersonal abuse as a victim or via knowing the victims** (18 interpreters). 2. **Interpreter's life experiences** (3 interpreters): • "Where I am is the basis." • "My self-reflecting work was helpful." • "Past experiences influence the viewing." 3. **List of characteristics of a survivor of abuse** (2 interpreters): • "I used only the information I was given." • "I followed the list."	38%
Unspecified (1 interpreter)	2%

Six visual heuristics[6] were identified based on the drawing-centered criteria, which were derived from the analysis of questionnaires and interviews: (1) ease of understanding, (2) out of the norm, (3) dominant mood, (4) seeing the whole, (5) within the norm, and (6) elaboration. The data were organized thematically and sorted by counting the number of mentions of each rule of thumb, according to which interpreters discriminated drawings created by abused drawers from drawings created by non-abused drawers. Table 2 shows the breakdown of the heuristics, which are illustrated by the representative quotes from the interview data. The table shows a total of 50 statements, even though they originate from 36 reports. That is because some of the interpreters indicated utilizing more than one decision criterion. For interpreters who indicated more than one criterion, no attempt was

6 The term "visual heuristic" has been used to emphasize that interpretations or judgments regarded visuals and to distinguish heuristics concerning visual materials from heuristics related to nonvisual data, such as determining which strategy to pick for product development or organizational management.

made to determine whether they were used hierarchically. The priority for the analysis was to identify the criteria.

It has to be noted that not all the interpreters who reported drawing-centered methods screened drawings for cues of abuse. A handful of the interpreters looked for indicators of general distress without attributing it to a specific cause, such as abuse. Those interpreters looked for indicators of a "problem with the drawers' self-perceptions or worldviews," which may or may not be related to abuse. For example, one interpreter who reported looking for things that were out of the norm stated, "I don't know if they are abused, but I put drawings that are 'not right' on this pile." In other words, those interpreters determined whether they saw indicators of out-of-the-norm worldviews but withdrew from making assumptions about the potential causes.

Table 2

Heuristics and illustrative statements derived from the drawing-centered reports.

Heuristics	Illustrative statements from the drawing-centered reports	N / %
Ease of understanding	"Things that are easy to understand."	15/42%
Out of the norm	"Anything that is out of the norm that makes me want to talk to them more."	10/28%
Dominant mood	"What dominates, the negatives or the positives?"	8/22%
Seeing the whole	"Assess the whole picture."	7/19%
Within the norm	"That which is normal." "That which is expected."	5/14%
Elaboration	"How elaborated, developed or time consuming are drawings?"	5/14%

1. *Ease of understanding:* From among the interpreters who reported drawing-centered criteria, 42 percent searched for things that were "easy to understand." The interpreters listed specific thematic and visual cues that they considered easy-to-understand indicators of abuse, such as fear, pain, lack of love, uncertainty, painful memories, drugs, unhappiness, a dramatic view of the world, sadness, and harsh and heavy dark lines.

2. *Out of the norm:* Twenty-eight percent of the drawing-centered reports indicated that interpreters screened the drawings for "anything that is out of the norm" or "anything that is out of the norm that makes me want to talk to them more." The goal of diagnostic judgments is to make predictions about whether people who created the drawings were abused; therefore, anything outside the norm raised red flags for many

interpreters. The interpreters who devised an out-of-the-norm heuristic followed their immediate, negative gut reactions to identify abuse: "Anything odd that feels wrong is abuse" or "When I don't like something [it signifies abuse]." One interpreter was very specific about visual elements that alerted her attention, stating, "Life and death, fight or die, war, all those sad words were raising my attention. I am aware that normal people can draw differently, but if I had to put them on a pile, that is what I looked for." Figure 5 shows the most often reported visual indicators of abuse, whereas Figure 6 shows the most often reported visual indicators of non-abuse. These indicators of abuse and non-abuse were found *easy to understand* in their respective categories by nearly all interpreters: between 92 and 95 percent of interpreters found these indicators of abuse (Figure 5) *easy to understand*, and between 93 and 97 percent found these visual indicators of non-abuse (Figure 6) easy to understand.

Figure 5

Visual indicators of abuse that the interpreters found easy to understand.

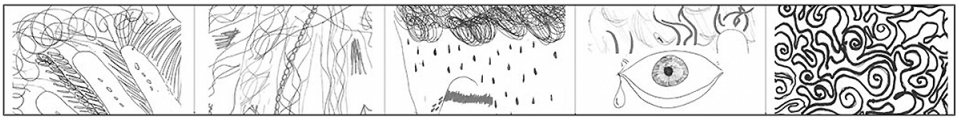


Figure 6

Visual indicators of non-abuse that the interpreters found easy to understand.

3. *Dominant mood:* Twenty-two percent of the interpreters in the drawing-centered group screened the drawings to assess whether an overall general theme, mood, emotion, feeling, or cognition was positive or negative. The interpreters examined the drawings to determine whether the depictions were "uppers" or "downers," as one interpreter put it. Another interpreter specified her criterion in this way: "If about loneliness, helplessness, fear, but nothing to counteract, then abused."

4. *Seeing the whole:* Nineteen percent of the interpreters who examined the drawings in search of the cues of abuse or non-abuse strongly indicated that they examined the entire image to infer the meaning of the drawing and make the sorting decision that followed. They described the decision process as being dependent upon looking at the entire image in order to assess the meaning of individual elements and their arrangement to each other and the entire composition. For example, one interpreter reported, "You have to look at the whole picture from all sides to make your choice."

