SEMANTIC OF ICONIC LANGUAGES

The IKON language and linguistic resources

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ABSTRACT • Written language production evolved from the representation of meanings to the representation of sounds, and more recently is now increasingly integrated by elements such as emoticons, emojis, and stickers. Our main question is: how can we represent verbal language through icons? In this regard, we have successful experiments: *Emojiitaliano* for the translation of *Pinocchio* (Chiusaroli et al., 2016), Augmentative and Alternative Communication (AAC), and others. These systems rely on different semantic approaches to translate concepts into pictograms, ideograms, or abstract symbols (Albacete et al., 1994; Tenny, 2014). The contribution of the present work is threefold: we give a review of different semantic approaches in modern iconic languages and semasiographies; we then present IKON, a new iconic language conceived as a novel step into the evolution of iconic languages introducing the use of lexical resources and semantic ontologies to build more precise icons.

KEYWORDS • Semantics; Icons; Visual semiotics; Semasiographies; Linguistic Resources.

Die Grenzen meiner Sprache bedeuten die Grenzen meiner Welt.
Ludwig Wittgenstein

1. Introduction

Our primary research interests include iconic languages, semasiographies, and visual semantic systems equipotent to natural languages. Visual signs in such systems represent meanings rather than sounds. Furthermore, these systems are intended to express potentially anything (similar to natural languages) rather than a specific domain. IKON, a brand-new icon-based language, will be the core theme of this work. Providing an overview of the role of visual modality in research and society, its potentiality, and its limitations, the authors have the goal of introducing IKON in this panorama by describing the semantics of the language, the icon design methods, and the icon evaluation. IKON began as an idea in the mind of the mathematician and polyglot Cesco Reale when he noticed that in the realm of visual languages (Bliss, AAC, etc.) an iconic language that could systematically represent anything was missing. Drawing from his multilingual know-how, he has been collaborating with linguists, graphic designers, computer scientists and other specialists to define the starting vocabulary, morphological and syntactic rules, graphic guidelines, IT requirements and project strategy. The first set of IKON's words was mapped based on semantic and frequency lists such as semantic primes (Wierzbicka, 1996) or Swadesh list (see Reale et al.,

2021). Once the core vocabulary is defined, there is a plethora of possibilities for expansion (e.g., creating a more precise kinship system, or the subdivision of colors in an ever-growing detail). The basic principle is to have different icons for different meanings, and we do that by analyzing how natural and planned (e.g. Esperanto) languages encode the concepts and what is most convenient for us, reaching a balance between the theoretical and the practical aspects.

Secondly, as IKON maps concepts from its own set of words, we propose linguistic resources for its development. These tools allow the analysis of words to build icons with a high level of pictorial resemblance to the referent, especially with abstract words.

First, we are going to define some expressions that we use in this paper:

Visual language. A language that is communicated through visual interaction (writing, icons, sign language, etc.).
Writing. The use of graphic marks to represent specific linguistic meanings, connected or not to an oral language.
Semasiography. Any system of writing that uses graphemes that denote meanings. It means "writing the meanings", it is a non-phonetic system to communicate information without the necessary intercession of forms of speech. It is a language not based on spoken words but constituted by semagrams. It can be a pasigraphy (such as *Bliss* or *Safo*) or a logography (such as *Sitelen Pona* or *Sitelen Emoji*).
Pasigraphy. It is a visual language that is primarily meant to be handwritten, and in some rare cases can also be pronounced. Examples: *Bliss*, *Safo*, *Nobel*, etc. Special examples: *LoCoS* and *aUi*, even though pronounceable, were created primarily as semasiographies, and there are no known speaking communities.
Logogram or logograph. A grapheme that does not represent a sound (phonemes or syllables), but the meaning of a phrase (such as £ *pound sterling*), polimorphemic word (such as § *paragraph*), or morpheme (such as @ *at*) in a spoken language.
Logography: semasiography or written language, in which logograms constitute an important part; it is used to represent a spoken language (ancient logographies: Chinese, Hieroglyphs, …; modern logographies: *Sitelen Pona*, *Sitelen Emoji*, …).
Iconic language. A visual language composed of icons, that can be drawn or nowadays used through electronic devices such as computers, tablets, smartphones, etc. (road signs, Emojis, Alternative Augmentative Communication languages, …).

The remainder of the paper has the following structure: we set a theoretical background for semiotics and visual modality. Section 3 discusses the main visual semantic languages (semasiographies and iconic languages). Section 4 introduces the IKON language, grammar, and novel design tools. The subsections describe how lexico-semantic resources such as FrameNet, WordNet, and online corpora are implemented. The preliminary findings of the iconometer test, which was used to evaluate our icons, are then presented. The latter section of this work concludes with comments and recommendations for further work.

