Demography and the Cultural Evolution of Pictorial Styles

GRANITO, CARMEN

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Carmen Granito

Abstract

Image-making is a nearly-universal human behaviour. Cultures around the world have made images to convey information about living kinds, objects and ideas for at least 75,000 years. However, from a stylistic point of view, the visual strategies and conventions to represent things in pictures can vary greatly over time and space; in particular, pictorial styles can differ in figurativeness, varying from inter-subjectively recognisable representations of things to stylised and abstract forms. Are there any patterns to this variability, and what might its ecological causes be?

In recent Cultural Evolution research, factors such as demography and the structure of interaction between groups of individuals have been shown to affect the evolution of languages and technology. Capitalising on these studies, I investigate the style evolution in relation with the socio-demographic variable of population contact, and in particular the influence of inter-group contact on the figurativeness of pictorial representations. For this purpose, I firstly conducted an experimental study, simulating isolated and contact social groups with laboratory micro-societies performing a drawing task; secondly, I quantitatively analysed a real-world dataset of Aboriginal Australian rock art from contact and isolated communities; then I qualitatively explored the evolution of a contemporary pictorial communication item: emoji.

Results show that pictorial representations from isolated groups tend to become abstract and opaque to outsiders, whereas in contact groups they retain figurativeness and external understandability. This supports the idea that intergroup contact is an important factor in the cultural evolution of pictorial styles, because the need to communicate with outsiders and be accessible to the widest possible audience encourages figurativeness. I discuss the implications of these findings for the archaeology and anthropology of art, and the parallels with language evolution.

Finally, addressing the need for research outreach in Cultural Evolution, I designed the blueprint of an exhibition aimed at disseminating my research findings while offering lay audiences an engaging and transformative experience.

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Carmen Granito

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Declaration

The work in this thesis is based on research carried out at the Departments of Anthropology at the University of Durham, England. No part of this thesis has been submitted elsewhere for any other degree or qualification and it is all my own work unless referenced to the contrary in the text.

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1 Introduction

1.1 Style

Style is a fundamental notion for the disciplines that study art and, in general, the design of pictorial representations. However, the definition of style varies between and within those disciplines. In art history, style is commonly defined as a system of forms characterised by recurring elements, formal relationships, and qualities generating emotional reactions (such as colour intervals), that are consistently found in the arts of a culture during a historical period (e.g. the Gothic, the Baroque, etc.; Schapiro, 1953). In the field of archaeology, one school of thought defines style in behavioural terms as a "way of doing things" with the function to signal individual and collective social identity (Wiessner, 1990); others, instead, follow Dunnell's definition of style as opposed to function, that is as cultural forms (e.g. attributes of objects) that are adaptively neutral and therefore vary stochastically in time and space (Dunnell, 1978). In anthropology of art, style is usually considered as a vehicle of a group's vision of the world; in representational art, for example, the style of figuration is viewed as a means to select and fixate the aspects of the world that are relevant to a certain culture (Layton, 1991).

This project considers styles not as period-related fashions, identity-marking devices or expressions of world views, but as visual strategies for representing three-dimensional things on bi-dimensional surfaces. In particular, I focus on one specific dimension of style: figurativeness, defined as the degree to which a scene is composed of inter-subjectively recognisable items (Willats, 1997); on this dimension, pictorial representations can vary between two extreme poles: figurative representations – where depictions of objects are universally recognisable – and abstract representations – where depictions are simple and highly schematic and therefore have very limited inter-subjective recognisability (see Figure 1).

The figurative-abstract dimension is often confused with the Peircean distinction between iconic and symbolic (Peirce, W2.56). Peirce distinguished between iconic signs, which bear direct perceptual resemblance to their referent (e.g. a photograph of Mary is an icon of Mary), and symbolic signs, which do not bear perceptual resemblance to their referent (e.g. the character "A" is a symbol of the sound /a/). However, while there are some similarities between the figurative-abstract

dimension and iconic-symbolic dimension of pictures, they do not entirely overlap. Sometimes figurative pictorial signs are not iconic in the original Peircean sense: a pictorial sign might bear visual resemblance to some recognisable things (i.e. be figurative), yet it might not bear direct perceptual resemblance to its intended referent (i.e. be iconic); for example, a clearly recognizable drawing of New York cityscape that is meant to stand for the meaning "jazz" is a figurative sign but not a Peircean icon for "jazz", as it does not bear direct perceptual resemblance to jazz music. In other words, while the distinction iconic-symbolic concerns the relationship between a pictorial sign and its intended reference or meaning, the distinction figurative-abstract only concerns the superficial form of the pictorial sign, the strategy used to depict elements composing a scene, regardless of the ultimate intended referent of the overall sign. This is why the articles composing this thesis use the latter terminology rather than the former.

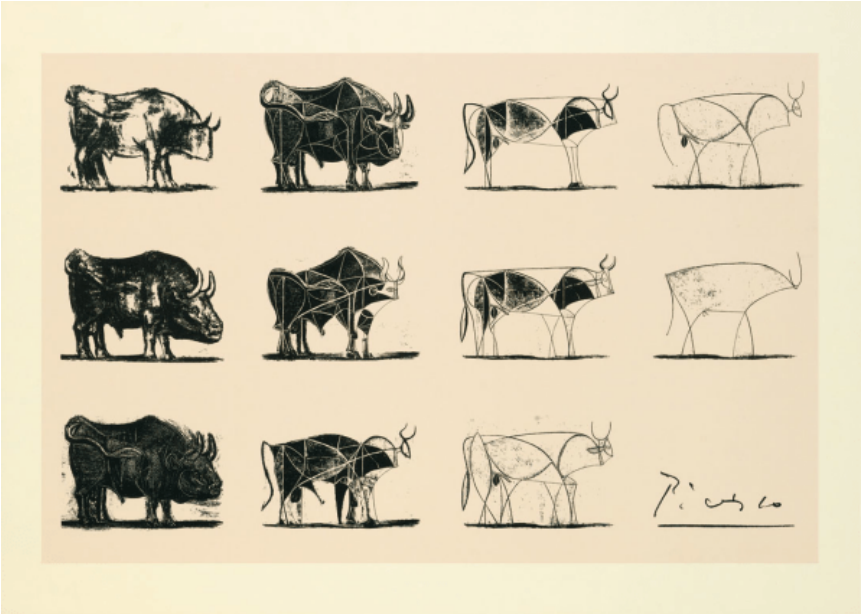

Figure 1 A series of eleven lithographs by Pablo Picasso representing a bull. They exemplify different styles of representation, from more figurative (left hand side) to more abstract (right hand side)

Styles of representation vary greatly within and between populations and change through time. According to one line of thought, there are no directional changes in the history of pictorial styles (Hagen, 1985); considered as part of the set of cultural traits that are selectively neutral, i.e. that do not affect the fitness of the population in which they occur, changes in style over time and space would be explained by stochastic processes (Dunnell, 1978). On the other hand, others think that variation in style is indeed directional and follows one pattern of change, namely the progress from rough sketches towards realistic, vision-like representations (Wamberg, 2009; Zerffi, 1876). In contrast with both positions, this work is based on the idea that pictorial style can be an adaptive cultural trait responding to a complex system of factors from the natural and cultural environment.

Anthropologists, archaeologists and historians have produced rich descriptions and interpretations of variation patterns in style of representation and of the factors that play a role in them (Boas, 1927; Riegl, 1893; Schapiro, 1953; Woelfflin, 1915), especially in relation with the social context of production (Barry, 1957; Fischer, 1961; Plog, 1990; Silver, 1981). These pioneering studies provided invaluable insights in the exploration of stylistic change, but they could not explain it in terms of the causes and specific mechanisms that drive it.

In the last decades, Cultural Evolution (CE) has made substantial progress in explaining cultural variation by identifying its causal factors (Mesoudi, 2015). In particular, regularities have been identified in how cultural traits vary in relation to the socio-demographic context; for example, variables such as population size and density and the degree of cultural contact have been shown to have an impact on the evolution of cultural domains such as languages and technology (Derex & Boyd, 2016; Fay et al., 2010; Henrich, 2004; Kline & Boyd, 2010; Lupyan & Dale, 2010; Powell et al., 2010; Reali et al., 2018; Trudgill, 2011; Wray & Grace, 2007). Capitalising on these CE studies, I intend to explore the cultural evolution of styles in relation with the socio-demographic variable of population contact, and in particular the influence of inter-group contact on the figurativeness of pictorial representations and their understandability. For this purpose, I will use quantitative methods from CE, such as experiments with laboratory micro-societies and quantitative empirical studies on real-world data.

In this introductive chapter, I firstly review previous accounts of patterns of change in styles of representation from art history, archaeology and anthropology. Then I briefly introduce principles and methods of Cultural Evolution and discuss

major findings on the relationship between socio-demographic factors and the evolution of technology, verbal languages and graphical representations. Building on these, I set the research questions of the thesis and outline the chapters that will answer them. Finally, addressing the need for research outreach in the field of CE, I review key models of exhibition design and outline the principles for the design of an exhibition on my research topics, conceived as an outreach activity and presented in this thesis.

1.2 Models of style change

Between the 19th and 20th centuries, art historians and anthropologists analysed how styles of representation succeeded over time and across cultures and tried to establish general rules behind this variation.

1.2.1 Art history

Art historical models identified cycles, poles, or stages of stylistic change. Woelfflin (1915) proposed a polar structure where pairs of features (e.g. linear-picturesque, closed-open, composite-fused) characterised successive historical epochs. Frankl (1938) analysed the possible combinations of elementary forms and derived a cyclical scheme where a "style of Being" (dominated by static forms that make style stable) and a "style of Becoming" (with incomplete forms lending themselves to modification) alternate repeatedly.

Art historians holding a unilinear vision of evolution as a sequence of progressive steps, instead, focussed on the ways styles depict the natural world, and identified progressive stages of development from geometric or simple to naturalistic or complex forms. Riegl (1893) held that art evolves from haptic styles, representing the object as discrete and isolated, to optic styles, representing the whole perceptual field. Similarly, Loewy (1907) argued that art evolves from conceptual representation, with schematised bi-dimensional forms organised in linear patterns, to perspective representation, imitating phenomenological vision.

In these models, stylistic change was triggered by intrinsic laws of development of forms, and reference to psychological or social factors was little or expressed in the vague terms of personality, world views, or forms of social life. These ideas were never investigated systematically and were difficult to test rigorously (Schapiro, 1953).

1.2.2 Unilinear evolutionary anthropology

Victorian evolutionary anthropologists made pioneering attempts to experimentally test their explanations of stylistic change. Rather than describing the process of complexification from schematic to naturalistic style, they wanted to explain the emergence of schematic styles in the first place. Pitt-Rivers (1875) theorised that abstracted designs in ancient ornaments were degenerations of accurate depictions (see Figure 2); in an experiment where a naturalistic drawing was copied successively in several chains of participants, he showed that the drawings deteriorated along the chains. Balfour (1893) used successive copying to explain the evolution of art, identifying three stages: 1) individuals adopted natural peculiarities of materials as ornaments; 2) they reproduced those patterns even when they were not present; 3) through successive copying, novel designs emerged as a consequence of unconscious variation (i.e. the unintentional differences between a copy and the model, due to lack of skills) and conscious variation (i.e. due to the intention to vary the model). In a series of transmission chains, Balfour showed that final drawings had no resemblance with the initial ones, supporting the idea that mere successive copying could give rise to gradual but radical changes in designs. Similarly, Haddon (1895) argued that geometric patterns resulted from a process of descent with modification whereby naturalistic pictures are gradually simplified until they are no longer recognisable. Simplification through successive copying was also supported by empirical studies; Evans (1875), for example, showed the gradual modification of coin designs from the original Ancient Greek to the deriving Ancient Briton coins.

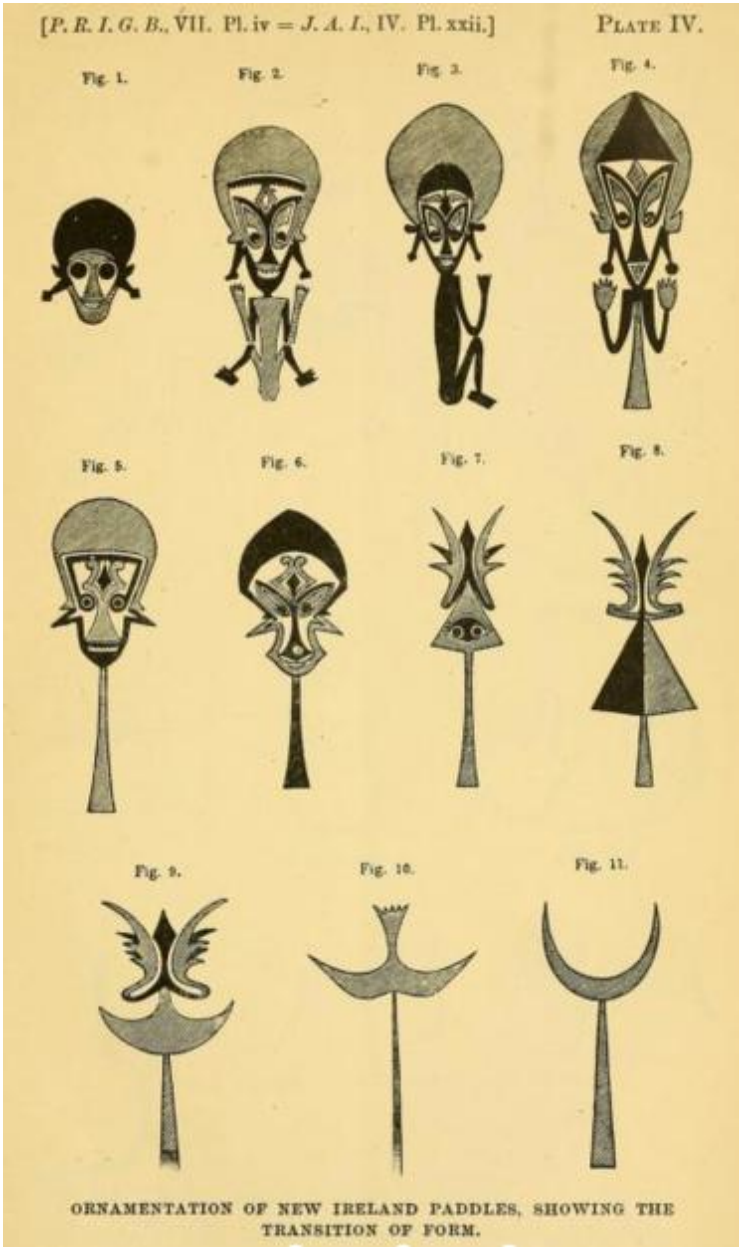

Figure 2 Pitt-Rivers' reconstruction of the evolutionary sequence in the ornamentation of Melanesian paddles from figurative to abstract designs (Pitt-Rivers, 1875).