5. *Within the norm:* Fourteen percent of the interpreters who reported screening the drawings in search of specific visual cues mentioned looking for indicators of normal states that were depicted by the drawings. One interpreter reported this strategy as the only decision criterion, and four interpreters reported this criterion in conjunction with other criteria. The interpreters described states "within the norm" as typical situations—expected and usual. Normal states, according to the interpreters, were those that interpreters ordinarily encounter daily. Interpreters expected to see normal states in their daily lives, and so those states did not require any special attention. One interpreter considered any drawing that might be created by her or her children as an indicator of normality: "If I could draw it or my kids could draw [it], I did not think anything about them." Other examples of comments indicating normal states included "Normal is no problem" and "If it looks balanced, then no problem."

6. *Elaboration:* Fourteen percent of the reports in the drawing-centered group indicated that interpreters classified the drawings based on their elaboration—that is, by how much ink was on the page. This criterion stemmed from the interpreters' belief that abused or traumatized individuals create drawings that are tediously drawn or take a great deal of time. The interpreters specified this criterion through the following statements: "A detailed drawing that takes a lot of time is abuse," "Drawings the abused have more substance, more force," and "The abused put a lot of themselves into drawings." The elaboration heuristic is the only heuristic found by this study that is specific to trauma. The other heuristics can be presumed as applicable to other situations in which perceptual judgments have to be made.

Research Question 2: Can heuristics improve the accuracy of judgments?

All interpreters were included in statistical analyses to determine whether there were differences in accuracy[7] rates between the drawing-centered and non-drawing-centered approaches. The accuracy scores for individual interpreters were calculated for each approach, using linear regression to assess whether any of the strategies were associated with higher accuracy rates. There was no significant relationship between accuracy and the non-drawing-centered approach, whereas the association between accuracy and the drawing-centered approach achieved significance. The drawing-centered reports consisted of heuristic criteria; hence, this result indicates that heuristic criteria may be a meaningful factor in visual interpretation.

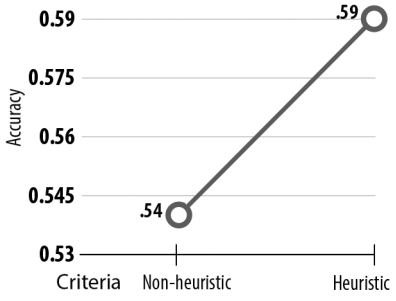
For the drawing-centered approach, the regression model showed a significant effect of heuristic-based decisions on accuracy

7 Accuracy rate = proportion of drawings that were correctly identified.

(β = .04, p < .001), which accounted for 29 percent of the variance in accuracy $F(1, 59) = 23.274$, $p < .001$. Figure 7 graphs the regression, showing that, on average, interpreters who reported at least one heuristic as their sorting criterion correctly identified 59 percent of the drawings, whereas interpreters who reported non-drawing-centered or non-heuristic-based criteria correctly classified 54 percent of the drawings. The two proportions do not add up to 1 or 100 percent because they are independent from each other and are not mutually exclusive. To explain how these proportions work: hypothetically, interpreters in each group could correctly identify all stimulus drawings, none of the drawings, or some of the drawings and achieve an average accuracy rate falling between 0 percent and 100 percent.

Figure 7

A graph of the regression: Accuracy rates relative to the sorting criteria.



In sum, the increase of four percentage points in the accuracy rate indicates a marginal difference in interpreters' performance. Whether this marginal difference supports the hypothesis that heuristics can improve accuracy can be debated. It can be taken as not supportive, or it can be interpreted as indicative of a general direction of an association between higher accuracy and the use of heuristic-based criteria in some situations. Certainly, more research with a larger number of participants is needed to evaluate how this association performs in other contexts to assess the reliability of the latter interpretation.

Research Question 3: How does the interpreters' self-reported abuse status relate to the quality of the interpretive judgments?

The descriptive statistics in Table 3 show the tendency rates. Tendency is the proportion of drawings that were judged as created by drawers who were abused, whether or not those judgments were correct. On average, of all 60 interpreters, those who did not report having been abused classified 33 percent of the drawings as created by the abused. Interpreters who self-identified as having been abused classified 47 percent of the drawings in the sample as created by the abused—14 percentage

points higher than those who did not self-identify in that way. These findings indicate that judges who reported having been abused saw indicators of abuse in the drawings more frequently than judges who did not report having been abused, regardless of whether those purported indicators were correct. The results have been interpreted as lending support to the hypothesis that interpreters who self-identified as having been abused were sensitized to seeing indicators of abuse in the drawings more frequently than judges who did not self-identify as having been abused, as measured by tendency.

Table 3

Tendency rates relative to the abuse status of the interpreters.

Interpreter	Minimum	Mean	Maximum	Standard Deviation	Number of Interpreters
Abused	0.24	0.47	0.90	0.15	39
Non-Abused	0.14	0.33	0.59	0.12	21

The same association, but more prominent, was found for gender. To illustrate this association, the five highest tendency rates in the sample have been examined against the gender of the abused interpreters. As shown in Table 4, the highest tendency scores were extremely high and were achieved by female interpreters who were abused. For male interpreters who were abused, the highest tendency scores were lower than those of the abused women but higher than the scores found among the non-abused interpreters. In other words, some female interpreters who were survivors of abuse and earned the highest scores on tendency saw indicators of abuse in nearly all drawings in the sample. They judged between 69 and 90 percent of the drawings as created by abused drawers. Men who self-identified as survivors of abuse and earned the highest tendency scores saw indicators of abuse in 65 percent of the drawings. For comparison, the highest tendency scores for non-abused interpreters were 59 percent (Table 3), suggesting they saw indicators of abuse in 59 percent of the drawings.