2. Theoretical background

If one wants to go deeper into the logic and epistemological background of the acquisition of signs of all kinds, i.e., also pictures, music, etc., the triadic model proposed by Charles S. Peirce is the traditional theory: "A sign is either an icon, an index or a symbol". The first works by imitating the reference object, the second by showing the effect of an object (e.g., smoke for fire),

and the third by convention or habit. Even modern studies about Digital Communication considers Peirce's model of the sign a basic framework within the study of graphical user interfaces and their icons (Zuanelli 2010)[1]. To Peirce "a sign […] is something which stands to somebody for something in some respect or capacity. It addresses somebody, that is, creates in the mind of that person an equivalent sign, or perhaps a more developed sign" (1898: 228). The effect of a sign, especially a pictorial sign, is not exactly predictable; the communicative intention may well differ from the communicative effect. Not two people on this earth share the same knowledge of the world and experience. On this basis, they will also potentially interpret the same sign differently (Jappy 2013: 7) and this is the major challenge for visual languages.

According to theories such as the *dual coding theory* and the *picture superiority effect*, the visual modality has a significant advantage over the other human senses, and mental image generation benefits learning. As a result, visual information is critical for knowledge acquisition. We shall discuss these theories in further detail in the following subsection.

2.1 Picture Superiority Effect

Pictures are one type of information thought to stimulate profound levels of processing. Research indicates that we are better at learning and retaining content seen in pictures than in text, a phenomenon known as the Picture Superiority Effect (Nelson et al., 1976; McBride & Dosher, 2002). A variety of reasons explain the effect. One is that 'visual stimulus' is encoded twice in memory, as verbal code, and as an image. Words simply generate a linguistic code. Dual coding of pictorial information improves access to the semantic store increasing the encoding strength (Paivio, 1991). The development of the Picture Superiority Effect rises in step with chronological age, being stronger in adults (Whitehouse et al., 2006). Visual formats are indeed taking over the complex world of communication, from data visualization (Savikhin, 2013; Eberhard, 2021) to the comprehension of healthcare information such as administration of medicines, pharmaceutical labeling, patient information leaflets (Dowse & Ehlers, 1998; Katz et al., 2006). More recently, they played a significant role during the coronavirus disease COVID-19 pandemic (Delicado & Rowland, 2021). All this pushes researchers to expand their studies into the visual realm, trying to improve their applicability in real-world situations. The next section presents the most relevant visual languages: semantic pasigraphies (3.2), AAC languages (3.3), logographic systems like emojis (3.4), and VCM (3.5).

3. Related work: modern visual semantic languages

3.2 Semantic pasigraphies: Bliss and LoCoS

3.2.1 Bliss symbols

Beginning in 1949, Charles K. Bliss created a symbolic script intending to make a pictorial world language. Despite numerous attempts to inspire people to use this mode of communication,

[1] For example, the trashcan icon is indexical of the process of deletion; similarly, a diskette icon is indexical of the process of saving. This interpretation hints at more complex metaphorical-metonymic process (Zuanelli, 2010: 13).

the result remained poor. *Bliss* was discovered in the 1970s as a communication medium for persons with impairments. However, it is now rarely used (see AAC languages, section 3.3). *Blissymbolics* for AAC devices employs a broad selection set technique. It contains a combinatorial system for producing new *Blisswords* from about 900 Bliss-Characters representing conceptual primitives, which are the primary building blocks for *Blisswords*. *Bliss* makes it possible to attach inflectional morphology to words using indicator symbols for verb tenses, adjectives, adverbs, and noun plurals (Tenny, 2016). The examples in Figure 1 show the representation of complex concepts by compositionality, and classifiers, e.g., superscript ^ for verbs, superscript x for plurals, and syntactic structures.

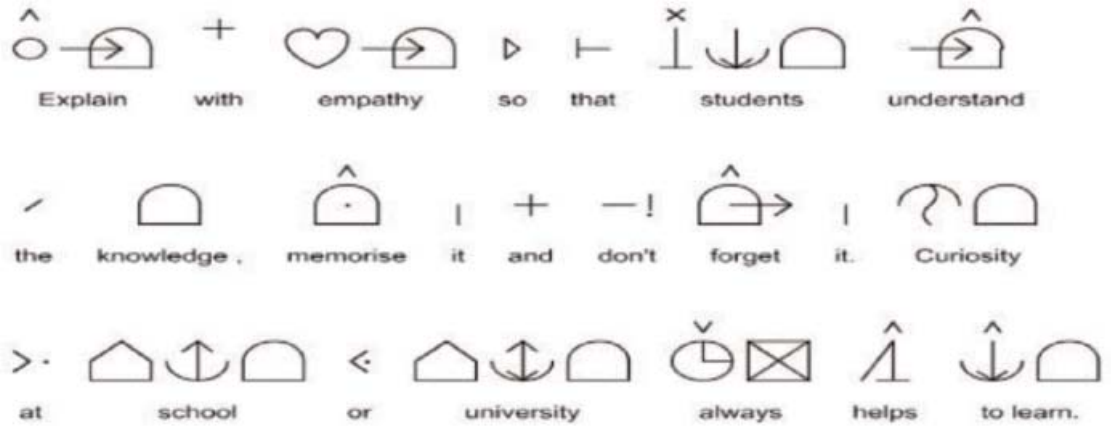

Figure 1. An example of Blissymbolics.