Boas (1927) challenged the evolutionary theories of style arguing that geometric decorations and realistic representations did not evolve from one another, but they sprang from two different intentions: to embellish with pure forms and to express a meaning. In both cases, the recurring formal patterns arose from the affordances of materials and tools available, and from artists' motor habits.

Furthermore, although unilinear evolutionists considered styles in relation with social context, they had a mistaken notion of evolution, according to which societies were homogeneous units undergoing fixed stages of progressive change from "savagery" to "civilisation". In their view, the art of small-scale societies was the

result of degradation due to deficient skill, technique, or intellect typical of the less developed stages (Layton, 1991).

1.2.3 Ethno-archaeological studies on the effects of social structure on style

A set of ethno-archaeological studies specifically investigated the effects of social structure on pictorial styles. Barry (1957) found a positive correlation between severity of socialisation (i.e. pressure on children towards independence rather than obedience) and complexity of art style in a sample of non-literate societies. In the same sample, Fischer (1961) investigated the correlation between stylistic complexity and social stratification (egalitarian *vs* hierarchical societies). He argued that social structure determined the kinds of situations artists desire as secure: the ideal situation in egalitarian societies is one where ego possesses a large number of equal comrades and the group of peers is well isolated from other groups (for fear of disruption), whereas in hierarchical societies security depends on relationships with people in differentiated hierarchical positions and comes from incorporating strangers through submission. Such "social fantasies" are expressed in art through certain patterns: Fischer found that, in egalitarian societies, pictorial designs were repetitions of simple elements and that large amounts of empty space isolated groups of elements from each other; on the other side, in hierarchical societies, pictorial designs were crowded of unlike complex enclosed figures, often incorporating multiple elements and leaving little unused space.

Two comparative studies further tested Fischer's theory of artworks as "cultural cognitive maps" (Fischer, 1961). Dressler & Robbins (1975) found that pottery designs in the city-state of Athens were more complex and crowded in periods of greater social stratification. Similarly, Merrill (1987) compared artistic designs of Shoshone-Bannocks before and after European colonisation, when their socio-political organisation shifted from egalitarian to hierarchical; she found a parallel major change from simple to complex designs.

These studies provided insight on how structure of style might reflect structure of society and its levels of complexity. However, their rationales were often based on undefined psychological notions such as "social fantasy".

1.3 Introduction to Cultural Evolution

1.3.1 Cultural Evolution: basic principles and methods

Cultural Evolution Theory (Boyd & Richerson, 1985; Cavalli-Sforza & Feldman, 1981; Mesoudi, 2011; Mesoudi et al., 2006) is the study of cultural transmission, the

process by which non-genetic information (knowledge, beliefs, values, skills or practices) is passed from individual to individual through social learning. According to CET, over time, those cultural traits that lend themselves to better transmission increase in frequency in a population and, by combining with other traits, eventually result in various complex cultural adaptations. CE studies culture using similar methods to those used by biologists to understand biological change, but suitably modified to incorporate the differences between biological and cultural processes (Boyd & Richerson, 1985).

The approach of CE solves many of the theoretical and methodological problems of the models reviewed above, and it provides a promising framework to study change in pictorial style. Firstly, differently from unilinear evolutionism based on the Spencerian idea of evolution as inevitable progress, CE adopts a Darwinian notion of evolution, according to which cultural traits change their frequencies in populations in response to local environments, with no inevitable increase in complexity over time (Mesoudi, 2011). In this view, pictorial styles do not undergo fixed stages in all human societies climbing a ladder from rough to refined, but they are shaped by the concurring pressures acting in the different contexts of production and fruition.

Secondly, in order to systematically investigate how socio-demographic factors can drive stylistic change, we need to complement macro-level correlations between social and stylistic variables with the individual-level micro-mechanisms of interaction generating those patterns. Cultural evolutionists aim to identify the individual-level factors that determine the differential fitness of cultural traits and eventually lead to the macro-level phenomena. At the same time, CE gives importance to the role of demographic processes, such as changes in population size, structure, and distribution, in driving cultural change; these dynamics, affecting transmission mechanisms, inevitably influence the stability of traditions and cultural innovation (Steele & Shennan, 2009).

Furthermore, if we want to test hypotheses on the relation between socio-demographic and stylistic variables, qualitative approaches are not sufficient. While they are useful in detecting patterns in the ethno-archaeological record and formulating theories that account for such regularities, we need quantitative methods to test them. CE uses a variety of quantitative empirical analyses to investigate correlations of variables measured on real-world data; moreover, in laboratory experiments, hypotheses can be tested in a controlled environment, where a single variable can be isolated and manipulated; experiments also allow to

understand why variables are related the way they are, by simulating the micro-mechanisms of interaction and transmission of information (Mesoudi, 2007; Mesoudi & Whiten, 2008).

In the family of evolutionary approaches to culture, a number of issues are still objects of debate (e.g. see Acerbi & Mesoudi, 2015; Claidière et al., 2014). For example, there is a pluralism of views on the nature and workings of the transmission of cultural traits, especially when compared to transmission mechanisms in biological evolution; while more orthodox Cultural Evolution argues for the major role of replication and copying of traits in cultural transmission (Henrich & Boyd, 2002; Mesoudi & Whiten, 2008), the area of Cultural Attraction Theory highlights transformational and constructive aspects, typical of processes such as memory and communication commonly involved in transmission (Claidière & Sperber, 2007; Morin, 2015; Scott-Phillips, 2017; Sperber & Claidière, 2008). Related to this, the importance of cognitive constraints in culture change is also debated; while orthodox CE has focussed more on the social aspects of cultural transmission, CAT also emphasises the effects of cognitive factors in cultural change (Sperber, 1996; Sperber & Hirschfeld, 2004). However, despite the ongoing debate, over the last decades, the evolutionary framework altogether has made substantial progress in explaining cultural variation within and between populations in a variety of domains, including technology (Caldwell & Millen, 2008, 2010; Mesoudi & O'Brien, 2008), arts and crafts (Eerkens & Lipo, 2005; Jordan & Shennan, 2003; Morin, 2013; Rogers & Ehrlich, 2007; Shennan & Wilkinson, 2001; Tehrani & Collard, 2002, 2009b, 2009a), oral traditions (Graca da Silva & Tehrani, 2016; Tehrani, 2013), and communication (Caldwell & Smith, 2012; Garrod et al., 2007; Kirby et al., 2008; Morin & Miton, 2018; Scott-Phillips & Kirby, 2010).

1.3.2 Demography and the cultural evolution of technology

A number of experimental studies have used laboratory micro-societies performing a variety of technology design tasks (e.g. related to architecture, engineering, crafts and graphic design to mention a few) in order to investigate the cultural evolution of technology (e.g. Caldwell & Millen, 2008; Muthukrishna et al., 2014; Zwirner & Thornton, 2015). They have shown that knowledge and skills accumulate over generations of participants (the "ratchet effect", Tomasello, 2009), resulting in gradual improvements in performance: later generations produce designs that are more successful than earlier generations.

In this context, a growing number of studies have focussed on the effects of demography on technological complexity. Theoretical models predict that increased technological complexity correlates with larger population size (Henrich, 2004) or higher population density and migration rate (Powell et al., 2010). A set of experimental studies support this idea showing that larger groups are able to produce and maintain more complex tools, techniques, and skills than smaller groups (Derex et al., 2013; Derex & Boyd, 2016; Kempe & Mesoudi, 2014; Muthukrishna et al., 2014). Empirical studies have also provided evidence in this direction (Collard et al., 2011, 2013; Henrich, 2004; Kline & Boyd, 2010; Powell et al., 2010). The rationale behind this correlation is that smaller populations have lower rates of invention due to having fewer inventors, and when inventions do emerge they are more likely to be lost in smaller groups because of random loss or incomplete transmission (Richerson et al., 2009).

However, the relationship between cumulative cultural evolution (CCE, the social-learning process through which adaptive modifications accumulate over time) and population size is still controversial (Collard et al., 2016; Henrich et al., 2016; Vaesen et al., 2016). It might be the case that increased population size enhances CCE only as long as it does not trigger social coordination problems (Fay et al., 2019). It is also unclear if population size has an effect on complexity in non-technological domains, as the first study tackling this question did not find a consistent relation between population size and complexity in folktales (Acerbi et al., 2016).

1.3.3 Demography and language evolution

Research in sociolinguistics and language evolution has investigated the relationship between language change and a number of socio-demographic factors, such as the degree of contact of a community of speakers, speaker population size, and between-group competition (Koplenig, 2019; Lupyan & Dale, 2010; Reali et al., 2018; Roberts, 2010; Trudgill, 2011; Wray & Grace, 2007).

Sociolinguist Trudgill argued that languages spoken in *societies of strangers* (high-contact, large sized, unstable, loosely knit communities with small amounts of socially shared information) typically develop morphological simplicity (lexical and morphological transparency, regularisation, loss of redundancy). On the other hand, *societies of intimates* (low-contact, stable, small sized, tightly knit communities with large amounts of socially shared information) favour linguistic complexity (increase in morphological opacity, irregularisation, increase in redundancy; Trudgill, 2011).

This is generally thought to be due to the large-scale learning by non-native adults taking place in societies of strangers, where speakers are more likely to 1) be non-native speakers or have learned the language from non-native speakers, and 2) use the language to speak to outsiders, i.e. individuals from different ethnic and/or linguistic backgrounds (Lupyan & Dale, 2010). In such contexts, the large-scale learning by non-native adult speakers who have passed the critical threshold for language acquisition would act as a strong selective filter for complexification (Wray & Grace, 2007) and would quickly erase complex morphology whenever it emerged (for an alternative view, see Koplenig, 2019).

Conversely, when complexification occurs in societies of intimates, it is more likely to fixate because a) statistically, the random spread of such non-optimal features has a much greater effect on small-size populations (Nettle, 1999), e.g., the idiosyncrasies of a few influential individuals could spread more easily in those contexts, and b) such societies tend to be more conservative and can thus preserve even complex features whenever they emerge, e.g. in smaller and tightly-knit communities, teachers have more control than in larger societies and can encourage the preservation of norms, however complex they may be.

The core idea behind Trudgill's theory is that the greater the distance between speakers of a language in terms of social ties, background and shared information, the greater the need for simplicity in communication; vice versa, communities where speakers are involved in close relations and share much information are a suitable environment for complexity. Therefore, when languages are used for inter-group communication and serve as interfaces between strangers, they will become more regular and transparent, whereas languages used mainly for intra-group communication will tend to be more complex and opaque. In other words, in high-contact communities, languages become easier for non-natives to understand and learn, whereas in small isolated communities, languages are more difficult for non-natives to understand and learn.

1.3.4 Demography and the cultural evolution of graphical communication

Substantial progress has been made in CE in explaining patterns of change in graphical communication. In particular, several experimental studies have looked at the role of socio-demographic variables such as population size and degree of within-group interaction in shaping graphical sign systems (Fay et al., 2008, 2010, 2018; Fay & Ellison, 2013; Garrod et al., 2007; Garrod & Doherty, 1994; P. G. T. Healey et al., 2001, 2007; P. G. T. Healey, Garrod, et al., 2002; P. G. T. Healey,

Swoboda, et al., 2002; Kirby et al., 2015). Such families of studies typically adopted graphical communication tasks in laboratory micro-societies, where groups of participants – organised in a variety of experimentally manipulated social conditions – play Pictionary-like drawing games with easily confusable items (e.g. 'microwave', 'television', 'computer monitor') and can only communicate by drawing (for a detailed review of different methods and experimental designs, see Galantucci & Garrod, 2011).

These studies have shown that, over repeated graphical interactions within the same group of participants, pictorial representations change from being figurative and semantically transparent to being abstract and semantically opaque; the pictorial signs developed during this process of symbolisation are hard to interpret and learn for naïve observers who have not taken part in it (Garrod et al., 2007); the resulting graphical conventions can also be transmitted over generations of participants (Caldwell & Smith, 2012). These findings support the idea that abstract symbols evolved from initial figurative representations, and that a similar process of abstraction underlies the evolution of a number of real-world writing systems from pictographic to alphabetic (Clayton, 2013, 2019; J. Healey, 1990; Sacks, 2007; Tversky, 1995).

A related set of studies have suggested a relationship between group size and semantic transparency of pictorial representations (Fay et al., 2008, 2010; Fay & Ellison, 2013). They have shown that, while pictorial representations become more abstract and harder to interpret over repeated interactions in pairs and over generations of participants, semantic transparency is retained during interactions in larger groups compared to smaller groups; in the former case, representations are easier for naïve observers to understand and learn, suggesting that larger groups develop lower degrees of arbitrariness.

Finally, it has been shown that individuals at their first graphical interaction tend to adopt figurative styles of representation, whereas individuals with a previous history of graphical interaction tend to adopt an abstract style (P. G. T. Healey et al., 2007).

1.4 Research questions

In the opening of *Art and Illusion*, art historian Ernst Gombrich asked a big question that later became famous as "the riddle of style": "Why is it that different ages and different nations have represented the visible world in such different ways?" (Gombrich, 1960). This thesis aspires to contribute to addressing that riddle

and explore possible factors that influence visual strategies adopted for representing things and ideas in pictures.

The set of findings from language evolution and graphical communication reviewed above suggest that the structure of interaction between groups of individuals might play a role in shaping the verbal and graphical communication systems used in those groups. This thesis aims to understand whether the level of inter-group contact or group isolation can affect the shape of pictorial representations and produce similar effects to those found in verbal languages; in particular, this work aims to address the following questions:

- Does the degree of contact or isolation of cultural groups affect the level of semantic transparency of pictorial representations used in those groups? In line with language evolution, do pictorial representations become easier to understand in contexts of inter-group contact?
- Does group contact or isolation have an effect on the development of figurative or abstract styles in pictorial representations?
- How are these two aspects of pictorial representations – transparency and style – related?
- Is the role of group contact different from that of group size?