Table 4

Highest Tendency scores among the interpreters who were abused.

Highest Tendency scores in Percentages	Interpreter's Gender
90%	Female
85%	Female
69%	Female
65%	Male
65%	Male

These results suggest that self-reported abuse status predicts that interpreters who have been abused will have a high predilection for seeing indicators of abuse and will judge images as displaying more indicators of abuse than interpreters who have not self-identified as victims of abuse. This result can be expected to manifest particularly strongly among women who self-identify as having been abused in comparison to interpreters who have not been abused.

Discussion

The study presented in this article sought to examine the interpreters' decision criteria, personality characteristics, and emotion-laden experiences as factors affecting interpretation of images that were created for diagnostic assessment. The study queried what decision criteria interpreters from varied professions employ to judge the abuse status of drawers from their self-representational drawings, which represented drawers' self-perceptions and worldviews. The study measured the accuracy of the judgments relative to the judging criteria to test the hypothesis that heuristics can improve accuracy. Interpreters were asked to sort drawings that were created by undergraduate students (for another study) into two groups: drawings that interpreters believed were created by drawers who had experienced interpersonal abuse as victims and drawings that they believed were created by the non-abused.

The questionnaires and interview data were examined against the model of fast and frugal heuristics as adaptive tools for naturalistic decision-making. The results of this study indicate that 60 percent of the interpreters devised simple heuristic rules to guide their decision process. These heuristics—including ease of understanding, out of the norm, dominant mood, seeing the whole, within the norm, and elaboration— were used as decision criteria and implicated the selective reliance on perceptual cues to aid in the management of a cumbersome task of interpretation of many images (196 drawings), which, on the whole, were complex in form and rich in content.

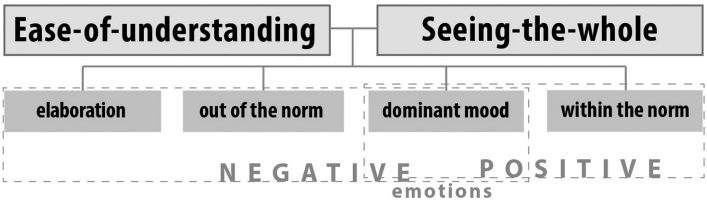
Figure 8 shows how the six heuristics function in the decision process and how they relate to each other against the backdrop of affective judgments. For interpreters who searched for cues in the drawings, each rule of thumb (heuristic) reflects a criterion according to which images were judged. For instance, an interpreter reported *seeing* [each drawing] *as a whole* to determine the *dominant mood*: "If about loneliness, helplessness, fear, *but nothing to counteract*, then abused." Most often, interpreters approached the sorting task intending to find things that were *easy to understand*, or familiar and easily discernible patterns in the images. They

searched for patterns that enabled them to construct coherent wholes—that is, images that make sense. To look for patterns is to apply or devise criteria that make a good fit with the task at hand.

The *seeing the whole* criterion reflects the holistic nature of perceptual judgments, while other heuristics point to specific applications of that criterion. As shown in Figure 8, the *seeing the whole* heuristic is on par with looking for cues that are *easy to understand*. These two heuristics have been positioned as overarching criteria in the decision space that spans from negative to positive valuations of emotions. Emotions are organisms' automatic responses to the environment and relate to functioning in the world that is seen through the lens of whether something is bad or good for the organism, according to Damasio (2012). In an interpretive decision process, emotional valuation is a factor affecting decisions and choices. An area of negative valuation transitions into an area of positive valuation. In the context of this study, an area of negative valuation contains criteria that relate to abuse (*elaboration* and *out of the norm*), whereas an area of positive valuation is associated with criteria that relate to non-abuse (*within the norm*).

Figure 8

Heuristics in the decision process and affective judgments.



The *dominant mood* heuristic is positioned halfway between the positive and negative valuation areas. It belongs to both because it is used for the determination of whether a prevailing mood, theme, feeling, or function of an image is positive or negative. Looking for what dominates requires seeing the whole first. Assessing the dominant mood depends on *ease of understanding* as well, as interpreters reported making judgments about the dominant mood based on depictions that were easier to understand than others. The challenge in design is to identify those visual cues or perceptual variables that make the strongest impact on judgments.

When applied to image design and visual communication design, the decision model designates the criteria of rejection and acceptability. The *within the norm* criterion may or may not be associated with the desirability of a design. Without relevant research, it can be presumed that the *within the norm* criterion indicates acceptance at best or a neutral approach to a design. Through user testing, one can assess what makes a design desirable and what the desirability criterion is. The criterion would occupy the positive valuation area in the model.

The challenge for designers is to establish what expectations and sensory cues in a design are associated with positive and negative emotional responses in specific groups of users. Designers must pay attention to gender and emotion-laden factors, as they always influence judgments and can bias attitudes toward designs in powerful and unexpected ways. By the same token, emotional biases in both genders can be utilized by designers to construct gender-specific visual messages that will achieve a desired emotional impact and influence subsequent decisions.