3.2.2 LoCoS

The Japanese Yukio Ota developed *LoCoS* starting in 1964, also with the goal of language-independent communication. Locos can be written across three rows. The center of the row is for the main message. Symbols in the top row describe the verb below them, and symbols in the bottom row describe the noun above them. Grammatically, constituents such as nominal, verbal, and prepositional phrases as well as tense usage can be identified. The symbols are logically structured, but like the *Bliss* symbols, they have only a low iconicity and can hardly be decoded intuitively. Both *Bliss* and *LoCoS* are suitable for handwritten communication, and LoCoS can also be pronounced.

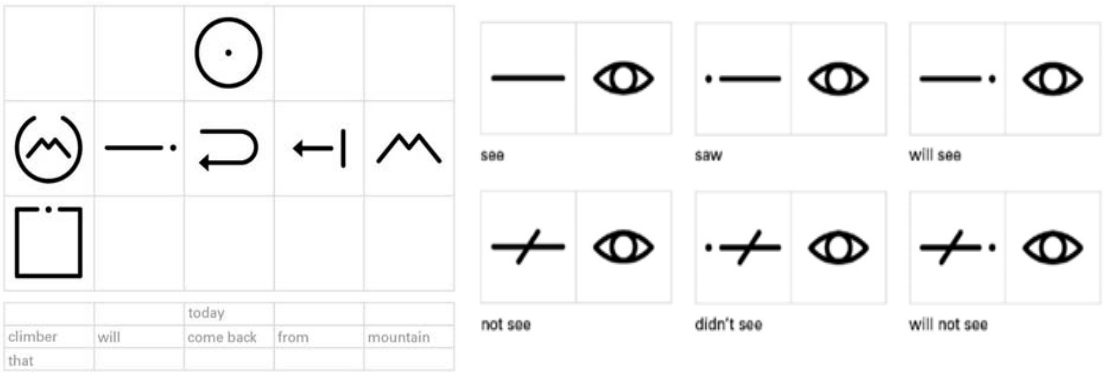

Figure 2. Example of LoCos.

3.3 AAC (Augmentative and Alternative Communication)

Language representative systems for AAC are intended to enable or assist communication for people with impairments who cannot express themselves verbally, bridging the gap to acquiring a written language. AAC is far more iconic. *Metacom*, a pictogram system intended specifically for children, is a prominent example in Germany, with frequently quite realistic and detailed graphics. *Pixon*, *ArasAAC*, *FreeSpeech*, *PCS*, *Widget*, *Minspeak*, *Sclera*, and *Beta* are well-known language systems with this audience (Reale 2021: 6). Minspeak is unique in that it employs ambiguity to limit the number of pictograms used. A red apple can signify "red", "apple", or "eat" depending on how lexical and grammar keys (e.g., APPLE) are used to express specific words (=EAT). It, like *Bliss*, provides inflectional morphology to the user but, unlike *PCS* or *Bliss*, abandons the goal of iconicity for its symbols. It is also the quickest due to its keyboard arrangement and tiny choice set (12 words per minute)[2].

3.4 Emojis

Emojis are currently the most widely used visual communication system on the planet (92% of Internet users worldwide use emojis). They are generally used in informal computer-mediated communication, usually in verbal clusters, to express the user's communicative intent. They serve as tone markers and enhance the meaning of a sentence by indicating the illocutionary force (Dresdner & Herrings, 2010).

Chats with emojis display characteristics of conceptually oral communication. Using emojis simplifies the conveying of spontaneity and familiarity. Nevertheless, emoji communication often lacks grammatical components. It is impossible to convey complex concepts when critical means for sentence construction, such as tense, mode, and case, are unavailable (provided you do not create specific rules as in *Emojiitaliano*, using the available emojis). Despite that, some consider it an emergent graphical language (Ge & Herring, 2018). Sina webo, a microblogging platform, provided some new insights (Herring, 2018; 2020) about emojis use at the level of morphology, syntax, semantics, and expanding vocabulary. For the future Konrad et al. (2020) suggest that emojis used as tone markers (like emoticons) are reaching the third phase of graphic icons' evolution: conventionalization and decline.

3.5 VCM (Visualisation des Connaissances Médicales)

Jean-Baptiste Lamy et al. (2008) created a pictogram system, specifically for physicians, which uses pictograms to explain medical concepts in an understandable way to prevent errors, such as when prescribing pharmaceuticals. According to Lamy, these errors result from the complexity of specialist information, which is often not read in full by the doctor due to time constraints. VCM has subsequently been used in a graphical interface for accessing drug knowledge and has been shown that it allowed physicians to access drug knowledge faster and with fewer errors than through a textual interface (Lamy et al., 2008b). Like every graphical user interface, the few hours required to learn the language and the interface pay back in the long term as it shortens

[2] See Tenny (2016) for a detailed linguistic analysis of AAC, its devices and a comparison with natural languages.

the time necessary for receipt by a ratio of 1.8 if compared to printed instructions (Lamy et al., 2008). The systematic semantic attributes such as external shape, color, and the medical intervention indicated by a little pictogram in the upper right corner are linguistically positive aspects of the VCM system. The upper left displays causal meanings for the medical problem, such as germs or tumors. This type of classifier system allows complicated medical concepts to be conveyed in one pictorial sign.