Chapter 2 of this thesis addresses these research questions with an experimental approach, simulating isolated and contact social groups with laboratory micro-societies performing a graphical communication task.

Chapter 3 addresses the research questions analysing real-world data, using a dataset of Aboriginal Australian rock art from contact and isolated indigenous Australian communities.

Finally, Chapter 4 addresses the research questions by exploring the evolution of an item of contemporary popular culture, emoji, and sets the ground for the design of an exhibition project.

1.5 Outreach through exhibitions

1.5.1 Reaching out to the wider audience

While Chapter 2 and 3 present quantitative studies aiming to answer the research questions outlined above, Chapter 4 includes the project of an exhibition conceived as an outreach activity. In the last decades, public engagement has become increasingly urgent for academic researchers (Owen et al., 2016). Funding bodies

expect that the research community should value public engagement initiatives (National Co-ordinating Centre for Public Engagement, 2010; Owen et al., 2016; RCUK, 2010) and realise impact on society through them (Research Council UK, n.d.). Engaging with the public is considered of strategic importance for academia not only for improving transparency of public money spend, but also because it can help strengthen relevance of research for the wider audience and responsiveness to their needs (Duncan & Spicer, 2010; National Co-ordinating Centre for Public Engagement, 2010).

The research area of biological evolution has a long-standing practice of public engagement, including the development of educational tools for school children (Chanet & Lusignan, 2009; Cook, 2009; Kover & Hogge, 2014; Passmore & Stewart, 2002; Pobiner et al., 2018; Scoville, 2019; University of California Museum of Paleontology, 2020), media coverage (Horenstein, 2009), and a long record of exhibitions in museums and science centres around the world (Bloomfield, 2012; Ceci, 2009; Diamond & Evans, 2007; Dominici & Cioppi, 2012; Falchetti, 2012; Giusti, 2012; Harcourt-Smith, 2012, p.; MacDonald & Wiley, 2012; Padovani et al., 2013; Wycoff, 2008). In recent years, the research area of cultural evolution has made good progress in public engagement as well. In particular, it has engaged with the audience of policy makers by proposing applications of research findings to social policy development (e.g. see The Evolution Institute, 2018), and it has also received good media coverage (e.g. see BBC News, 2016; 'BBC Radio 4 - Beyond Today, Anti-vax', 2019; Harkness, 2018; Kendal, 2014). Furthermore, some core areas of cultural evolution, such as animal culture, the evolution of technology and language evolution, were the topics of *Culture Evolves*, an exhibition held at the Royal Society on its 350th anniversary.

However, cultural evolution is still under-represented in museum exhibitions and public displays, notwithstanding its great potential for engaging stories, catchy objects, interactive exhibits, and topics that resonate with people's everyday life. This represents a missed opportunity as museum exhibitions are effective learning tools for the understanding of evolutionary theory (Giusti, 2006; Spiegel et al., 2012) and are considered the most appropriate places for engaging the public in evolution-related topics (Diamond & Kociolek, 2012).

The third study of this thesis includes a blueprint of an exhibition that aims at a) providing principles and guidelines on exhibition design to researchers with no previous experience in the field, and b) proposing an exhibition concept which can

disseminate my research topics and findings as well as become a transformative experience for the audience and realise social impact.

1.5.2 Exhibitions as an outreach tool

According to a traditional educational model, the main goal of exhibitions is disseminating knowledge through object display and providing the public with opportunities for learning (Conn, 1998). In this view, exhibitions are an instance of the "postal" model of communication, where a sender – the curator or the institution – transmits a message to the receiver – the audience (Silverman, 2002).

However, exhibitions can be much more than that. Alternative models exist which highlight the role of public displays in museums, galleries and other cultural institutions as social agents (social work model, Silverman, 2002). In this view, exhibitions are meaning-making experiences acting on multiple levels, where knowledge transmission only represents the surface layer; at a deeper level, exhibitions provide "moments of insights, transformation and deep significance" which help visitors develop a new understanding of the society in which they live and the social relationships they entertain.

Furthermore, according to the "identity work model", the transformative experience of an exhibition is not limited to the visitor's understanding of society and others. Ultimately, visiting an exhibition triggers a reflection on the visitor's own identity and self. In this view, exhibitions are a setting for public performances of identity, places which offer visitors an opportunity to explore who they are, discover new aspects of themselves as well as try on new different roles (Rounds, 2006).

Finally, such a multi-layered meaning-making process does not need to be imposed top-down on the visitor by the institution or curator. Participatory models of exhibitions propose the active involvement of visitors at different stages, and potentially at any stage. Based on the idea that exhibitions are not *about* something or *for* somebody but *with* us all (Bedford, 2016), visitors' intervention can then become inbuilt in the exhibition process from design to crowdsourcing to the experience of the visit (Simon, 2010).

Building on these models, the exhibition blueprint presented in Chapter 4 is based on a set of strategic principles:

- Society thinking: triggering a reflection on how recent global social changes have deeply influenced the way we communicate visually, in

particular with digital graphics, and how this has had an impact on interpersonal relationships;

- Identity performing: providing opportunities for exploring own identities through performing actions which allow to reflect on how we express our ideas visually, problematise conscious and unconscious stereotypes, understand how these impact our visual communications;
- Participation: embedding participatory mechanisms in the visitor experience which offer opportunities to be active agents in a collective cause.

1.6 Notes on chapter format and authorship

As a thesis by publication, each chapter corresponds to an article published or submitted to a journal and is formatted in the style of the specific journal. Authors' contributions to each article are specified at the beginning of each chapter.

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2 Style of pictorial representation is shaped by intergroup contact[1]

Carmen Granito*[a], Jamie Tehrani[a], Jeremy Kendal[a], Thom Scott-Phillips[a,b]

[a]Department of Anthropology, Durham University, Durham, DH13LE, UK
[b]Department of Cognitive Science, Central European University, Budapest, 1051, Hungary
**Corresponding author email and ORCID id: carmen.granito@durham.ac.uk*

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Abstract

Pictorial representation is a key human behaviour. Cultures around the world have made images to convey information about living kinds, objects and ideas for at least 75,000 years, in forms as diverse as cave paintings, religious icons and emojis. However, styles of pictorial representation vary greatly between cultures and historical periods. In particular, they can differ in figurativeness, i.e. varying from detailed depictions of subjects to stylised abstract forms. Here we show that pictorial styles can be shaped by intergroup contact. We use data from experimental micro-societies to show that drawings produced by groups in contact tended to become more figurative and transparent to outsiders, whereas in isolated groups drawings tended to become abstract and opaque. These results indicate that intergroup contact is likely to be an important factor in the cultural evolution of pictorial representation, because the need to communicate with outsiders ensures that some figurativeness is retained over time. We discuss the implications of this finding for understanding the history and anthropology of art, and the parallels with sociolinguistics and language evolution.

Social Media Summary

Cultures develop very different styles of pictorial representation across time and space. Why do they vary from largely recognisable figures of people and things to very abstract and opaque forms? One reason could be the presence or absence of intergroup contact. A study with experimental micro-societies shows how the need to communicate with outsiders can ensure that pictorial signs retain figurativeness over time.

2.1 Introduction

Pictorial representations are ubiquitous in human culture. We find them in visual art, pictographic writing systems, road signs, graphic design, book illustrations, comics, and animations, just to mention a few examples (Drucker & McVarish, 2009;

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Harthan, 1997; Hockney & Gayford, 2016; Sabin, 2001). Pictorial representations are tangible expressions of ideas, mental models, and ways of understanding the world. They are highly versatile: they can visualise simple physical objects as well as very complex and abstract concepts and situations; as such, at the individual level, they are external cognitive tools that help elaborate, manipulate, store and retrieve ideas that would be difficult for the mind alone to handle, such as beliefs about supernatural agents (Mithen, 1998, 2004, 2009). Pictorial representations are also effective attention-catching devices, especially when depictive and decorative techniques enhance their aesthetic appeal (Donald, 2009; Gell, 1992). They are sometimes easier to remember than words (Madigan, 2014; Scaife & Rogers, 1996) and, unlike spoken words, they are durable material objects that can reach different audiences and thereby influence minds and affect behaviours in different times and places (Donald, 2006; Gell, 1998). At the social level, pictorial representations are an effective tool of social coordination, a powerful means to disseminate ideas within a community, transmit them from generation to generation, and create shared worldviews; this makes them ideal vehicles to disseminate ideologies, both religious and secular (Collins, 2016; Donald, 2009; Mithen, 2009). Humans have made use of pictorial representations since before the Upper Palaeolithic (Bahn, 2016; Henshilwood et al., 2002), and image-making is likely to have played an important role in the evolution of human cognition and sociality (Renfrew & Morley, 2009).

A central set of questions across several fields – in particular art history, anthropology, archaeology, and the evolution of graphical communication systems – concerns the relation between styles of pictorial representation and characteristics of the social and demographic contexts in which they are produced (Boas, 1927; Conkey & Hastorf, 1990; Dressler & Robbins, 1975; Fay, Garrod, & Roberts, 2008; Fischer, 1961; Garrod, Fay, Lee, Oberlander, & Macleod, 2007; Gombrich, 1960; Healey, Swoboda, Umata, & King, 2007; Lévi-Strauss, 1962; Merrill, 1987; Peregrine, 2007; Schapiro, 1994; Silver, 1981). Pictorial representations vary across time and space in the strategies and conventions used to visualise things and ideas on a bi-dimensional surface. In particular, pictorial styles can greatly differ in their degrees of figurativeness, varying from largely inter-subjectively recognisable depictions of objects, people, animals and scenes, to very stylised and abstracted forms (Willats, 1997; see Figure 3). Several cases have been observed where changes in figurativeness occurred in conjunction with contact between cultural groups, e.g. in Aboriginal art (Layton, 1992b; Morphy, 1991, 1998; Morphy & Layton, 1981), Jewish

art in medieval Germany (Shatzmiller, 2013), Greco-Oriental art in the Hellenistic period (Versluys, 2017), Early Christian art in Syria (Verstegen, 2012).

However, the empirical causality and generality of the relationship between changes in the nature and extent of intergroup contact and changes in styles of pictorial representations has not been fully established in an experimental setting. Some previous studies in experimental semiotics have suggested a relationship between group size and semantic transparency of pictorial representations (Fay et al., 2008; Rogers, Fay, & Maybery, 2013; for a review of experimental semiotic studies, see Galantucci, Garrod, & Roberts, 2012), but have not investigated the role that intergroup contact might play, nor have they studied style as a factor distinct from transparency. Healey et al. (2007) tested the effect of having a shared interaction history on the styles of representation adopted by pairs of drawers, comparing same-group pairs having a previous shared interaction history with different-group pairs at their first interaction; however, they did not look at the effects of group contact over time.

Figure 3 Examples of figurative and abstract style of representation. Leonardo da Vinci Last Supper (1495-1498) and a piece of Warlpiri art (Australia). Both represent people sitting together, but they do so in radically different ways. The first uses figures (humans) that could be recognised potentially by any observer, whereas the second uses stylised shapes that are far less likely to be recognised as persons by observers not belonging to the Warlpiri community.

Here we use laboratory micro-societies to experimentally investigate the effects of intergroup contact on two aspects of pictorial representation, namely style (figurative or abstract forms) and transparency of meaning (ease of interpretation for outsiders). Drawing on methods developed to study the cultural evolution of graphical communication (Caldwell & Smith, 2012; Fay, Garrod, Roberts, & Swoboda, 2010; Garrod et al., 2007; Gombrich, 1960; Healey et al., 2007; Tamariz & Kirby, 2014), we use a Pictionary-style task in groups, where participants communicate given concepts to each other by drawing alone. The task was

embedded in a design that simulated contexts of cultural exchange and isolation as experimental conditions by manipulating the degree of interaction between groups of participants. We then looked at the differences in transparency and style of the drawings resulting from the game sessions by running two surveys with naïve participants. We hypothesised that: (1) pictorial representations produced in contexts of group isolation are more difficult for outsiders to interpret than those produced in contexts of intergroup exchange; and (2) this difference in transparency of meaning is due to a difference in style of representation; specifically, the pictorial representations resulting from the contact condition will tend to be figurative (i.e. to contain inter-subjectively recognisable objects, living beings, scenes), whereas pictorial representations from the isolation condition will tend to be more abstract in character. The rationale is that, differently from isolated groups, in contexts of contact the need to communicate with members of different cultural groups causes pictorial signs to retain figurativeness and maintain accessibility to potentially any audience. Signs used in contexts of isolation are more free to develop symbolic, abstract, and other features that reduce comprehensibility to outsiders.

We note that the distinction figurative-abstract does not entirely overlap with the Peircean distinction iconic-symbolic usually found in the experimental semiotics literature (e.g. Caldwell & Smith, 2012; Garrod, Fay, Lee, Oberlander, & Macleod, 2007). This is because sometimes figurative pictorial signs are not iconic in the original Peircean sense (Peirce, W2.56): a pictorial sign might bear visual resemblance to some recognisable things, yet it might not bear direct perceptual resemblance to its intended referent; for example, a clearly recognizable drawing of New York cityscape that is meant to stand for the meaning “jazz” is a figurative sign but not a Peircean icon for “jazz”, as it does not bear direct perceptual resemblance to jazz music.

The distinction between figurative and abstract styles of representation is relevant to important developments in the study of human cultural evolution and the origin, significance and development of the earliest pictorial signs. In particular, by suggesting possible evolutionary paths for figurative and abstract signs, and their relation to the social contexts of production, this study might contribute to the debate on whether or not early geometric patterns produced by hominins served a symbolic function (Henshilwood et al., 2018; Hodgson, 2014, 2016, 2019; Mellet et al., 2018; Tylén et al., 2017).

2.2 Methods

The study is composed of two phases. In Phase 1 (Data production) laboratory micro-societies played a Pictionary-like task in one of three conditions: isolation, contact or a control condition, which were simulated by manipulating the degree and structure of interaction between participants. The drawings produced at this stage were then used as stimuli in two surveys run in Phase 2: in one, naïve participants were asked to match the drawings with their meanings; in the other, other naïve participants had to say whether the drawings contained recognisable figures or not. Ethical approval was granted by Durham University Anthropology Committee. All participants gave their consent.