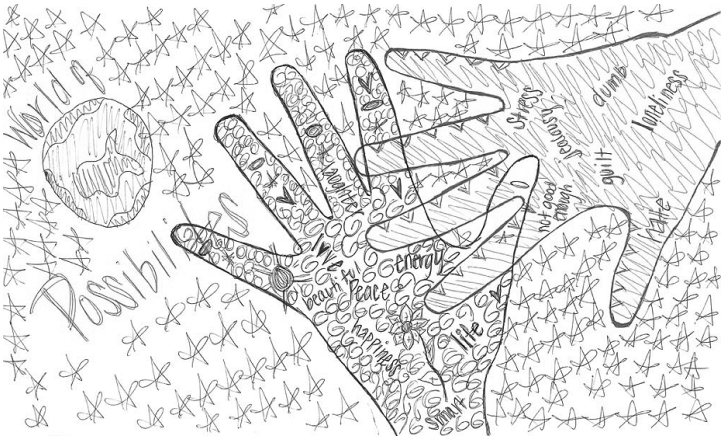
Looking at things holistically and discerning easy-to-understand patterns are typically effortless operations because the cognitive work is done intuitively or implicitly and without the interpreters' awareness. Most decisions and choices are made by the cognitive unconscious according to the learned patterns that have been acquired through interactions with the environment. The pattern-seeking behavior is enforced by looking at things holistically in search of familiar visual cues.

The intuitive decision process becomes deliberate to the point of being halted when interpretation is problematic. Figure 9 shows a drawing that was difficult for interpreters in this study to judge. The difficulty of judging was indicated by the longer time it took interpreters to sort the drawing and by the rate of "non-abused" and "abused" judgments that were assigned to this drawing: 50 percent of interpreters judged it as having been created by a non-abused drawer, and 50 percent determined it was created by an abused drawer. Several interpreters commented that this image has a balance of positive and negative cues, and they could not decide how to interpret it or, subsequently, how to sort it.

Drawings that lacked a dominant mood, feeling, or theme were often perceived as ambiguous. This finding is not surprising. Designers know all too well the situations in which "poor gestalts" or unresolved compositions are poorly received and perceived as unstable and unnerving. They simply do not make "good forms." The difficulty with judging the drawing in Figure 9 is consistent with what Ramachandran and Hirstein (1999) described as a psychological phenomenon of the "peak shift" effect. That is, forms that distinctly extend in one dominant direction trigger stronger reactions than shapes that extend equally in more than one direction. By the same token, Ramachandran and Hirstein (1999) extended their argument toward art: "Art is most appealing if it produces heightened activity in a single dimension (e.g., through the peak shift principle or through grouping) rather than redundant activation of multiple modules" (p. 15).

Figure 9

An ambiguous "Inside Me–Outside Me" drawing that was difficult to judge; created by a non-abused female.



The visual heuristics can be viewed as representative of a more general rule of thumb, that is proposed by Gigerenzer: the *take the best* heuristic. The *take the best* criterion can be understood as a criterion that interpreters applied intuitively (Goldstein & Gigerenzer, 2002). It is a cognitively economical method for making judgments concerning situations about which people know little. Proponents of the fast and frugal heuristics model argue that people automatically decide on the *best* criterion that fits a given situation, especially in unfamiliar situations. In the study presented in this article, all interpreters lacked information about how abuse is manifested visually, and for 35 percent of the interpreters the topic of interpersonal abuse itself was unfamiliar. Hence, it has been concluded that the visual heuristics found by the study exemplify the *take the best* heuristic.

The study found that the heuristic criteria were associated with marginally higher accuracy of judgments in comparison to the interpreters who reported life experiences as the criteria. But since the difference in the accuracy rates between the two groups is small, the result can be interpreted both ways: it can be viewed as supportive of the hypothesis that heuristics can improve the accuracy of judgments, or it can be interpreted that the study did not provide enough evidence to support that hypothesis.

One way to understand the result is to consider it vis-à-vis the cultural context from which the imagery displayed in the stimulus drawings originated. The drawings displayed popular iconography from vernacular culture. Hence, the perceptual expertise needed for the interpretation of the drawings was based on familiarity with popular Western culture and did not require aid in the form of heuristic criteria. The perceptual competence, in this case, depended on general skills in pattern recognition that are connected to the neurobiological foundation of perceptual processes, which are shared across people within and across cultural domains. The stronger dependence on pattern recognition makes the perceptual processes less dependent on the decision aids.

The idea that visual perception is based on general skills in pattern recognition that are connected to the neurobiological foundation of perceptual processes is not isolated or novel. Designers are aware of gestalt principles of visual grouping that inform understanding of how to design effectively. For example, an article in *Visible Language* argued this view from the perspective of participatory design (Zender, 2017). Whatever the interpretation of the finding of the study may be, it is important to keep in mind that best decisions are those that are appropriate to a given task and a situation: "Decision performance is about the fit between cognition and environment" (Keller et al., 2010, pg. 262).

There is more to the economy of the decision process than higher accuracy alone. A general view has been that reliance on heuristics and nonconscious processing lowers the cognitive load of the processing and speeds up subsequent judgments. That, in turn, frees the brain so that it can focus on things that require deliberate decisions. Heuristics have been shown to speed up the process through the *selectivity of attention*. The implication of the selectivity of attention is aligned with the results of a 2019 study on visual attention that found that people attend to the important features in images first: "When visual stimuli are intermingled, they are understood based on visual hierarchy . . . by recognizing the most important features first" (Kim and Fritsch 2019, 109).