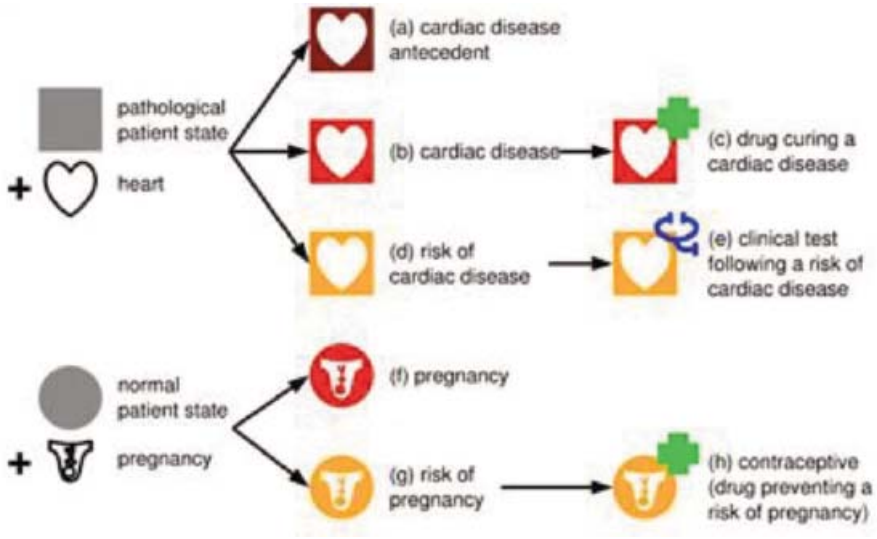

Figure 3. The VCM system.

All the visual systems presented above are forced into certain inevitable parallels by the structure of natural language which they must represent. Mapping to smaller linguistic units gives writing systems advantages in terms of smaller selection sets, better combinatorics, and easier learnability. But they lose iconicity. Visual systems make a trade-off between learnability and coverage.

4. The IKON project

4.1 Introduction to IKON language

IKON aims to bridge the gap between iconic languages and spoken languages by solving the constraints of existing iconic languages. IKON supports semantic compositionality by joining icons (as in *Bliss*, *Minspeak*, and *LoCoS*), the use of grammar categories (as in *Bliss*), the consistent use of *iconemes* (as in *VCM*), the possibility of a 2D syntax (as in *LoCoS*), high iconicity (as in *AAC* languages and *Emoji*), and broad language coverage. This project intends to develop a visual language that adheres to the following basic values: internationality, interculturality, language independence (the syntax and representation of meanings should be as independent of natural languages as possible), completeness, inclusivity, and consistency (see also Reale et al., 2021). As shown below, it does not mean that IKON is not based on existing systems, but we try to maximize comprehensibility across cultures and languages. IKON is indeed based on other natural, planned, and visual languages, e.g. it takes many ideas from Chinese, Egyptian hieroglyphs, Maya, Bliss, AAC, and particularly Esperanto, which is more regular and less ambiguous concerning various

lexical, morphological, and syntactic aspects. For this reason, we will often compare IKON with Esperanto.

Meloni et al. (2022) also reported a pilot study on the application of IKON for anamnesis in the dental domain by using single pictograms and complex iconic sentences with a syntactic structure.

4.1.1 Compositional rules and grammar

In contrast to Minspeak's semantic compaction encoding, IKON has created a far less confusing method. That is, each icon is highly recognizable and corresponds to a well-defined meaning. Each meaning has one icon, however in some situations, iconic synonyms exist, and we expect that a growing number of icons will have synonyms in the future. That is due to two factors: linguistic and graphic. The linguistic reason is that some cases require alternative representations of the same concept since some individuals or cultures may comprehend one better than the other. The graphic reason is that it can be desirable to create a variety of graphic realizations of the same description. The IKON system employs a set of preset forms and strategies to ensure system coherence and a flexible framework. This is a graphical-semantic interface because we utilize signifiers to build scenes that best convey that concept based on a meaning analysis. Figure 4 illustrates the compositional rules, namely how we graphically encode concepts. We always strive for pictographic icons i.e., the most telling example of an item making comprehension easier and nearer the concrete human experience. Pictographic forms are simple when dealing with objects and concreteness.

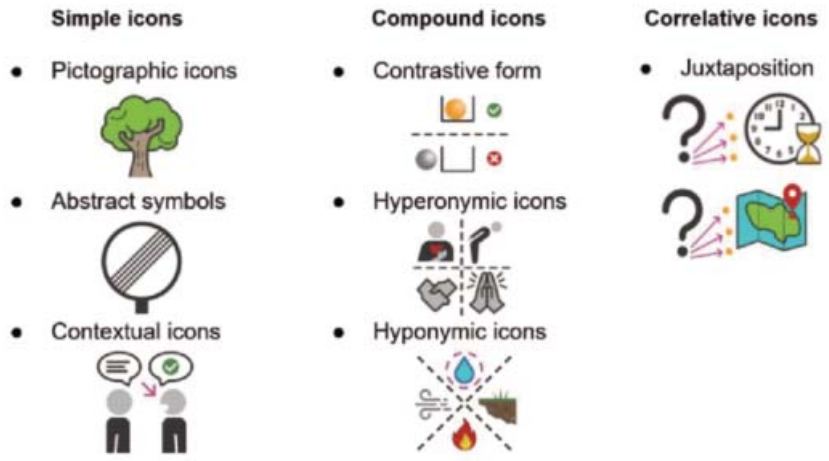

Figure 4. Compositional rules for IKON, namely pre-set graphic strategies to represent meaning through icons.