2.2.1 Phase 1 – Data production

2.2.1.1 Participants

54 students from Durham University participated in exchange for a lottery prize of £50 in Amazon vouchers.

2.2.1.2 Apparatus

A5 notebooks and black felt-pens were used for drawing. Experimenters used stopwatches to time group performance, and a group sheet to collect playing times and any cheating episodes in order to later assign rewards to participants.

2.2.1.3 Stimuli

Two lists, A and B, each of 12 target words, were selected from two merged databases of English words (Brysbaert, Warriner, & Kuperman, 2014; Stadthagen-Gonzalez & Davis, 2006) containing measures of psycholinguistic variables, such as concreteness (the degree to which a word refers to a perceptible entity, measured on a rating scale from 1-very abstract to 5-very concrete) and imageability (how easily a word elicits a mental picture of its referent, measured on a rating scale from 1-low imageable to 7-highly imageable, and converted into a scale from 100 to 700). Half of the words in each list were highly abstract (concreteness score ≤ 2) and half highly concrete (concreteness score ≥ 4), and all had low inter-subjective variability (SD ≤ 1.1). The words were chosen to be potentially confusable in their graphical representation (e.g. *fame* and *glory*; or *sweat* and *anxious*), and the degree of imageability was controlled (all words had medium imageability scores i.e. 300 to 500). List A included *actor*, *blaze*, *gear*, *mill*, *sweat*, *trap* (concrete) and *anxious*, *envy*,

fame, *gain*, *gloom*, *glory* (abstract); list B included *cloth*, *jean*, *midwife*, *nylon*, *patch*, *womb* (concrete) and *ancient*, *bliss*, *dodgy*, *smart*, *spooky*, *wise* (abstract).

2.2.1.4 Procedure and experimental design

A total of 54 participants took part in the experiment. They were split in six groups of nine. Two groups played in the isolation condition, two in the contact condition and two in a control condition controlling for effective population size. These conditions differed in how the groups were organised, as specified below. We ran each condition twice, once with each wordlist (A or B).

Participants were informed that they were about to play a drawing game similar to the game Pictionary: they had to communicate concepts only by drawing, with no speech, gestures, numbers, letters, mathematical or currency symbols. In each round of the game there was one director (who had to draw), one matcher (who had to guess), and either one or seven observers, depending on condition (see below). At all times, a public copy of the full list of possible answers (in alphabetical order) was always visible to the whole group.

At the beginning of each round, each director was given a randomised list of the 12 target words, and was required to draw them one by one in the given order; each drawing constituted one trial. This list was only visible to the director, and the random order of the list changed with each round.

On each trial, the director drew until the matcher said "stop"; the matcher then pointed at the answer on the public answer list and the director gave feedback: for correct answers, they put a tick next to the drawing, otherwise a cross. In case of wrong answer, directors were not allowed to then reveal the correct answer. Matchers only had one guess, after which the director moved onto the next word, regardless of whether the guess was correct, or not. This process was repeated for 12 trials, i.e. until the full list of words had been completed. The participants then changed roles, in a way determined by experimental condition, as described below (see also Figure 4).

In all conditions, speed and accuracy were encouraged through a prize-penalty system. The playing time of each group in each round was recorded and assigned individually to each of the members. At the end of each game, each participant had a record of the overall time they spent playing. The fastest three participants in each session received a £20 coupon each, the second three a £15 coupon, the last three a

£10 coupon. A 7 second penalty was added to group playing time for every incorrect guess, and 14s for each cheating episode (i.e. talking and using numbers or letters).

Isolation Condition. Here each group of nine participants was split in three mini-groups of three, and each participant only ever interacted with the two other members of their mini-group. After each round of 12 drawing trials, the three participants rotated roles. This meant that over six rounds each of the three different roles (director, matcher, observer) were counter-balanced. Such six-round blocks (henceforth, "home block") were iterated six times in a row. This created a total of 36 rounds, and 432 drawings (as did both other conditions, described below).

Contact Condition. Here each group of nine participants were, as in the isolated condition, split into three mini-groups of three, but they also had occasional contact with members of other mini-groups. Mini-groups alternated a home block with a "travel block", where each member of a mini-group interacted with the one member from each of the other two mini-groups. After completing a travel block, participants went back to their home mini-group to play another home block. Each mini-group alternated home blocks and travel blocks three times, for a total of six blocks.

Control Condition. Here each group of nine participants was not split into mini-groups, and so each participant interacted with the eight other members of their group: instead of one director, one matcher and one observer (as per the other conditions), there was one director, one matcher and seven observers. Each participant interacted in equal measure with each of the others, and the total number of rounds was identical to the groups in the other conditions. This condition controls for effective population size, i.e. for the total number of individuals that come into contact with the evolving set of pictorial signs. This is necessary because otherwise the effective population size would be a confounding variable: while in the isolation condition the effective population size is 3, in the contact and control conditions it is 9.

In summary, the difference between conditions lies in the structure of interaction between participants (see Figure 4). A difference in drawing transparency and style between contact and isolation conditions is likely to be due to the presence/absence of intergroup contact and not to effective population size, if a similar difference is found between contact and control conditions. Also, participants played director and matcher roles, and played these roles with the same partners, at a lower rate in the control condition than the other two conditions. We account for this feature of

the design when interpreting the results (see Discussion). Full details of the ordering and counter-balancing employed in each condition are provided as Supplementary Information (see A.1.3).

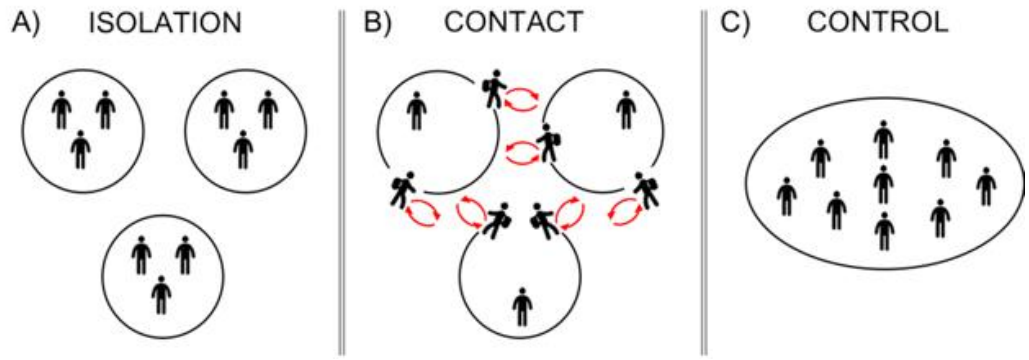

Figure 4 A schematic illustration of the three conditions. A) Isolated groups: in each mini-group, each participant plays only with same-group members; B) contact groups: in each mini-group, each participant alternates playing with same-group members and different-group members; C) control group: one large group of nine people, each interacting in equal measure with each other.

In all conditions participants were asked, after completing the game, to privately draw all the concepts individually on a set of cards labelled with the target words. They were instructed to draw them in the way that they would do it for their home groups. This was done in order to capture sign types, rather than tokens of types. Tokens can differ from their types, sometimes dramatically so, when they are produced in an episode of interaction under time pressure. It was these drawings that were used in the surveys in Phase 2. Figure 5 shows representative examples of these final drawings (bottom row), alongside drawings from previous rounds (the full set of drawing is available at Granito, Tehrani, Kendal, & Scott-Phillips, 2018).

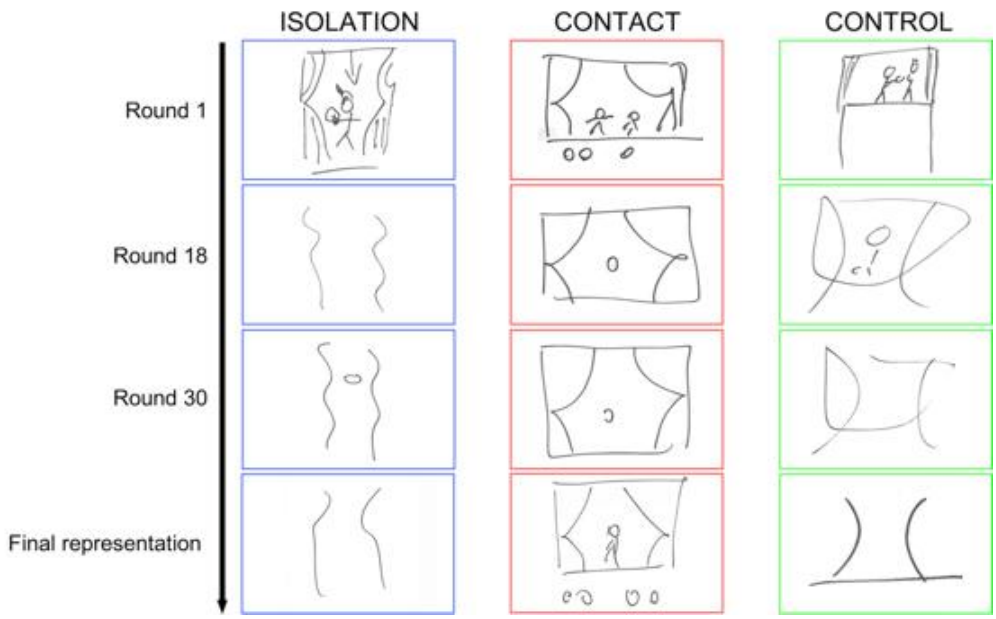

Figure 5 Drawings of "actor" from successive rounds from each experimental condition (Phase 1). The final drawings (bottom row) were later used as stimuli in two surveys on transparency and style of representation (Phase 2).

2.2.2 Phase 2 – Surveys

2.2.2.1 Transparency Survey

In this survey, naïve participants (i.e. people who did not take part in Phase 1) were asked to match different drawings from the Pictionary game with their meanings.

2.2.2.1.1 Participants, stimuli and procedure

180 people were recruited through the online platform Prolific and took part in an online survey designed with Qualtrics in exchange for a payment of 6£/hour. Stimulus materials were the 648 individual drawings produced at the end of Phase 1. Each participant was presented with the full list of 12 target words (i.e. all words from List A or List B, in alphabetical order). They were then presented with 36 drawings from the end of Phase 1, one at a time, and asked to guess which of the 12 possible target words the drawing represented. In each case, these 36 drawings were all sampled from the same condition (isolation, contact, or control) and the same list (A or B). In other words, each participant in this survey saw drawings only from one condition and one list, but which condition and which list varied between participants.

2.2.2.2 Style Survey

In this survey, naïve participants (different to those from both Phase 1 and the Transparency Survey) were asked to say whether drawings contained inter-

subjectively recognisable figures or not. This provides a measure of whether the drawings had a figurative or abstract style. (We mention here in passing that other equally reliable measures are possible that treat the abstract-figurative distinction as a continuum between two poles rather than a binary category, e.g. see Tamariz & Kirby, 2014). Note incidentally that style of representation (abstract or figurative) does not overlap with complexity (simple vs complex); abstract drawings might be very complex, e.g. intricate doodles with no intended reference.

2.2.2.2.1 Participants, stimuli and procedure

The whole dataset of 648 individual drawings produced at the end of Phase 1 was presented to each of 10 participants (students at Durham University), giving a total of 6480 style judgments. Order of presentation was randomised. Participants were shown a target drawing and were asked to indicate (with a "yes" or "no" on an answer sheet) whether, in their opinion, the drawing included things that the participant could clearly recognise and that some other reasonable person would also clearly recognise.

All survey data are available at Granito et al. (2018).

2.2.3 Statistical Information

To estimate the effect of the experimental conditions on the transparency of meaning of drawings and their style of representation, interpretation accuracy and style were analysed by drawing with aggregated binomial regression models using a logit link function; models were run with McElreath's Bayesian rethinking R package (McElreath, 2016; R Core Team, 2017). We constructed multilevel models and generated posterior estimates using rstan package's Hamiltonian Monte Carlo. The equivalent frequentist models are available in the Supplementary Information (see §A.1.2.2).

We constructed two models, "Transparency" and "Style", with a binary response variable for correct interpretation and figurativeness, respectively. The models included the following fixed variables, each with an associated coefficient (slope), β: condition (isolation, contact and control, recoded into dummy variables with isolation as "00", i.e. the baseline, for ease of interpretation); kind of concept (abstract/concrete); and list of concepts (list A/list B). The models also included separate varying intercepts (with normally-distributed hyperparameters to describe the standard deviation of the population of intercepts) for each drawing and for each concept represented. For Transparency only, we also specified a

varying intercept for questionnaire, since – for practical necessities – in the transparency survey, drawings were sorted into different questionnaires taken by different sets of participants.

In order to assess the effect of condition, we compared each model for out-of-sample deviance (WAIC) against a null model, which only included the intercepts representing the multi-level structure and the two covariates kind of concept and list of concepts, but no condition coefficients (i.e. effectively, the isolation condition).

For relevant fixed variable coefficients, β, we quote the posterior mean, standard deviation and the highest posterior density interval (89% HPDI), in units of log-odds (negative and positive effects of the predictor variable on the response variable compared to the baseline category, isolation, lie either side of zero). To compare the absolute effect of each condition on the probability of the outcome, we extracted posterior samples of the models' estimates for the condition parameters and converted them into probability distributions by applying the logistic function (McElreath, 2016). See Supplementary Information for the statistical models (§A.1.1.2).

2.3 Results

2.3.1 Quantitative results

Are drawings from the contact condition more likely to be interpreted correctly than drawings from the isolation and control condition?

Yes. The Transparency model had a lower WAIC than the null model ($WAIC_{transparency}$ = 6629.9, $WAIC_{null}$ = 6634.5, with $WAIC_{transparency}$ weighting 91%) and the standard error for the difference between the two WAIC scores was a little smaller than their difference (difference, dWAIC = 4.7, dSE = 3.28). This indicates that the condition parameters (in the Transparency model) may be a useful predictor of out-of-sample data (see Figure 6 a).