When people utilize heuristics as the criteria that guide the decision process, they automatically ignore and deem irrelevant information that does not fit the criterion or criteria (Damasio, 2012; Gladwell, 2005, p. 143). In other words, they operate according to the selectivity of attention. As an example, one interpreter who sorted drawings according to the out of the norm criterion said, "I was looking for anything that is out of the norm that makes me want to talk to them more." This selective attention was one of the contributing factors to the astonishing efficiency of this interpreter's performance, who on average took only 4.6 seconds to evaluate a drawing. This interpreter reviewed and classified 196 stimulus drawings in 15 minutes. This interpreter was not only impressively speedy, but also more accurate than other interpreters.

Regarding personality characteristics, this efficient and successfully performing interpreter could be described as open toward others, interested in others, nonjudgmental toward others, open toward nondiscursive experiences, creative, and self-accepting. These characteristics were measured through the diversity of professional interests, cultivation of special skills, and volunteer work. These personality characteristics, discussed in an earlier section, have been found among successful diagnostic interpreters. This interpreter's personality profile is also aligned with the findings from research on decision making in product design. Almendra and Christiaans (2009) found that participants' self-esteem plays a role in the decision process: "Subjects with high self-esteem who are assertive and not

averse of risk taking and uncertainty are more likely to decide in ways that allow processes to progress towards a consistent final solution" (p. 517).

In sum, personality characteristics add a genetic dimension to the factors affecting interpreters' judgments, whereas the naturalistic framework accounts for the holistic approach to the perceptual and experiential factors. The argument is that a layperson's skills, knowledge, preferences, and professional expertise in any field are all cultivated by one highly capable mind, be it conscious or unconscious, and contribute to the development of interpretive skills.

Moreover, the study has demonstrated that emotion-laden experiences, such as the experience of abuse as victims in both genders—and in women, in particular—play a powerful role in altering worldviews, which in turn dramatically affect the interpretation of images. This result is aligned with studies on decision-making under the influence of stress and negative emotions such as anxiety, anger, or embarrassment. Such studies indicate that stress and negative emotions can drastically alter the decision process (Tierney & Baumeister, 2019).

The heuristic model pertains to one aspect of the decision process. Deliberate decisions make up the other side. Damasio's (2012) view is that conscious deliberation takes care of reflection over knowledge: "We apply reflection and knowledge when we decide on important matters in our lives" (p. 287). He gives examples of decisions about how to conduct relationships with loved ones and friends, career planning, and moral behavior. Deliberate decisions involve long and careful consideration. Their processing, according to Damasio (2012), competes with the immediate perceptual processing for the limited processing power of the brain to the extent that it can "overwhelm external perception" (p. 287).

In light of this argument, the decision process of interpreters who reported relying on life experiences and did not report more specific decision criteria can be construed as follows: The interpreters shifted their attention inward to recall relevant experiences. The inward move, the recall, and reflection on the experiences may have activated the conscious deliberation process, which made the decision process longer. Seventy-eight percent (n = 18) of the interpreters in this group self-identified as victims of abuse. The data have shown an association between the interpreters' experience of abuse as victims and longer judging time. Some of the abused interpreters indicated wanting to give the drawers full and careful consideration. By the same token, as the abused interpreters recalled the trauma of abuse, they may have gotten distracted by their recollections. Alternatively, as they carefully deliberated the stimulus drawings, they may have experienced the limited processing power of the brain and became overwhelmed by the seriousness of the task and numerous perceptual variables. (Keep in mind that the drawings were rich in form and complex in content.)

Limitations

There are limitations to this study that warrant attention. First, considering the sample design and recruitment strategies with a high self-selection rate of participants, none of whom had training in the evaluation of diagnostic drawings, the results from this study are not generalizable to the broad population of Americans, but rather, apply to individuals who are open to nondiscursive experiences and are interested in other people. A larger sample of diverse interpreters is needed to gain confidence in the conclusions drawn from this study, especially regarding the reliability of an association between heuristics and the accuracy of judgements.

Second, the interviews were conducted after the sorting task. Therefore, the reports were retrospective and might have been interpreters' rationalizations that were automatically created to suffice as insights into the decisions that were nonconsciously realized (Nisbett & Wilson, 1977). There is a risk that interpreters did not access their internal processes but guessed what their decision criteria were. The reason for delaying the request "Tell me how you decided or judged" was informed by research that indicated that questioning the decision process as it occurs can be confusing and can negatively affect the ability to make sound judgments.

Psychology and cognitive science postulate that the decision process takes place on a spectrum between the cognitive unconscious and conscious deliberation (Damasio, 2012). People lack the tools to assess to what degree and which part of the brain was mobilized in the decision process. In defense of introspection, Damasio (2012) argued, "Engaging in introspection turns out to be a translation, within the mind, of a process that complex brains have been engaged in for a long time in evolution: talking to themselves, both literally and in the language of neuron activity" (p. 195). Moreover, Damasio (2012) stated, "Introspection, as we have seen, can provide misleading information. But the risk is well worth taking, given that introspection offers the only direct view of what we wish to explain. Besides, if the information we gather leads to flawed hypotheses, then future empirical testing will reveal them to be so" (p. 195). Thus, self-reports were used as phenomenological indicators of interpreters' awareness of their interpretive criteria and methods, not as veridical statements about the invisible processes that underlie interpretation (Ericsson & Simon, 1984). So, the results should be viewed with an understanding of the limitations of retrospective insights.