Representing abstract concepts requires a more complex process. One of the primary characteristics of advanced language use is abstraction. Thus, the challenge is to anchor abstract words (e.g., verbs) to a visual referent. Meloni et al. (2022) described IKON's cases in which only the recourse to usually culture-specific linguistic images, conventional symbols such as traffic signs, or symbols from graphical computer interfaces could give concreteness to what concrete is not.

Some concepts and items might be easily recognized if represented within a given context (contextual icons). Contextual icons (e.g., *agree*) are built as visual scenes with participants where

arrows, circles, and color oppositions point to one specific sub-element of the whole picture. In this case, what is highlighted is what it means. This class of icons extensively uses "morphological signs" (Cohn, 2012) such as arrows, gibberish, and other markers:

> Like other verbal languages, visual languages appear to use distinctions between attachment and binding to other signs that follow bound forms versus free forms. […] For example, speed lines and speech balloons are "bound morphemes" that cannot appear without affixing to a root object like someone running or speaking (Cohn, 2012: 102)

Compound icons are semantically more complex, obtaining meaning in a variety of ways. Some forms, such as hyperonymic and contrastive, are derived from our cognitive processes and the structure of the speaker's mental lexicon (beginning with Saussure's theories of language organization and progressing to cognitive semantics). In lexical semantics, sense relations, although context-dependent, are treated as a stable property of individual lexical items, and conceptual categorization is considered a basic cognitive tool (Croft & Cruse 2004). It is perhaps noteworthy that Wierzbicka (1996) includes *a kind of* as one of her semantic primitives. Thus, the use of prototypes as an instance of something conceived more abstractly is suitable to face the complexity of lexical architecture. Hyperonymy is found in natural languages (e.g., Chinese), iconic systems (e.g., Pictoperanto), and Egyptian hieroglyphs (Reale et al., 2021)

Correlative icons are the simple juxtaposition of two or more elements that might function as independent icons (e.g., *what* = *which* + object, *when* = *which* + *time*, *where* = *which* + *place*). IKON aims to avoid some of the ambiguities that can be found in natural and planned languages. For example, IKON distinguishes between relatives and interrogatives (both *ki-* in Esperanto, *wh-* in English), demonstratives from universal quantifiers (both *ĉi-* in Esperanto, leading to confusing forms such as *ĉijare* = *this year* and *ĉiujare* = *every year*), adjectives from persons (e.g., in Italian *tutti* means *all* or *all persons*, both *-u* in Esperanto, e.g., *ĉiu* means *every* or *everybody*), and adds *same* and *other* in the table.

Beyond the categorization and combination of meaning in stored morphological signs, meanings in iconic language can take on several more complex representations. Common semantic phenomena like metonymy and synecdoche also appear in the graphic form (Cohn, 2012). For example, our icon for *tax* (Figure 5) uses metonymy: we depicted the most telling example of a government building that stands for the administration that works in that building and rules over the territory. Again, metonymically, the government stands for the State to which we pay our taxes. Moreover, the arrow binds the two parts of the meaning "calculated money goes to State" reflecting their relation and representing the world around us. As we will see, this strategy led to better comprehension in our test.

Figure 5. Icon for *tax*.

Following this introduction, the following section will provide an experimental approach to IKON lexicon development, namely the integration of linguistic resources to conduct semantic

analysis and, ultimately, icon design. It is critical to comprehend what visual scene we want to portray and how to encode it in one of the above-mentioned strategies.

4.1 Development of the language with lexico-semantic resources

We divided the approach into three sub-sections describing three different tools: FrameNet, WordNet, and online corpora.

4.1.1 Frame semantics and FrameNet

Frame semantics is a theory developed by Fillmore and his colleagues over the past four decades (Fillmore 1976, 1982, 1985, Fillmore and Baker 2001, 2010). The basic idea of frame semantics is that "the meanings of most words can best be understood based on a semantic frame, a description of a type of event, relation, or entity and the participants in it"[3]. FrameNet (Fillmore, 2003) is an online lexicon of English lexical units (LUs) described in terms of Frame Semantics. A semantic frame contains information about the various syntactic realizations of frame elements (syntactic valency) and their semantic properties. Frame elements (FEs) are the basic components of a frame, and they are defined as "situation-specific semantic roles" (Boas, 2005). FEs can be core elements i.e., essential to the meaning of a frame, or peripheral when FEs do not uniquely characterize a frame. Individuating the semantic frame of a lexical unit is quite significant in IKON when meaning disambiguation is required.