There was a positive effect of contact against the baseline category isolation ($\beta_{contact}$ mean = 1.75, SD = 0.20, HPDI = 1.44 to 2.07), whereas there was no clear effect of control over isolation in the log-odds of correct interpretation ($\beta_{control}$ mean = -0.21, SD = 0.20, HPDI = -0.51 to 0.11). Comparing the median estimates from the posterior probability of correct interpretation between conditions, we found that the probability of correct interpretation for drawings from the contact condition was 38% higher than the isolation condition (HPDI = 27% to 47%) and 42% higher than

the control condition (HPDI = 30% to 50%), whereas there was only a very small difference in probability between control and isolation (3% advantage of isolation over control, HPDI = 2% to 10%). Figure 6a illustrates the predicted effect of the conditions on the probability of correct interpretation and shows a trend that is consistent with our hypothesis: drawings coming from the contact condition were more likely to be interpreted correctly than drawings coming from the isolation or control conditions, which had instead similar low interpretation accuracy.

Are the drawings from the contact condition more likely to be figurative than the drawings from the isolation and control condition?

Yes. The Style model had a lower WAIC than the null model ($WAIC_{style}$ = 5032.5, $WAIC_{null}$ = 5043.0, with $WAIC_{style}$ weighting 99%), but noting that the standard error for the difference between the two WAIC scores was a little smaller than their difference (difference, dWAIC = 10.5, dSE = 9.74). This provides some evidence that the condition parameters are a useful predictor of out-of-sample data (see Figure 6b).

There was a positive effect of contact against the baseline category isolation ($\beta_{contact}$ mean= 1.71, SD = 0.20, HPDI = 1.41 to 2.03), whereas there was no clear effect of control over isolation in the log-odds of a drawing being figurative ($\beta_{control}$ mean = -0.09, SD = 0.21, HPDI = -0.41 to 0.25). Comparing the median estimates for the posterior probability distributions between conditions, we found that the probability of figurativeness for drawings from the contact condition was 34% higher than the isolation condition (HPDI = 23% to 44%) and 35% higher than the control condition (HPDI = 23% to 46%), whereas there was only a 1% probability advantage of isolation over control (HPDI = 4% to 7%). Figure 6b illustrates the predicted effect of the conditions on the probability of figurativeness and shows a trend that is consistent with our hypothesis: drawings coming from the contact condition were more likely to be figurative than drawings coming from the isolation or control conditions, which had instead similar low probabilities of figurativeness.

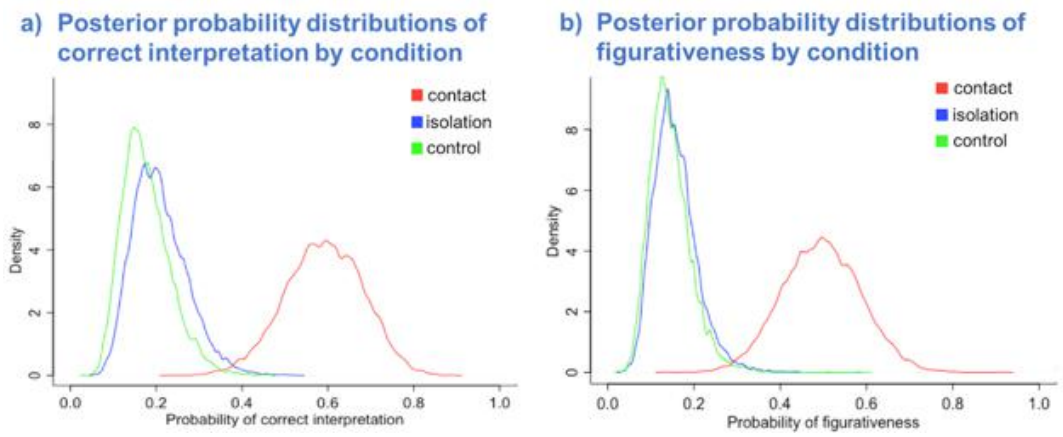

Figure 6 Posterior probability distributions from the (a) Transparency and (b) Style Bayesian models. Drawings from the contact condition were more likely to be correctly interpreted, and more likely to be judged as figurative (N=648).

A methodological issue of experiments where participants repeatedly interact in groups is that data (in our case, drawings) produced within a group are not independent. To address this issue, we ran two additional models (one for Transparency and one for Style) including a cluster variable for group as a random variable generating a varying intercept (McElreath, 2016). We found that the new models imply nearly identical predictions as the original models and that the effect of condition was essentially the same (see Supplementary Information for details, §A.1.2).

2.3.2 Qualitative Results

In this section, we will briefly discuss the processes of change in the drawings during the game from a qualitative point of view, informed by the results of the quantitative analysis and by referring to the representative sample shown in Figure 5.

In the isolation condition, over repeated interactions with same-group members, representations change from figurative and detailed depictions of objects and people to extremely simplified lines and abstract shapes, so much that they lose any resemblance to the things of the world. The final pictorial representations typically need group-specific cultural information to be interpreted, therefore outsiders are less likely to interpret their meanings correctly. This process mirrors the findings of previous work in the evolution of graphical communication systems (Caldwell & Smith, 2012; Garrod et al., 2007). However, unlike previous observations (Fay & Ellison, 2013; Fay et al., 2008), the same processes of stylistic simplification and increase in opacity take place in both the isolation and the control condition, which

differ for number of group members (3 in isolation vs 9 in control). This suggests that the difference in effective group size and rate of playing director/matcher roles did not affect the change in style and degree of transparency of drawings.

A different process of change is observed in the contact condition. During the initial home rounds, just as in the initial stages of the isolation and control conditions, participants develop a shared common ground within their home groups and start to establish initial group-specific conventions using increasingly stylised forms. However, in the first travel block, where participants have to interact with different-group members, those initial conventions do not allow effective communication. Therefore, participants switch to a figurative strategy in which the elements of the drawings "look like something" and require less group-specific information to be interpreted. A similar return to a figurative strategy in pairs of participants which do not share an interaction history was also observed in (Healey et al., 2007). However, in our case, shared interaction history does not appear to play a role in producing the final effect. During the game, participants repeatedly alternate travel blocks and home blocks; when participants go back to their home groups after a travel block, in the early stages of the game they just tend to switch back to their home stylised conventions; however, as the game progresses and the encounters with different-group members iterate, participants tend to adopt the figurative strategies developed during the travel blocks even when playing with same-group members, with which they do share an interaction history. This is probably because storing and using a single version of a representation to use in any occasion of interaction is less cognitively heavy than storing multiple representations, one for each occasion of interaction. Playing under time pressure, participants presumably selected for each meaning the graphical representation they found to be most effective in communicating quickly. Over time, drawings in the contact condition may become slightly less detailed so as to reduce the drawing effort, but they still maintain largely inter-subjectively recognisable figures.

2.4 Discussion

Overall, these findings support the hypothesis that intergroup contact influences the development of styles and transparency of pictorial representation. Our results show that drawings from the contact condition are more transparent and more figurative than drawings from the isolation and control conditions. In other words, compared to the contact condition, drawings evolve to become abstract and opaque in the two conditions where there was no intergroup contact. This appears to be

unaffected by whether the no-contact effective group size was the same (control) or smaller (isolation) than the group size in the contact condition. We conclude that the effect is due to the possibility for participants in the contact condition of having to communicate with outsiders: as a consequence of the need to make representations accessible to potentially any audience, style retains figurativeness and the drawings retain external interpretability.

In our experimental design, two unavoidable confounds are theoretically possible but empirically implausible (for a similar case, see Garrod & Doherty, 1994). The first is that experience of playing with the same individual was lower in the control condition than in the other two. This is a direct consequence of keeping task experience and total trial numbers balanced across conditions. The second is that there was a lower active participation rate (i.e. the frequency of engagement of a participant as either director or matcher rather than observer) in the control condition than in the other two. This is a direct consequence of creating one large group of 9 individuals but keeping constant the total number of trials. However, it seems extremely unlikely that low same-partner interaction rate and low active participation rate in the control condition would encourage the evolution of abstract pictorial signs. If anything, fewer interactions produce less abstract signs (Garrod et al. 2007), and we would expect active engagement to generate more abstract graphics as a result of shared attention and learning. As such, it is more plausible that the control condition exhibited a similar evolution of abstract drawings to that of the isolation condition because of the absence of intergroup contact rather than for a lower same-partner interaction rate or a lower active participation rate.

As a possible real-world example of this effect in action, consider two different areas of Aboriginal Australia, Arnhem Land and the Western Plateau, and compare their artistic productions. At the time of European contact, Arnhem Land was populated by a large number of high-contact Aboriginal groups engaged in intense networks of ceremonial and commercial exchanges (Davidson, 1935; Grey, 1841; Mulvaney, 1976; Petri, 1950); whereas groups in the Western Plateau were fewer and more isolated, entertaining only rare or very sporadic interactions (Birdsell, 1976; Mulvaney, 1976). In both contexts, visual art played an important role in religious gatherings and covered a storytelling function by encoding ancestral myths and events from everyday life in conventionalised visual forms (Layton, 1992a). However, the visual forms adopted to illustrate those stories differed greatly between the two areas. In the Arnhem Land groups, there was a strong prevalence of silhouette traditions including recognisable animal and human shapes (Layton,

1992a, see Figure 7 left, top and bottom). By contrast, in Western Plateau groups, artworks prevalently included highly stylised, geometric motifs, such as concentric circles, semicircles, wavy lines (Morphy, 1998), see Figure 7 right, top and bottom). Western Plateau motifs were also difficult to interpret for ethnographers, and in the lack of local informants, the meanings of many motifs remained obscure (e.g. see Basedow, 1903; Mountford, 1937, 1955). This difference in forms of representation between the two areas occurred across material supports and pictorial means, for example it can be found in rock art motifs (Layton, 1992a; Taylor, 2005; Figure 7 top, left and right) as well as in portable paintings (Morphy, 1998; Figure 7 bottom, left and right). The silhouette-geometric distinction is widely overlapping with our distinction between figurative and abstract styles. This analysis is of course speculative, but it nevertheless illustrates how the effects observed in our study might translate into real-world phenomena. (A quantitative study on this case is currently in preparation.)

Figure 7 Aboriginal art as a real-world example. Left: Examples of Arnhem Land rock art (top, from Lewis, 1988) and bark painting (bottom, Narritjim Maymuru, Bamabama, 1976) mainly presenting figurative motifs. Right: Examples of Western Plateau rock art (top, from Basedow 1903) and painting (bottom, Charlie Eagle Tjapaltjari, Wallaby Dreaming in the Sandhills, 1977) mainly presenting abstract motifs.

More generally, and regardless of whether the above speculation is correct, our results contribute to the ethnographic literature by providing an experimental demonstration that correlated changes between intergroup contact on one side and representational transparency and figurativeness on the other, are likely to be causal. In our experiment, the increase in figurativeness and transparency occurs exactly and only when the need for communication with outsiders is present. Of course, intergroup contact sometimes occurs between groups that have no intention to communicate with each other, and in these cases we should not expect that phenomenon to occur.

At the same time, the experimental context is clearly idealised, and real-world scenarios are likely to present more noise. Artistic representation in particular is likely to be influenced by other factors related to political context, religious ideas, identity marking and ostentatious displays of skill or creativity, which might drive greater elaboration and improvisation in design by individuals seeking to "stand out" from the crowd. In this paper, we are isolating the specific factor of intergroup communication and simulating one particular process. An important goal for future research is to systematically analyse style in real-world pictorial representations, in particular considering artistic representations with a storytelling function, with the goal to determine the relative strength and generality of the link between intergroup contact and representational style.

Another parallel example in the real world is language change. Research in sociolinguistics and language evolution has shown the existence of a correlation between the degree of contact of a community of speakers (among other socio-demographic factors) and language complexity (Lupyan & Dale, 2010; Reali, Chater, & Christiansen, 2018). Languages spoken in societies of strangers (high-contact, large sized, loosely-knit communities with small amounts of socially-shared information) are more lexically and morphologically transparent, regular, and less redundant than languages spoken in societies of intimates (low-contact, small sized, tightly-knit communities with large amounts of socially-shared information; Trudgill, 2011). This is generally thought to be due to the large-scale learning by non-native adults taking place in societies of strangers, which would act as a selective filter for complexification (an example of this is the process of pidginisation; McWhorter, 2011; Wray & Grace, 2007). In other words, in high-contact communities, languages become easier for non-natives to understand and learn, whereas in small isolated communities, languages are more difficult for non-natives to understand and learn. Our study shows that this correlation, between degree of contact of a community of speakers on the one hand, and transparency of meaning on the other, might be causal, for reasons that are in line with sociolinguistic theory. It may be the case that intergroup contact is a driver of communicative transparency regardless of the specific communication medium.

Author Contributions

C.G. conceived the study and collected the data. C.G., J.T. and T.S.P. designed the study. C.G. and J.K. analysed the data. All of the authors contributed to writing the manuscript. All authors gave final approval for publication.

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Conflict of Interest

None.

Ethical Standards

The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008.

Research Transparency and Reproducibility

Dataset of drawings and survey data are deposited at Figshare: https://figshare.com/s/a4f03733f97a2ddf661d

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3 Styles of pictorial representation are shaped by group contact: a case study of Australian rock art[2]

Granito C.[a, b, 1], Scott-Phillips T.C. [a, b,c], Kendal J.R. [a, b] & Tehrani J.J. [a, b]

[a] Department of Anthropology, Durham University, Durham, DH13LE, UK

[b] Durham Cultural Evolution Research Centre, Durham, DH13LE, UK

[c] Department of Cognitive Science, Central European University, Budapest, 1051, Hungary

[1] Corresponding author: carmen.granito@durham.ac.uk

Abstract

Image-making is a nearly-universal human behaviour, yet the visual strategies and conventions to represent things in pictures vary greatly over time and space. In particular, pictorial styles can differ in their degree of figurativeness, varying from inter-subjectively recognisable representations of things to very stylised and abstract forms. Are there any patterns to this variability, and what might its ecological causes be? Empirical and experimental studies have showed that demography and the structure of interaction of cultural groups can play a key role: the greater the degree of contact with other groups, the more recognisable and less abstract are the representations. Here we test this hypothesis on a real-world dataset. We constructed a balanced database of indigenous Australian rock art motifs from both isolated and contact Aboriginal groups. We then ran a survey asking participants to judge the recognisability of the motifs and to provide interpretations. Results show that motifs from contact Aboriginal groups were more likely to be judged as inter-subjectively recognisable and also elicited more convergent descriptions than motifs from isolated groups, strongly supporting the idea that intergroup contact is likely to be an important factor in the cultural

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evolution of pictorial representation. We discuss the implications of these findings for the archaeology and anthropology of art, and the parallels with language evolution.