Third, one-person coding—the result of time constraints and lack of funding—poses a methodological limitation of this study. In an ideal world the coding would have been performed by more than one person, and inter-rater reliability measures would have been reported. Future research projects that build on the study presented in this

article can incorporate inter-rater reliability measures to increase the validity of the data and analysis.

Fourth, the study's method was not granular enough to capture the decision processes of the interpreters who reported relying on life experiences broadly conceived. Those reports have not been linked with specific operational decision criteria. The interpreters in that group might have applied heuristics without realizing it or without mobilizing enough introspective effort that would allow the interpreters to identify and report more specific criteria for the decision process.

Significance and Future Research

The study presented in this article empirically tested the utility of a framework that can be applied to studies of interpretive judgments. This integrative framework makes possible empirical research that accounts for both biological and cultural dimensions of interpretation. The framework perfectly fits the intuitive and open-ended foundation of the creative process by relying on naturalistic methods as they are applied in real-life situations. This study sets a stage for developing an empirically grounded methodology for exploring how people infer meanings from images. Whether used independently or together with the heuristic decision model, Brunswik's (1952) ecological approach to perceptual judgments is suitable to both qualitative and quantitative methods. Ample research that utilizes his methodology in perceptual and cognitive psychology can inform future researchers studying how images are interpreted (Juslin & Montgomery, 1999; Kirlik, 2009). Similarly, the heuristic approach that links processes of image interpretation with visual cognition and heuristic judgments applies a body of knowledge from those research areas as well.

The results illustrate how Brunswikian principles of perceptual judgments, especially Brunswik's (1952) emphasis on the selectivity of perceptual judgments, can be applied to studies of visual interpretation. Importantly, he provided both a theory that is grounded in empirical research and a methodology that is well suited to such research that is concerned with visual interpretation as a decision process. Brunswikian calls for experimental studies that mirror real-life situations are not new. For instance, naturalistic methods flourish in user testing in human-computer interaction design. User studies provide naturalistic or real-world settings without the label "naturalistic." Users' interactions with the computer are set up to simulate real-world or real-life situations. However, they are applied without a theoretical grounding—that is, without a general theory that can explain how people make sense of the external world with which they interact. A Brunswikian model can provide such a framework.

The results of this study lay the foundation for a model of visual interpretation as a complex decision process that is affected by specific factors. The results show that visual interpretation is not a matter of visual perception alone, but involves a complex process of decision making that depends on the decision criteria, personality factors, gender, and emotional biases. The model can be expanded by future studies of other factors. Moreover, the results show that people are successful in making inferences, consciously or not, about the meaning of images in situations with incomplete information and limited access to time or decision aids, such as statistical tools or additional information about the subject. Those inferences are consequential insofar as they guide subsequent decisions and actions.

Importantly, the study conceptualizes interpretation of images as a decision process of a certain kind: one that relies on abductions—that is, creative leaps of ideas. The sorting task required that interpreters make guesses about the drawers' state of mind based on how interpreters judged what they saw in the drawings. In Peircean terms, abduction is "the process of forming explanatory hypotheses" (CP, 5.171). It is an "act of insight" by which new knowledge can be obtained (CP, 5.181). In general, abduction is at the core of creative and aesthetic endeavors, including design (Merrell & Queiroz, 2010). Designers make abductions all the time, although without attaching the "abduction" label to the process.

The results of the study draw designers' attention to the significance of images that are outside the norm. Knowing the characteristics of images that deviate from the norm can play a strategic role in utilizing the images to capture attention and to elicit specific affective responses in the users and audiences. That is especially true for images representing universal, common emotions such as fear, anger, sadness, happiness, disgust, and surprise (Damasio, 2012, p. 131). Further, knowing which indicators of negative emotions tend to be associated with the deviation from the norm can be strategically utilized in the design of images.

Future research, first, can investigate the following questions about the decision process and the decision context: Under what conditions do people utilize heuristics? When do people utilize deliberate decision processes? And which decision criteria are more effective and under what conditions? Future research also can lead to a better understanding of the subjective factors that affect the decision process by asking about the characteristics of interpreters who devise heuristic strategies more often than others and in what situations.

Second, future studies can evaluate the heuristic-based model of visual interpretation using the think-aloud method (Nielsen, 1993, 2012) rather than retrospection. Participants can be asked to speak aloud the criteria by which they judge images during the process of judging. Moreover, such studies can evaluate whether the thesis of the study—that is, that people have competencies in visual analysis regardless of their

professional expertise—holds true for designers and non-designers when faced with varied types of images.

Recommendations for Design

The primary goal of visual design is to design for human use, that is, *to make things scrutable* and *easy to understand and use*. To understand visual design is a matter of understanding patterns, patterns within patterns, and patterns connecting with patterns. It is a gestalt. Directional signs or way-showing signs are ways to create patterns. The goal of design is to flatten the learning curve by making consistency and a hierarchy of patterns comprehensible as well as by building on what people already know and apprehend. This study contributes to such a goal. The results of this study suggest that examining decision making can lead to a better understanding of the process of visual interpretation. The conceptual framework of visual interpretation as a decision process that involves specific decision criteria can be utilized in human-centered design. The heuristic criteria that have been identified by the study (except for the elaboration heuristic)[8] are applicable to the study of how people make sense of visual designs. Here is how the heuristic criteria can guide designers' work:

(1) Designs must be *easy to understand* by people who use them.