Concerning verbs, it is necessary to assess the semantic types and thematic roles in the argument structure to include the right participants in the correspondent icon appropriately. For example, consider the Commercial_transaction frame, involving the following FEs: a BUYER and a SELLER who exchange MONEY and GOODS. It has the subframe Commerce_good-transfer, which describes the following situation: the SELLER gives the GOODS to the BUYER (in exchange for the Money). This frame can take different perspectives and create other frames: Commerce_buy, Commerce_sell. Consequently, it has its core elements in BUYER, SELLER, and GOODS. While money is not a core element and is implicit in the verb to buy, it should nevertheless be visually represented to convey the meaning of *to sell*, as shown in Figure 12, or *to buy* (with the arrow on the buyer).

The frame Commerce_pay belongs to the subframe Commerce_money-transfer, which involves the transfer of MONEY from the BUYER to the SELLER. In this case, the core element resides in MONEY, which must be graphically the focus of the icon. Accordingly, we designed the icon in Figure 6 with only hands, money, and the dashed arrow for the concept of a transaction[4].

Figure 6. The icons *to sell* (with the arrow on the seller) and *to pay* based on FrameNet analysis.

[3] https://framenet.icsi.berkeley.edu/fndrupal/WhatIsFrameNet

[4] In most cases GOODS are defined as "anything (including labor or time, for example) which is exchanged

Because the frames are semantic, they are often similar across languages. A multilingual FrameNet project[5] has been developed to build FrameNet parallel to the English version for languages around the world, including Spanish, German, Chinese, and Japanese (for an extensive description see Boas, 2005).

4.1.2 Wordnet

WordNet (Fellbaum, 1998) is by far the most popular lexical knowledge resource in the field of NLP. It is a computational lexicon of the English language based on psycholinguistic principles. Nouns, verbs, adjectives, and adverbs are grouped into sets of cognitive synonyms (synsets), each expressing a distinct concept. Synsets are interlinked using conceptual-semantic and lexical relations. For each synset, WordNet provides a textual definition or *gloss*. Synsets can contain sample sentences to provide examples of their usage. "WordNet interlinks not just word forms — strings of letters — but specific senses of words. As a result, words that are found near one another in the network are semantically disambiguated". The most frequently encoded relation among synsets is: i) the super-subordinate relation (also called hyperonymy, hyponymy); ii) meronymy, the part-whole relation holds between synsets; iii) verb synsets are arranged into hierarchies. Verbs towards the bottom of the trees (troponyms) express increasingly specific manners characterizing an event. All this linguistic information could be exploited during the design process of icons by extracting knowledge about how concepts are semantically related and how deep we need to go in our representation.

4.1.3 Corpus analysis

Corpus analysis tools are precious resources for investigating word meaning in context: they can shed light on a term's pragmatics and most frequent uses. As a result, they can assist us in developing consistent and authentic semantic explanations for icons. These resources are helpful when representing an abstract word (e.g., *time*), a modal verb (e.g., *must*), or conjunctions (e.g., *and*, *or*). They expand the reflection on the graphic conceptualization of the icon by providing information about the linguistic material that appears in the same sentence. In this part, we give a case study for the item *most* (Esperanto *plej*) to highlight the role of corpus analysis tools in icon design.

Most can be used as an adverb, adjective, noun, or pronoun. To refer to these various meanings, we use Esperanto. This is a practical choice because Esperanto – unlike English and most Romance languages – distinguishes between the meaning *plej* (corresponding to the use of *most* as an adverb/adjective) and the meaning *plejparte* (corresponding to *the most part*). Because the IKON database already has the icon for *plejparte*, we will provide the study we conducted for *plej*. To conduct cross-linguistic research, we used the *Leipzig corpora collection* (Goldhahn et al., 2012). A coherent depiction of the meaning *plej*, considers various languages asking which kind of lexemes *plej* modifies the most frequently (nouns? adjectives? and which kind of nouns

for MONEY in a transaction. Although GOODS is a core element of the frame, the annotated examples show that this FE is understood in context, but not realized syntactically suggesting its omission in the "visual translation".

[5] https://framenet.icsi.berkeley.edu/fndrupal/node/5561

or adjectives?). Accordingly, we searched for all the right "neighbor co-occurrences" of *plej* in English, German, French, Italian, Spanish, and Chinese. However, we soon met some limits: for example, English or German superlative forms are not exclusively expressed by *most/meist*. This did not allow for a complete examination of the corpus because searching for the word *most*/*meist* would have overlooked any adjectives with the suffix *-st*. Thus, we added the search for the Esperanto word *plej*. This allowed us to have a more precise perspective, although the authors are aware that other natural languages possess this distinction. What was discovered is that the words occurring right after *plej* with statistically significant scores – and this was also the case in romance languages - are adjectives like *granda (big), alta (high), and grava (important)*. These investigations gave us the first input for reflection and helped us to get to the visual representation of *plej* in relation to these adjectives. In Figure 7, you can see the final icon:

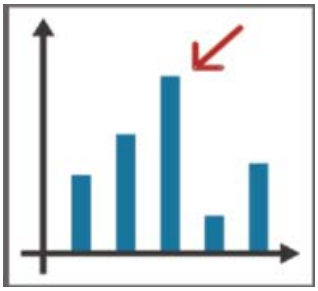

Figure 7. Final icon for *most*.