Keywords

Pictorial representation; cultural evolution; art styles; rock art; graphical communication; demography; culture contact; abstract art; figurative art; Australian art

3.1 Introduction

Image-making is a nearly-universal human behaviour. Humans have made images since before the Upper Palaeolithic (Bahn, 2016; Henshilwood et al., 2002) and image-making has played a crucial role in the evolution of cognition and sociality (Renfrew & Morley, 2009). Yet, the strategies and conventions for representing things and ideas in pictures vary greatly over time and across cultures. In particular, pictorial styles can vary along the dimension of figurativeness, ranging from inter-subjectively recognisable depictions of objects, people, animals and scenes, to very stylised and abstracted forms (Willats, 1997).

The question of what factors can influence this variation between abstract and figurative representations is a long-standing one (e.g. Balfour, 1893; Boas, 1927; Frankl, 1938; Gombrich, 1984, 1999; Haddon, 1895; Loewy, 1907; Pitt-Rivers, 1875; Riegl, 1893; Schapiro, 1953). Demographic factors and social structure are often invoked by archaeologists, anthropologists, art historians and experimental semiologists to explain variation in pictorial strategies (Conkey & Hastorf, 1990; David & Lourandos, 1998; Dressler & Robbins, 1975; Fay & Ellison, 2013; Fischer, 1961; Merrill, 1987; Peregrine, 2007; Washburn, 2013; Witkin, 1995; Wobst, 1977). In particular, empirical and experimental studies suggest that demography and structure of interaction between cultural groups may play a role in this variation. Correlational studies have shown an association between group density and intensity of social interaction networks on the one hand, and the diversity of pictorial traditions found in a region on the other (Conkey & Hastorf, 1990; David & Cole, 1990; McDonald, 2008; McDonald & Veth, 2006; Rosenfeld, 1993). Experimental studies on the figurativeness/abstraction dimension of style have shown that repeated interaction within the same group over time leads to the emergence of abstract symbols (Caldwell & Smith, 2012; Garrod, Fay, Lee, Oberlander, & Macleod, 2007; Granito et al., 2019), whereas occasional interaction

between individuals from different groups can cause shifts to more detailed figurative representations (Healey, Swoboda, Umata, & King, 2007). In a previous experimental study, we showed that group contact can affect the figurativeness of pictorial representation, with isolated groups producing abstract stylised drawings and contact groups producing figurative drawings in a graphical communication task (Granito et al., 2019). Several cases in history have also been observed where changes in the figurativeness of pictorial representation occurred in conjunction with situations of contact between different cultural groups, suggesting the trend of a figurative shift (Layton, 1992b; Morphy, 1991; Morphy & Layton, 1981; Shatzmiller, 2013; Versluys, 2017; Verstegen, 2012).

However, the question of whether contact between groups can affect figurativeness in real-world pictorial representation systems still needs to be addressed in a systematic quantitative fashion. Here, we address this gap in the literature by focusing on Australian rock art, which provides a fascinating natural experiment for studying the relationship between demography and pictorial styles. Rock art portrays a rich array of images that demonstrate considerable stylistic variation across Aboriginal groups, spanning a wide spectrum of figurativeness (see Figure 8). Aboriginal communities, meanwhile, occupy a range of ecological niches, some of which support relatively high population densities and inter-group contact, while others are inhabited by more isolated and dispersed groups. To investigate whether there is any relationship between styles of representation and the demographic profiles of these peoples, we constructed a dataset of indigenous Australian rock art collecting motifs from (i) low-contact Aboriginal groups from the desert areas of Australia, and (ii) highly interconnected groups from the north-western coast. We then used surveys of naive participants to test whether motifs produced by interconnected groups are more likely to be figurative than motifs produced by isolated groups.

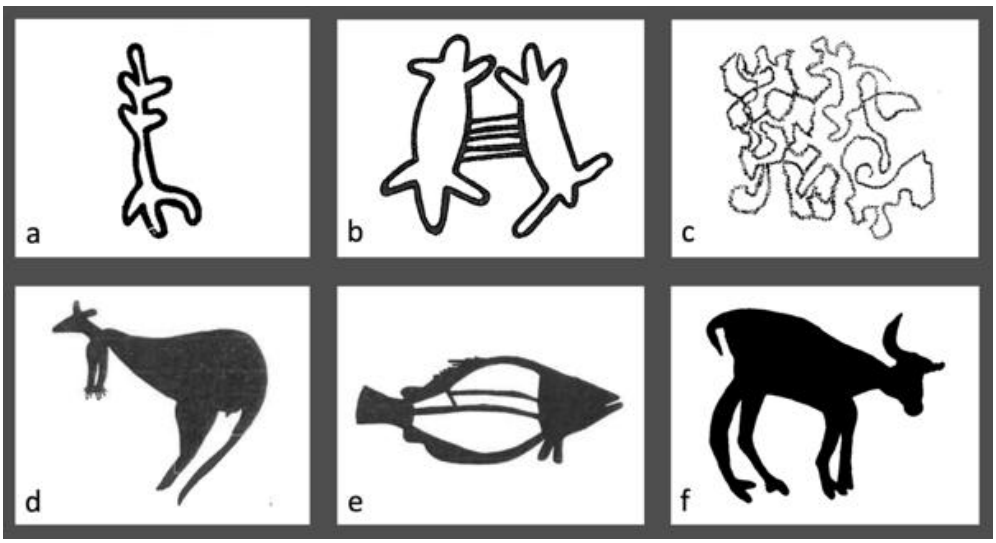

Figure 8 Examples of Aboriginal Australian rock art motifs: a) human (from Mountford, 1977); b) two animals (from Mountford, 1977); c) snakes (from Mountford, 1955); d) kangaroo (from Novotny, 1975); e) fish (from Novotny, 1975); f) buffalo (from Murray & Chaloupka, 1984).

The key idea behind the study is that, differently from isolated groups, in contexts of contact the need to communicate effectively with audiences from a number of different groups causes rock art motifs to retain figurativeness and maintain accessibility to the widest possible audience. In contrast, motifs used in isolated groups are more free to develop symbolic, abstract, and other idiosyncratic features that reduce comprehensibility to non-members. We recently tested this idea experimentally, showing how group contact can affect the style of pictorial representation in a graphical communication task (Granito et al. 2019). Here we explore the same idea in a real-world dataset.

3.2 Methods

3.2.1 Selection of material

3.2.1.1 The demographic context: isolation and contact of ethnolinguistic groups in indigenous Australia

The demographic data on the Aboriginal Australian context are based on ethnographic documentation referred at a time interval from the European contact (or earliest fieldwork in the continent) until the 1990s, a period which is well documented in ethnographic work. We considered as our group units the Aboriginal

ethnolinguistic groups as identified in AIATSIS[3] map of Indigenous Australia (Horton 1996; see Figure 9).[4]

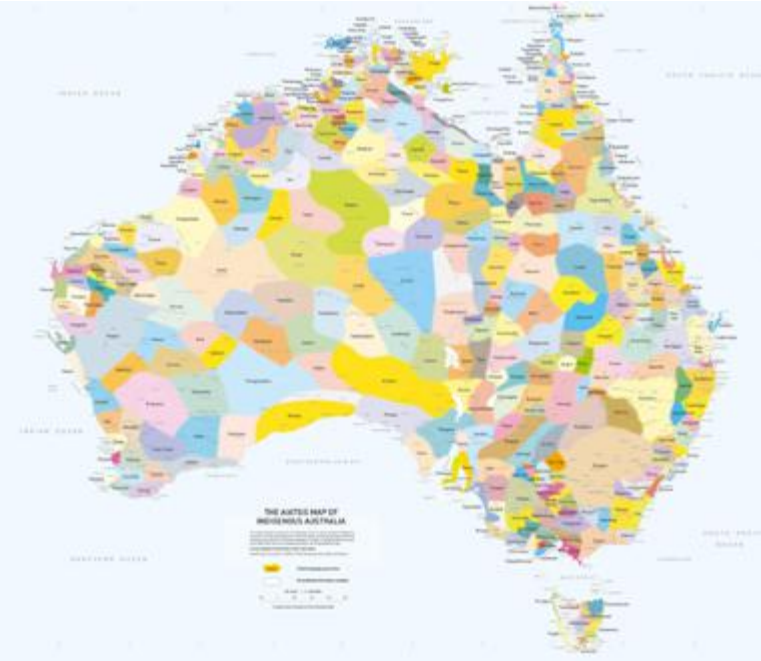

Figure 9 Map of Aboriginal Australia elaborated by D. F. Horton in 1996 for the Encyclopaedia of Aboriginal Australia of AIATSIS (Australian Institute of Aboriginal and Torres Strait Islander Studies). Each coloured blob indicates the approximate location of an ethnolinguistic group.

Aboriginal ethnolinguistic groups can be clustered in larger areas by drainage basins (Peterson, 1976; see Figure 10). Drainage basins tend to restrict communication between regions and lead to the development of regional cultural patterns and features (e.g. same language family, same types of rituals etc.). For each

[3] Australian Institute of Aboriginal and Torres Strait Islander Studies.

[4] AIATSIS map was developed by D. F. Horton along with the Encyclopedia of Aboriginal Australia as part of a research project and is an attempt to represent language or nation groups of the Indigenous peoples of Australia. Aboriginal and Torres Strait Islander groups were included on the map based on the published resources available between 1988 and 1994 which determine the cultural, language and trade boundaries and relationships between groups. The borders between groups are purposefully represented as slightly blurred, as they do not claim to be exact (AIATSIS, 2015). We used Horton's classification only as a proxy for measuring population-level variation in shared artefactual representation of meaning; the accuracy of any other aspect related to group identity is not relevant to our study.

area, we used two proxies to measure the amount of contact between the groups living in that area: group density and inter-group exchanges.

Figure 10 Peterson's areas corresponding to drainage basins (Peterson 1976; map from (Arthur, 2005)).

3.2.1.1.1 Group density

For each culture area, we computed the ratio between the number of groups that live in it and its surface (computed using the open-source software ImageJ). The idea is that a higher number of groups located close to each other in a smaller space creates a condition for more frequent contacts.

We found that group density was higher on coastal areas, in particular on the northern and eastern coasts, whereas it was lower in the interior regions and on the south-western coast (see Figure 11). In particular, group density was highest in the Timor Sea (0.000129 - 0.000134 groups/km^2) and South-East Coast (0.000117 - 0.000137 groups/km2) areas, and it was lowest in the Western Plateau (0.000017 - 0.000020 groups/km^2).

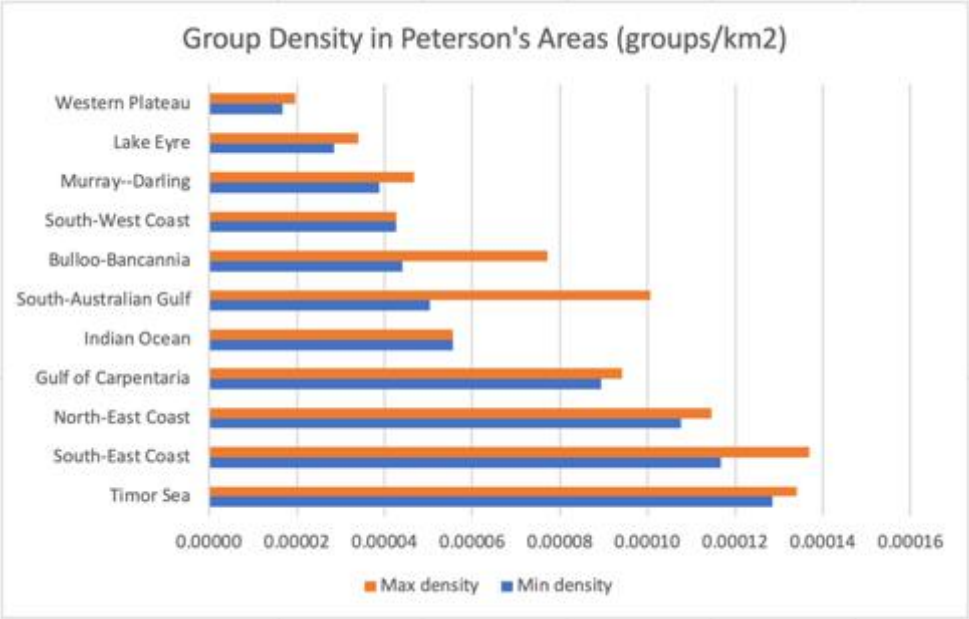

Figure 11 Density of groups in Peterson's areas (= n. groups / surface of area). Due to fuzziness of group boundaries, it is difficult to assign some borderland groups to one area with certainty. We then calculated min and max group number per each area, and corresponding density values. Note that while the min and max values differ noticeably for some intermediate positions (these are very small areas with a lot of uncertain assignations of groups), there are no major consequences on the density evaluation at the extreme ends, which are of interest here.

This is in line with previous ethnographic data on the distribution of the indigenous Australian population at the beginning of the colonial era. The first systematic estimate showed that the population was concentrated in the regions of the tropical north, along the eastern seaboard, and in interior wetland areas such as the Murray-Darling basin (Radcliffe-Brown, 1930; see Figure 12). Later studies confirmed that although the indigenous population at the time of European contact occupied the whole continent, the highest population densities were localised in coastal and riverine Australia, in correspondence with abundance of water sources (Gray, 2001; Mulvaney, 1976; see Figure 13). In arid areas, with relatively scarce resources, the population was much less dense and group territories were generally larger.

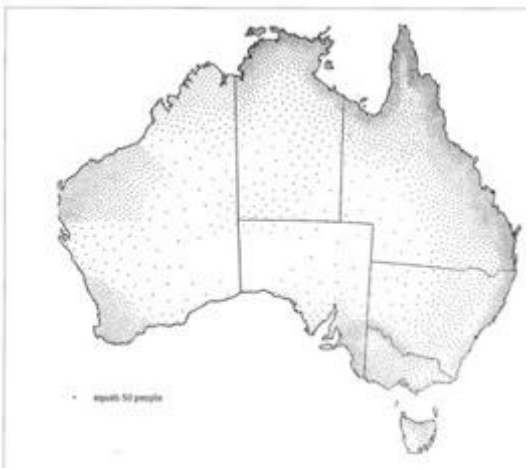

Figure 12 Radcliffe-Brown's 'Estimated number and distribution of Aboriginals in 1788'.