(2) Incomprehensible designs are associated with negative emotions and are construed as *deviations from the norm*. Such designs raise *red flags* in the minds of users and are usually rejected.

(3) Designs must have a clear and understandable (to users) *dominant purpose and function*.

(4) Designs must function as *coherent wholes*, not as assemblages of disparate elements.

(5) Designs must be built on *patterns that users recognize.*

These factors play a role in evaluating whether users can make sense of and be drawn toward or away from newly designed environments, communications, or devices. It is the responsibility of designers to create situations that enable people to reliably and intuitively learn to recognize new patterns of information. Designers are well-advised to keep in mind that what is normal for some may not be normal for others, because a sense of normalcy develops over time from experience. Hence, it is wise to avoid making assumptions about users based on one's own experience and instead to rely on users' feedback.

8 The elaboration heuristic is not applicable to non-trauma-related situations because it relates to the belief that trauma is associated with elaborated drawings.

References

Albee, G. W., & Hamlin, R.M. (1949). An investigation of the reliability and validity of judgments of adjustment inferred from drawings. *Journal of Clinical Psychology*, *5*, 389–392. https://doi:10.1002/1097-4679(194910)5:4<389::AID-JCLP2270050409>3.0.CO;2-0

Almendra, A. R., & Christiaans, H. (2009). "Decision-making in design: A comparative study." *ICORD 09: Proceedings of the 2nd International Conference on Research into Design, Bangalore, India*. 508–18. https://www.designsociety.org/publication/32319/Decision-making+in+Design%3A+A+Comparative+Study

Brunswik, E. (1952). *The conceptual framework of psychology*. University of Chicago Press.

———. (1955.) Representative design and probabilistic theory in a functional psychology. *Psychological Review*, *62*(3):193–217. https://doi:10.1037/h0047470

Burley, T., & Handler, L. (1997). Personality factors in the accurate interpretation of projective tests. In E. Hammer (Ed.), *Advances in Projective Drawing Interpretation*, 359–77. Charles C. Thomas.

Damasio, A. (2012). *Self comes to mind: Constructing the conscious brain*. Vintage Books.

Dollinger, S., Kazmierczak, E., & Storkerson, P. (2011). Creativity and self-exploration in projective drawings of abused women: Evaluating the Inside Me–Outside Me Workshop. *Journal of Creativity in Mental Health*, *6*(3):202–19. https://doi:10.1080/15401383.2011.607094.

Dreyfus, H. (1980). *Symbol sourcebook: An authoritative guide to international graphic symbols*. McGraw-Hill.

Eliasmith, C. (2004). Abduction. In E. Hochstein (Ed.), *Dictionary of Philosophy of Mind*. https://sites.google.com/site/minddict/abduction

Ericsson, K. A. (2005). Recent advances in expertise research: A commentary on the contributions to the special issue." *Applied Cognitive Psychology*, *19*:233–41.

Ericsson, K. A., & Simon, H. A. (1984). *Protocol analysis: Verbal reports as data*. MIT Press.

Figley, C. R. (Ed.) (1985). *Trauma and its wake: The study and treatment of post-traumatic stress disorder*. Brunner/Mazel.

Finkelhor, D., & Browne, A. (1985). The traumatic impact of child sexual abuse: A conceptualization. *American Journal of Orthopsychiatry*, *55*:530–41.

Frutiger, A. (1978). *Signs and symbols: Their design and meaning*. Studio Editions.

Gigerenzer, G. 2007. *Gut feelings: The intelligence of the unconscious*. Penguin Books.

Gigerenzer, G., & Brighton, H. (2009). Homo heuristicus: Why biased minds make better inferences. *Topics in Cognitive Science*, *1*:107–43. https://doi:10.1111/j.1756-8765.2008.01006.x

Gigerenzer, G., & Gaissmaier, W. (2011). Heuristic decision making. *Annual Review of Psychology*, *62*(1): 451–82. https://doi:10.1146/annurev-psych-120709-145346

Gigerenzer, G., Todd, P. M., & the ABC Research Group. (1999.) *Simple heuristics that make us smart*. Oxford University Press.

Gladwell, M. (2007). *Blink: The power of thinking without thinking*. Little, Brown.

Goldstein, D. G., & Gigerenzer, G. (2002). Models of ecological rationality: The recognition heuristic. *Psychological Review*, *109*(1): 75–90. https://doi:10.1037//0033-295X.109.1.75.

Greene, J. C., Caracelli, V. J., & Graham, W. F. (1989). Toward a conceptual framework for mixed-method evaluation designs. *Educational Evaluation and Policy Analysis*, *11*:255–64.

Güss, C. D. (2018). What is going through your mind? Thinking aloud as a method in cross-cultural psychology." *Frontiers in Psychology*, *9*:1292. https://doi.org/10.3389/fpsyg.2018.01292.

Hammer, E., & Piotrowski, Z. (1997). Hostility as a factor in the clinician's personality as it affects his interpretation of projective drawings (H-T-P). In E. Hammer (Ed.), *Advances in Projective Drawing Interpretation,* 349–57. Charles C. Thomas.

Handler, L. (1985). The clinical use of DAP. In C. S. Newmark (Ed.), *Major Psychological Assessment Instruments,* 165–216. Allyn and Bacon.