In the beginning, we considered representing *plej* through audio volumes. However, volumes have a maximum that is not included in the *plej* meaning and we could only insert three audio volumes. Instead, we determined that a histogram was the ideal compromise for representing all these meanings in a single image as it better conveys the concept of variety without being limited to three objects. In conclusion, this corpus-based study aided in orienting the reflection to represent the pragmatic meaning of *plej*. Nevertheless, some limitations of this methodology, such as the fact that the corpora genre influences the results, should be acknowledged.

5. Assessing IKON comprehensibility

5.1 Iconometer

Iconometer is a software developed by the University of Geneva (Peraya et al., 1999) to implement the theoretical approach proposed by Leclercq (1992) to assess the degree of polysemy of a visual representation (icon, diagram, figurative image, photograph) and measure its adequacy to its prescribed meaning. Iconometer was previously used within the IKON language to evaluate icons from the family domain and gender markers used to signify gender (Reale et al., 2021).

Test design. Our current goal is to compare participants' levels of certainty on icon interpretations in various domains: family relationships (*mother*, *father*, *children*…) modality (*must* (situational necessity) and *can* (permission)), conjunctions (*and*, *or*, *if*), contrastive icons versus simple forms, and so on. In some situations, we proposed two or more versions of the same icon; in others, we displayed only one version to see how it was received. The new iconometer test displays 30 visual images but no text to the subject. Below the images are 7-9 interpretations and the chance to write a personal response. The participant must assign 100 points to the various meanings based on their level of certainty. The participant must give the most points to the meaning that

seems most certain and can give each meaning between 0 and 100 points, as far as the sum is 100.

Participants. 73 people of diverse genders and ages (15-60) from 23 distinct countries (the most prominent being European (14 subjects from Italy), American and Canadian (10), and South-East Asian testers (13) between Laotian and Thai). Our participants spoke 28 distinct languages (including their mother tongue, and high and intermediate-level languages)[6]. The absence of individuals with a low level of education, monolingual, and little or no connection (cultural and linguistic) to the "Western world" is the study's major limitation. Future studies will investigate a simpler interface as well as the possibility of contacting monolingual subjects from remote locations and various educational levels.

5.1.2 Preliminary results

The test showed interesting results with the following set of icons:

Grandparent-grandchild relationships had low precision and certainty in the family set of icons, with 30.65% of accurate answers and an average of 27 (out of 100) points to *grandchildren*. The arrows and color contrast may not be enough to draw the reader's attention to the intended meaning. Vectors, as a semiotic mode, connect individuals in the scene but fail to specify which element is the intended referent: the participant from which the vector emanates or the vector at which the vector points? (Kress & Leeuwen, 2020). Indeed, the most common responses refer to the opposing side of the portrayed relationship. Other family relationships, such as *aunt* and *uncle*, produced better results. Gender identifiers (haircuts and symbols), as discovered in a previous study (Reale et al., 2021), are of significant assistance in this domain.

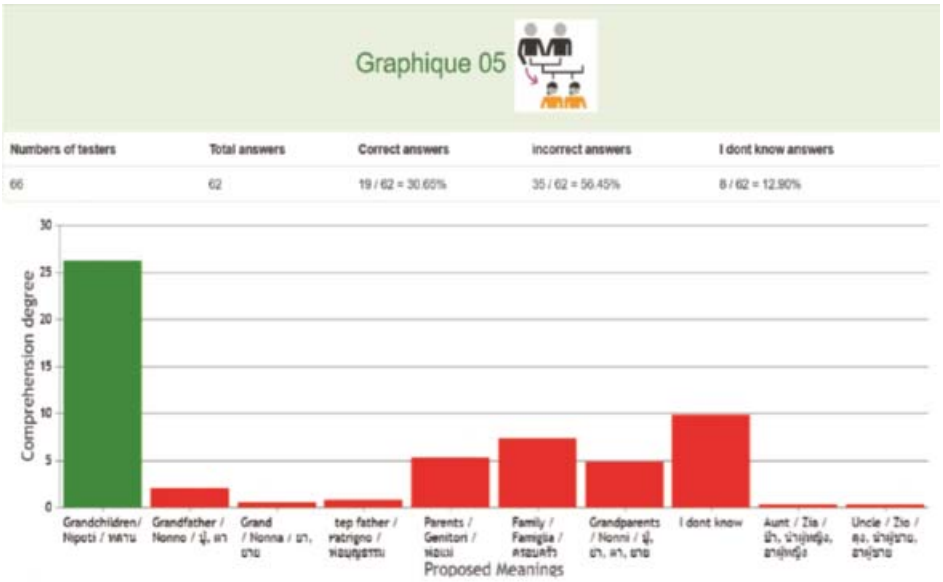

Figure 8. An example of our report for *grandchildren*. The green column is the points given to the exact answers; in red all other answers are considered incorrect.