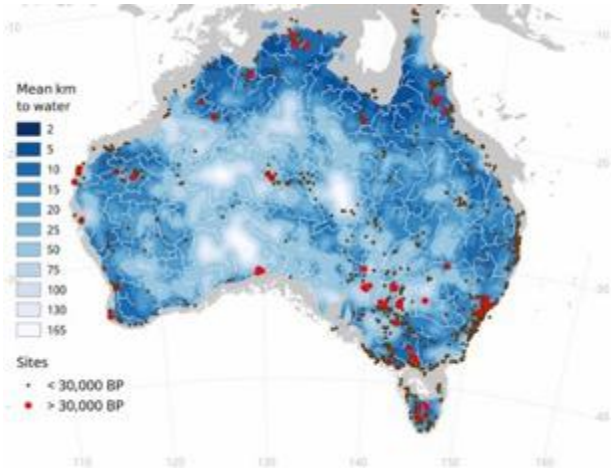

Figure 13 Mean distance from water (Bird, O'Grady, & Ulm, 2016).

3.2.1.1.2 Inter-group exchange

The second proxy for inter-group contact was inter-group exchanges. Trade among Aboriginal peoples are regarded by ethnographers as an especially intensive form of culture contact, often leading to extensive culture change (Micha, 1970; Petri, 1950a). In Aboriginal Australia, objects of trade and exchange were not only material goods such as tools, crafts and cult objects, but also intangible cultural items such as ceremonies and rituals. Objects and ideas travelled and were traded along the same routes (McCarthy, 1939), and much trading happened during gathering ceremonies (Peterson, 1976b). For each of Peterson's areas, we then collected and assessed ethnographic evidence of commercial and ceremonial inter-group exchanges.

In general, inter-group contact for trades and ceremonial gatherings depended upon the availability of water and plentiful food. Regular routes existed following water routes (Mulvaney, 1976; Roth & Etheridge, 1897). Overall, in coastal and riverine Australia, inter-group trades and gatherings were copious and frequent. There is rich ethnographic evidence of a wide network of intense trades and frequent inter-group ceremonial gatherings covering the whole Timor Sea area, including both Arnhem Land and Kimberley regions (Davidson, 1935; Grey, 1841; Mulvaney, 1976; Petri, 1950b). Inter-group trades and ceremonies comparable to those in the tropical north also took place in the Murray-Darling Basin area (Beveridge, 1889; Eyre, 1845; Howitt, 1904; Mathews, 1896b, 1896a, 1897a, 1903;

Mulvaney, 1976; Roth & Etheridge, 1897; Smyth, 1878; Watson & Chapman, 1914) and in the South-East Coast area (McDonald & Veth, 2006; Mulvaney, 1976); in the latter case, there is substantial evidence of long-distance ceremonial gatherings (Ainsworth, 1922; Backhouse, 1843; Bride & Sayers, 1898; Collins, 1975; Dawson, 1881; Howitt, 1904; Mathews, 1896a, 1897a, 1897b, 1901; Mathews & Everitt, 1907; Morgan & Buckley, 1852; Mulvaney, 1970; Shumack, 1967; Smyth, 1878; Tench, 1961).

The Cape York – South Australian route is also one of very intense exchanges of goods and high mobility of people following a chain of river systems from north to south (McCarthy, 1939; Mulvaney, 1976; Roth & Etheridge, 1897). The route crosses three Peterson's areas: it starts on the south-eastern coast of the Gulf of Carpentaria (Elkin, 1934; Roth & Etheridge, 1897), it crosses vertically the Lake Eyre area (Aiston, 1937, p. 192; Curr, 1886; Elkin, 1934; J. W. Gregory, 1906; Horne & Aiston, 1924; Howitt, 1904; Roth, 1904, 1910; Siebert, 1910; Smyth, 1878; Spencer & Gillen, 1912) and it terminates in the South-Australian Gulf area (Bruce, 1902; Elkin, 1934; Howitt, 1904, p. 190; Mathews, 1898; Smyth, 1878).

There is also some evidence of a trade route (E. Gregory, 1866; Petrie, 1904; Roth, 1910) and some inter-group ceremonial gatherings (Hale & Tindale, 1934; Roth, 1910) along the upper North-East Coast.

In arid regions, meanwhile, inter-group contacts were more sporadic, with very few opportunities for gatherings, which were restricted to a few localities and limited to occasional years of good rains (Birdsell, 1976; Mulvaney, 1976). Here exchange routes mostly followed the borders of Peterson's areas (Micha, 1970; Mulvaney, 1976). A "northern route" existed between Kimberley and the northern border of the desert area (Davidson, 1935; Eylmann, 1908; Meggitt, 1955; Spencer & Gillen, 1904, 1912, 1927); another route from Kimberley reached the southern border of Western Plateau via the border of the Indian Ocean area (the Kimberley-Southwest Australian Route, McCarthy, 1939); finally, a "central route" existed between the western Lake Eyre area and the eastern border of the desert (McCarthy, 1939).

On the basis of the ethnographic evidence, we could sort Peterson's areas into highly, partially and marginally connected areas (see Figure 14). Groups in Timor Sea, Murray-Darling, and the South-East Coast areas are highly interconnected, with intense networks of exchanges covering the whole of each area. In the Gulf of Carpentaria, Lake Eyre, Bulloo-Bancannia, South-Australian Gulf and North-East

Coast areas exchanges occur but the network involves only some groups in certain parts of each area. In the Western Plateau, Indian Ocean and Southwest Coast areas, groups only sporadically interact and the few exchange routes are limited to the border regions.

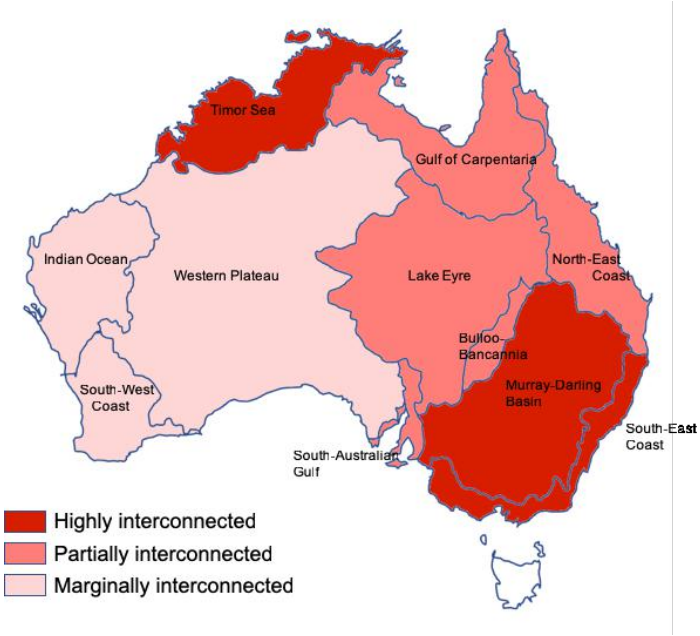

Figure 14 Intensity of commercial and ceremonial inter-group exchanges in each Peterson's area (based on the ethnographic record).

3.2.1.2 Selection of cases of isolation and contact

Timor Sea and South-East Coast are areas with both high density and high interconnection of groups. They are good cases of contact. The Western Plateau and the South-West Coast are areas with both very low group density and low interconnection. They are good cases of isolation.

For constructing our dataset of rock art motifs, we aimed at selecting rock art that was produced or used by indigenous Australian peoples at the time of European contact (1788) or in an interval around that time, in order for the sample of motifs to match the demographic context we considered (for an account of how demographic conditions and cultural identities stabilised in Australia around 2ka, see Williams, Ulm, Turney, Rohde, & White, 2015).

The South-East Coast was excluded because for most sites there is no ethnographic evidence of rock art being a living tradition at the time of contact or fieldwork (with the exception of a few sites documented in Flood, 1980; Gunn, 1984; Smith, 1983). This is because the South-East of the continent was the area of first European occupation, where colonisation had a devastating impact from very early

stages and, in many cases, native populations were wiped out before their cultures could be recorded (Sydney Prehistory Group, 1983). Also, for most rock art of the South-East coast there is no direct date available (Langley & Taçon, 2010). The few suitable rock art motifs available in the ethnographic record had poor visual quality.

The South-West Coast was excluded for scarcity and unavailability of data (only 3 rock art sites are documented, in two unpublished reports and one journal article).

In the Western Plateau and Timor Sea areas, instead, all sites present ethnographic evidence of rock art still being a living tradition at the time of European contact or at the time the fieldwork was conducted (Basedow, 1903; Davidson, 1935; Gould, 1969; Grey, 1841; Moore, 1971; Mountford, 1955, 1977; Mountford, 1937; Mulvaney, 1976; Petri, 1950b; Terry, 1931; Tindale, 1959). There is also abundance of good quality visual documentation in ethnographic monographs covering these areas.

Therefore, we collected ethnographic and archaeological monographs documenting the rock art sites of the Timor Sea and Western Plateau areas. An extensive list of rock art sites and related monographs covering those areas was taken from Layton (1992).

For each monograph, we selected motifs reported as produced or in use at/around the time of contact. For each culture area, 90 rock painting motifs were sampled at random from the complete set. We obtained a dataset of 180 motifs which were then used to build an online survey. The choice of dataset size was due to technical limitations of the software used for the design of the online survey.

3.2.2 Survey design and procedure

180 people were recruited through the online platform Prolific and took part in an online survey designed with SurveyMonkey in exchange for a payment of 6£/hour (ethical approval was granted by Durham University Anthropology Committee; all participants provided informed consent). Participants did not have previous knowledge of Aboriginal Australian art. Stimulus materials were the 180 Aboriginal rock art motifs selected as described in the previous section. The dataset of motifs was split (for technical limitations of the software) into six questionnaires of 30 motifs each, half sampled from the Western Plateau and half from Timor Sea. Each questionnaire was taken by 30 participants, therefore 30 responses were collected for each motif.

During the survey, each participant was presented with 30 motifs, one at a time. The order of presentation of motifs was randomised for each participant. For each motif, participants were asked two questions. Firstly, they were asked whether there were things in that image that they could clearly recognise and that they were sure that some other reasonable person would also clearly recognise. This was a yes/no answer and provided participants' judgments of inter-subjective recognisability (i.e. of figurativeness). We expected Timor Sea motifs to be more likely to be judged as inter-subjectively recognisable than the Western Plateau motifs.

After that, participants were asked what they recognised in the motif. Specifically, yes-respondents to question 1 were asked to say what it was that they recognised exactly; no-respondents were asked to say what they themselves could see in the motif, regardless of what other people would think (see Figure 15). In both cases, this was an open text answer. This provided a measure of how much participants were actually recognising the same or similar things in a motif. We predicted that descriptions provided for a Timor Sea motif have higher convergence than descriptions related to a Western Plateau motif, which should be more heterogeneous and dissimilar.

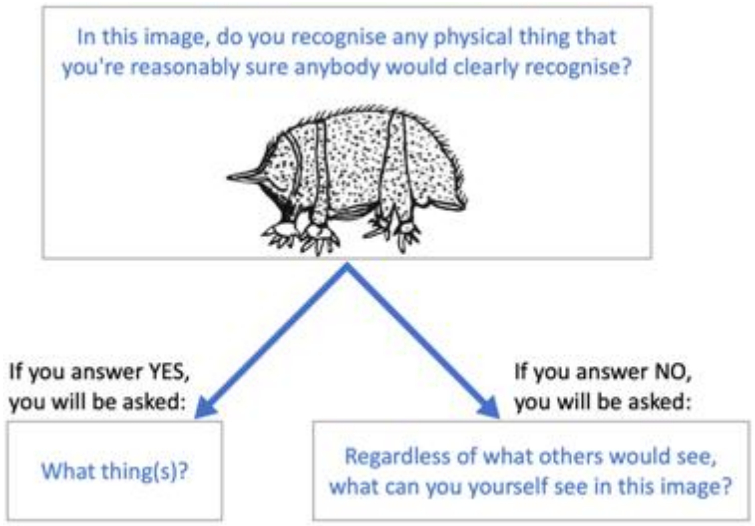

Figure 15 Sequence of questions in the survey.

3.2.3 Coding

Convergence of responses to question 2 was measured with the following procedure. In response to question 2, for each motif we obtained a list of 30 words/phrases. We split each list in clusters, based on these criteria:

- Same words/phrases belonged to the same cluster

- Synonyms (e.g. 'snake' – 'serpent') and expressions which only differed for syntax (e.g. 'turtle and man' – 'man and turtle') were also put in the same cluster
- Grammar mistakes were not considered (e.g. 'snake' – 'this is a snek' were also put in the same cluster)
- Words with a semantic overlap belonged to different clusters (e.g. 'cow' – 'goat', or 'fish' – 'shark')
- "Don't know"-type answers were each assigned to a separate cluster (the rationale behind this was that a don't know-type answer represents the highest level of non-recognisability of a motif, therefore it should maximise divergence of interpretation).

For each list of words/phrases, we then counted the items in each cluster and obtained a vector of counts. For each vector, we calculated its entropy (with R *entropy* function) as a measure of within-motif convergence of responses (see Supplementary Information for an example, §A.2.1).

Coding reliability for the clustering procedure was assessed by having an independent coder, blind to the hypothesis, code 20% of the material (i.e. 36 lists, half from Timor Sea and half from Western Plateau motifs). The agreement between the independent coder and the experimenter was very high (ICC=.977, F =87.5, p <.001). In cases of disagreement the first coder's decision stood.

3.2.4 Statistical information

To estimate the effect of the empirical condition "area" on the style of motifs, we analysed a) recognisability judgements by motif with an aggregated binomial regression model using a logit link function, and b) entropy of word lists by motif with a mixed-effects linear regression model. To account for a potential advantage in recognisability of motifs including anthropomorphic elements (i.e. representations of humans or anthropomorphic beings), we also included the binary variable Anthropomorphic Content coding for the presence or absence of such elements in motifs. Models were run with McElreath's Bayesian rethinking R package (McElreath, 2016; R Core Team, 2016). We constructed multilevel models and generated posterior estimates using *rstan* package's Hamiltonian Monte Carlo.