Herman, J. (1992). *Trauma and recovery: The aftermath of violence—from domestic abuse to political terror*. Basic Books.

Hiler, E. W., & Nesvig, D. (1965). An evaluation of criteria used by clinicians to infer pathology from figure drawings. *Journal of Consulting Psychology*, *29*(6): 520–29.

Hogarth, R. M. (2002). Deciding analytically or trusting your intuition? The advantages and disadvantages of analytic and intuitive thought. UPF Economics and Business Working Paper No. 654. October. https://ssrn.com/abstract=394920 or http://dx.doi.org/10.2139/ssrn.394920

Juslin, P., and Montgomery, H. (1999). *Judgment and decision making: Neo-Brunswikian and process-tracing approaches*. Lawrence Erlbaum Associates.

Keller, N., Cokely, E.T., Katsikopoulos, K. V., & Wegwarth, O. (2010). Naturalistic heuristics for decision making. *Journal of Cognitive Engineering and Decision Making*, *4*(3): 256–74. https://doi.org/10.1518/155534310X12844000801168

Kim, J., & Fritsch, M. H. (2019). For visual attention, are there any tendencies in form interpretation? *Visible Language*, *53*(2): 101–11.

Kirlik, A. (2009). Brunswikian resources for even-perception research. *Perception*, *38*:376–98.

Kirlik, A., & Storkerson, P. (2010). Naturalizing Peirce's semiotics: Ecological psychology's solution to the problem of creative abduction. In L. Mangani, W. Carnielli, & C. Pizzi (Eds.), *Model-Based Reasoning in Science and Technology: Abduction, Logic, and Computational Discovery*, 31–50. Springer-Verlag.

Levy, B. I., & Ulman, E. (1967). Judging psychopathology from paintings. *Journal of Abnormal Psychology*, *72*(2): 182–87.

Merrell, F., & Queiroz, J. (2010). Icons and abduction. *Signs*, *3*:162–78.

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: A sourcebook of new methods.* 2nd ed. Sage.

Neurath, O. (1936). *International picture language*. The Orthological Institute. A facsimile reprint of the 1936 English edition. University of Reading, UK: Department of Typography and Graphic Communication.

Nielsen, J. (1993). *Usability engineering*. Academic Press.

———. (2012). *Thinking aloud: The #1 usability tool.* Nielsen Norman Group website. https://www.nngroup.com/articles/thinking-aloud-the-1-usability-tool/.

Nisbett, R. E., & Wilson, T. D. (1977). Telling more than we can know: Verbal reports on mental processes. *Psychological Review*, *84*(3): 231–59.

Patton, A., Griffin, M., Tellez, A., Petti, M. A., & Scrimgeour, X. (2015). Using icons to overcome communication barriers during emergencies: A case study of the Show Me interactive tools. *Visible Language*, *49*(1–2): 80–95.

Patton, M. Q. 1990. *Qualitative research and evaluation methods*. 2nd ed. Sage.

Peirce, C. S. (1931–35). Harvard lectures on pragmatism. (1903). In C. Hartshorne & P. Weiss (Eds.), *The Collected Papers of Charles Sanders Peirce.* Volumes 1-6. Harvard University Press. https://colorysemiotica.files.wordpress.com/2014/08/peirce-collectedpapers.pdf

Ramachandran, V, S., & Hirstein, W. (1999). The science of art: A neurological theory of aesthetic experience. *Journal of Consciousness Studies*, *6*(6–7): 15–51.

Schmidt, L. D., & McGowan, J.F. (1959). The differentiation of human figure drawings. *Journal of Consulting Psychology*, *23*:129–33.

Scribner, C. M. (1989). Interpreting the interpreter: Case studies of ten intuitive D-A-P interpreters. [Doctoral dissertation.] University of Tennessee, Knoxville.

Scribner, C. M., & Handler, L. (1987). The interpreters' personality in Draw-A-Person interpretation: A study of interpersonal style. *Journal of Personality Assessment*, *51*(1): 112–22.

Storkerson, P. (2001). Semiosis and sensory cognition in multimedia communication. Paper presented at the Workshop on Semiotic Evolution and the Dynamics of Culture, University of Groningen, The Netherlands, November.

———. 2003. "Designing theory in communication." *Visible Language*, *37*(1): 13–42.

———. 2009. "Experiential knowledge, knowing and thinking." In K. Niedderer, L. Reilly, S. Roworth-Stokes, & C. Smith (Eds.), *Proceedings of the International Conference of the Design Research Society's Special Interest Group on Experiential Knowledge*, Electronic edition, 147-164. https://eksig.org/PDF/EKSIG2009Proceedings.pdf.

———. 2010. "Naturalistic cognition: A research paradigm for human-centered design." *Journal of Research Practice*, *6*(2): article M12. http://jrp.icaap.org/index.php/jrp/article/view/230/194

Tierney, J., & Baumeister, R. F. (2019). *The power of bad: How the negativity effect rules us and how we can ruleIt*. Penguin.

Waite, S., Grigorian, A., Alexander, R. G., Macknik, S. L., Carrasco, M., Heeger, D. J., & Martinez-Conde, S. (2019). Analysis of perceptual expertise in radiology—Current knowledge and a new perspective. *Frontiers in Human Neuroscience*, *13*: 213. https://doi.org/10.3389/fnhum.2019.00213.

Zender, M. (2017). DrawIt: A user-drawn design research method for symbol design. *Visible Language*, *51*(2): 35–61.

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