[6] In this version we are not able to determine a relation between nationality/language spoken and points assigned.

The adjective *gentle* is misunderstood for *love* in both options: one with a single person holding hearts and the other with the same person holding hearts toward another person. Out of 100 points, the former has an average of 1.2 points to the intended meaning; the latter has an average of 3.8 points, while love obtained 30 and 25 points. Although *love* and *gentle* are intimately related, the heart sign and the metaphor "heart as a container of emotions" (Gutiérrez Pérez, 2008) is too associated with love. However, testers choosing gentle slightly more frequently in the second version suggest that the design should follow a frame of "social interaction" (as described in FrameNet).

For the meaning of *tax*, the strategy described in section 4.1.1(figure 4) led to better comprehension. It has obtained an average certainty of 50 points and 35% of correct answers.

The graphic representation of modality (necessity and possibility) was a great challenge for us. As previously said, conceptualizing abstract concepts requires a more complex process. Overall, they were not perceived correctly and there was a low degree of certainty.

Must: we proposed three options (Figure 9):

Figure 9. Three versions of *must* are proposed in the iconometer test: a) a traffic policeman; b) a traffic policeman with a non-deictic index finger; c) a traffic light meaning *permission* as opposed to the traffic sign meaning *obligation.*

Version (a) had the lowest score, whereas version (b) received 9% of correct answers and 4.08 points for the definition *must* (obligation/necessity). Overall, version (b) conveyed the concept of *order* because testers also assigned points *to order* and *to oblige*. The index finger in this orientation appears to be critical for the sense of obligation and order, validating our hypothesis: pointing with the index finger can be an indexical non-deictic gesture with a general emphasis function in the dialogue (Allwood et al., 2007). It emphasizes what the speaker is saying in a conversation allowing the expression of the obligation and the necessity of an object or event (Meloni et al., 2022). Version (c) is the icon that performed slightly better (10.23 points to the correct meaning and 12% of correct answers). However, we gave as possible answers *permission*, *can*, and to *go*, which significantly obtained points.

Similarly, three solutions using road signs were proposed for *can* (situational possibility meaning permission). (Figure 10). Version (c) obtained better results (17% of correct answers and 18 points for "permission"). Once again traffic signs in a contrastive association seem to be a good option for more abstract concepts, provided they are widespread enough.

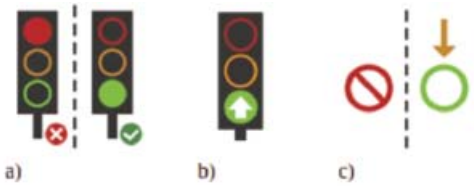

Figure 10. Three versions of *can* (*be permitted/possible*): a) contrastive icon using traffic light; b) single traffic light with green light; c) traffic sign for *prohibition* opposed to green circle for *permission*.

6. Discussion and future work

This section discusses the motives, problems, implications, limitations, contribution of the study, and recommendations for future work. Visual stimulation and communication are becoming increasingly relevant and overwhelming in our fast-changing world. The development of visual systems may play a role in language comprehension, with pictorial representations potentially being integrated as an aid for understanding. However, incorporating abstract terms with no concrete and unique referents is a constraint and a problem for visual languages. We learned from the overview of modern visual languages that there is always a trade-off between accessibility, learnability, and coverage. Some of these languages chose to have a large set of symbols and icons to represent (e.g., *Bliss*), while others chose a small selection set (*Minspeak*). IKON is a new iconic language that has built a much less ambiguous system in which each icon has a well-defined meaning, aiming to have broad language coverage. We described its semantics and strategies to represent meaning with pictorial resemblance to the reference object. We presented lexical resources such as FrameNet, WordNet, and online corpora throughout IKON development, suggesting their usage to construct more precise and accurate icons, especially when dealing with abstract terms (e, g., *buy*, *belong*, *agree*), albeit the unique graphic modality should be considered. The frame a word evokes, its semantic relations, and its context of use give us elements to construct our visual scene in a way that links concepts to the physical world. They have been utilized as an experimental method and should be reviewed more thoroughly.

Nonetheless, our iconometer test confirmed a few effective processes. For example, improved comprehension was found by analyzing and including core frame elements of a word (e.g., *tax*, *pay*, and *gentle*). After stating the pictorial value in our society, we find reasons for a visual constructed language in specific settings. We worked on an IKON application in the dentist-patient discourse to show how medical content may be successfully transferred into an iconic language (Meloni et al., 2022). It is possible and desirable to create iconic sentences. It enables people with language impairments or linguistic barriers to communicate in a complicated domain such as healthcare. The next step will be to work on semantic and syntactic notions, particularly in whole sentences, where the understanding rate is still low. Furthermore, the iconometer test can be modified to evaluate phrases based on "correct or semantically acceptable answers". Following methodologies that integrate linguistics, semiotics, and visual design, we plan to provide more insights into the construction and comprehensibility of iconic sentences. Finally, due to the extension and human-centered value of the IKON's lexicon, we will analyze its potentiality in language learning, providing accurate associations to learn new words.

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