We constructed two models: the "Recognisability" model had a binary response variable for recognisability of motifs; the Entropy model had a continuous response variable for entropy of word lists. Both models included the following fixed

variables, each with an associated coefficient (slope), β: area (Western Plateau/Timor Sea); anthropomorphic content (0/1). The models also included varying intercepts (with normally- or halfcauchy-distributed hyperparameters to describe the standard deviation of the population of intercepts) for each site of origin, for questionnaire (since – for practical necessities – motifs were sorted into different questionnaires taken by different sets of participants), and for motif ID.

In order to assess the effect of condition, we compared each model for out-of-sample deviance (WAIC) against a null model, which only included the intercepts representing the multi-level structure and the covariate anthropomorphic content, but no condition coefficients.

For the Recognisability model, for relevant fixed variable coefficients, β, we quote the posterior mean, standard deviation and the highest posterior density interval (89% HPDI), in units of log-odds (negative and positive effects of the predictor variable on the response variable lie either side of zero). To compare the absolute effect of each condition on the probability of the outcome, we extracted posterior samples of the models' estimates for the condition parameters and converted them into probability distributions by applying the logistic function (McElreath, 2016).

For the Entropy model, for relevant fixed variable coefficients, β, we quote the posterior mean, standard deviation and the highest posterior density interval (89% HDPI) (negative and positive effect of the predictor variable on the response variable lie either side of zero).

See Supplementary Information for the statistical models (§A.2.2).

3.3 Results

Are motifs from Timor Sea area (contact condition) more likely to be judged as inter-subjectively recognisable (i.e. figurative) than motifs from the Western Plateau area (isolation condition)?

Yes.

The Recognisability model had a slightly higher WAIC than the null model ($WAIC_{recognisability}$ = 5112.0, $WAIC_{null}$ = 5110.7, with $WAIC_{recognisability}$ weighting 34%), but noting that the standard error for the difference between the two WAIC scores was higher than their difference (dWAIC = 1.3, dSE = 1.6). This suggests that the condition parameter do not bring added value to predict out-of-sample data.

Nonetheless, the effect of condition is consistent with our hypothesis (see Figure 16).

There was a positive effect of Timor Sea over Western Plateau (β mean = 1.98, SD = 0.43, HPDI = 1.33 to 2.66) in the log-odds of recognisability. Comparing the median estimates from the posterior probability of recognisability between conditions, we found that the probability of a motif from the Timor Sea area being recognisable was 44% higher than the Western Plateau area (HPDI = 24% to 59%). Figure 16 illustrates the predicted effect of the conditions on the probability of recognisability and shows a trend that is consistent with our hypothesis: motifs coming from the Timor Sea area were more likely to be recognisable than motifs coming from the Western Plateau area.

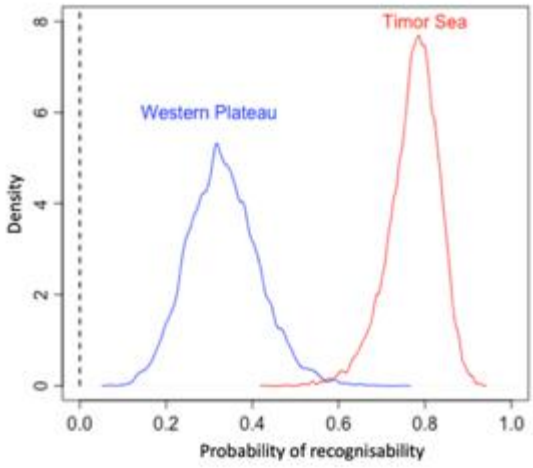

Figure 16 Posterior probability distribution by condition of a motif being judged as inter-subjectively recognisable depictions of things.

Do motifs from Timor Sea area (contact condition) elicit lists of verbal responses with lower entropy than motifs from the Western Plateau area (isolation condition)?

Yes.

The Entropy model had a lower WAIC than the null model ($WAIC_{entropy}$ = 161.5, $WAIC_{null}$ = 186.8, with $WAIC_{entropy}$ weighting 100%). This indicates that the condition parameters in the Entropy model may be a useful predictor of out-of-sample data; see Figure 17.

There was a negative effect of Timor Sea over Western Plateau (β mean = - 1.74, SD = 0.16, HPDI = -1.98 to -1.50). Comparing the posterior distributions of entropy between conditions, we found that entropy was lower for Timor Sea (mean=1.04,

sd=.13, HDPI = .83 to 1.24) than for Western Plateau motifs (mean=2.78, SD = .14, HDPI = 2.56 to 3). Figure 17 illustrates the predicted effect of the conditions on the distribution of entropy means and shows a trend that is consistent with our hypothesis.

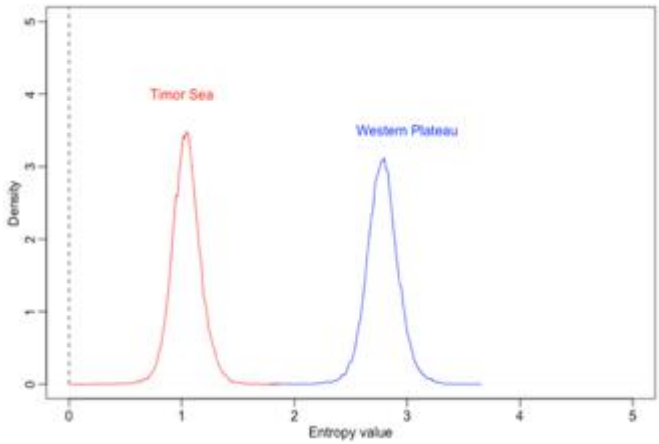

Figure 17 Posterior distribution by condition of entropy values of participants' descriptions of motifs.

3.4 Discussion

Overall, our findings support the idea that inter-group contact influences the development of styles of pictorial representation, in particular that contact can encourage figurativeness. Specifically, our results show that rock art motifs from the Timor Sea area of Aboriginal Australia, where groups entertain intense contacts, are (i) judged as more inter-subjectively recognisable than motifs from the Western Plateau area, which hosts more isolated groups, and (ii) tend to elicit more converging descriptions than the latter in naïve observers. In short, motifs from the contact groups in our sample were more likely to be figurative than motifs from isolated groups.

This study provides, for the first time, quantitative empirical support for previous experimental and qualitative studies on the relationship between the evolution of figurative styles and the demographic factor of inter-group contact. An important implication of our findings is that the abstract or figurative character of pictorial representations can carry information about their demographic context of production/use. This might be particularly valuable for reconstructing group interactions in historic periods for which material evidence is scarce. Distributions of specific artefact and motif types across sites have been used by many archaeologists as a clue to infer characteristics of social contexts, including

population-level structures of interaction (Barton et al., 1994; Braun & Plog, 1982; Conkey, 1985; Francis et al., 1993; Gamble, 1982; Jochim, 1983; Ucko & Rosenfeld, 1967; Wiessner, 1983; Wobst, 1977). However, this approach can be hampered by an insufficient resolution of the archaeological record. It might therefore be useful to also take into consideration more general stylistic features, like figurativeness of representation, to reconstruct scenarios of inter-group contact and isolation.

One potential limitation of our analyses is that our measure of convergence of participants' descriptions does not take semantic relatedness into account. The entropy measure accounts only for distinction between terms and not for similarity of meaning between different terms. Thus, a list of semantically related but different words (e.g. "cow, calf, goat") returns the same entropy value as a list of unrelated words (e.g. "sun, stool, necklace"). However, if anything, this limitation should penalise our hypothesis, since it seems reasonable to expect that semantically-related words are given more frequently in response to more recognisable motifs. In other words, if anything, our analyses might underestimate convergence for Timor Sea (contact) motifs. We conclude that this is a fine-grained detail of no substantive consequence for our general findings.

An objection could be made that in this study we did not check the correspondence between participants' descriptions of motifs and their original meanings. This was for two reasons. Firstly, participants were not asked to interpret the intended meanings of motifs, but to describe what things they could recognise in them. This was because in this case, we were not primarily interested in investigating the transparency of motifs (i.e. whether the intended meaning of a motif was clear or not), but in their style of representation (i.e. regardless of the intended meaning, whether the painter was adopting a figurative or abstract strategy of depiction). Secondly, for a large proportion of motifs, original Aboriginal meanings are lost and only interpretations reconstructed by ethnographers are available. Also, in many cases, the ethnographers' interpretations found in the literature only provide broad, categorical descriptions, of limited comparative use; for example, the motif in Figure 18 is described as "celestial hero" (Schulz, 1956), the motif in Figure 19 as "ceremonial design" (Mountford, 1977). A measure of accuracy of participants' guesses against this type of ethnographic interpretations would have not been informative.

Figure 18 Rock art painting from the Kimberleys representing a "celestial hero" (Schulz, 1956).

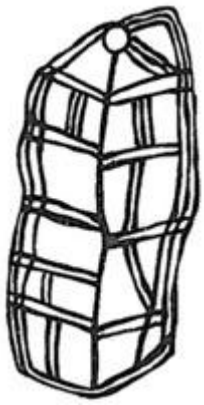

Figure 19 Rock art painting from Uluru representing a "ceremonial design" (Mountford, 1977)

Our findings link with previous archaeological and ethnographic work on differences and distributions in Aboriginal Australian rock art styles. Layton (1992a) identified two different types of motifs in Aboriginal rock art, geometric and silhouette, which largely overlap with our abstract-figurative distinction (examples in Figure 20). Layton's mapping of these types over the Australian territory shows a prevalence of sites with silhouette motifs in areas hosting high-contact groups, whereas sites with geometric motifs are mostly found in areas with low-contact groups. Taylor (2005) also locates figurative styles of Australian rock art in regions that seem to largely map onto the high-contact areas presented in §3.2.1.1.2 (seeFigure 21). The only exception to this is the Indian Ocean area (the most western region highlighted in green in Figure 21), which is classified as low-contact in our analysis of demography and exchanges; however, this might be due to scarcity of data on this region in our analysis. Overall, these findings reveal a pattern in the distribution of rock art styles over Australia that is consistent with our results.

A number of ethnographic studies show that, by virtue of their simple forms, Aboriginal Australian geometric motifs can be used to (a) encode multiple meanings and (b) conceal them from non-initiates and selectively reveal them to those entitled to it based on their affiliation, prestige, gender, age (Layton, 1977; Morphy, 1991; Munn, 1973). This applies both where geometric motifs are the predominant type, as in the Western Plateau, as well as in the Timor Sea area, where geometric patterns infilling animal silhouettes can have different levels of interpretation for initiates and non-initiates (Morphy, 1991). This suggests that the level of restriction and the multiplicity of the information conveyed through a single pictorial sign

might also play a role in shaping its style. The low intersubjective recognizability of abstract motifs might be exploited even in high-contact groups for encoding multiple layers of restricted information.

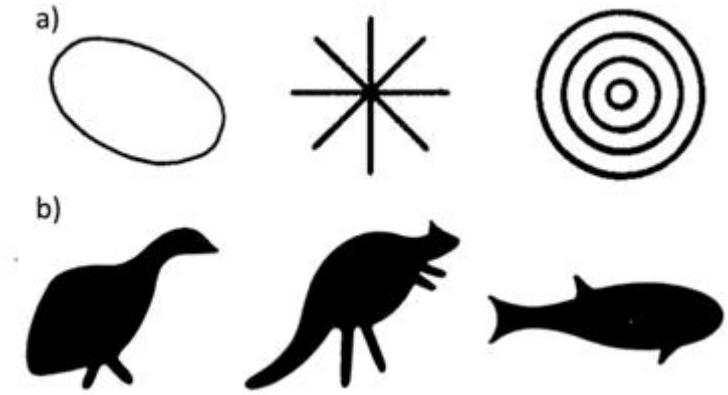

Figure 20 Examples of geometric (a) and silhouette (b) types of motifs from (Layton, 1992a).

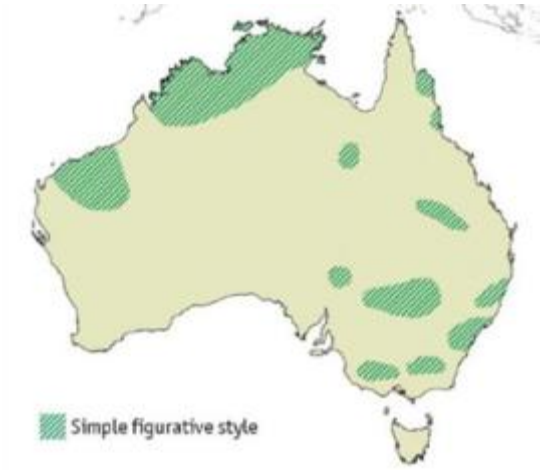

Figure 21 Areas of Australia where figurative rock art style is found (map from Taylor, 2005).

A second set of studies investigated the relationship between degrees of stylistic heterogeneity in hunter-gatherer rock art and the nature of social networks (Brandt & Carder, 1987; David & Cole, 1990; Godwin, 1990; Lewis, 1988; McDonald, 2008). By style, they do not strictly mean the abstract-figurative dimension of representation as analysed in this paper, but loosely "a way of doing things" (Wiessner, 1990), a set of recurring traits shared by the artefacts of a region with a prevalent function of marking group identity and territoriality. Based on information exchange theory, these studies assume that different environments and their effects on hunter-gatherer social networks influence the amount of stylistic variability in graphic systems, with more heterogeneous styles found in fertile than in arid areas. This would be due to a stronger need for group-identifying behaviours in fertile environments, where group density is higher, social networks are closed,

kinship and territorial systems are relatively rigid, and competition for resources is high (McDonald & Veth, 2006). However, in their investigation of Australian rock art, McDonald & Veth (2006) observe that in arid areas of Australia, unexpected peaks of heterogeneity can be found in some specific sites that served as aggregation locales, i.e. sites for gatherings and exchanges between groups. These explosions of heterogeneity of styles are argued to be due to the need of each group to assert their own identity in a place of contested group identity. In a future study, it would be interesting to compare figurativeness of motifs between these aggregation locales and sites of long-term settlement in arid areas. If gathering sites showed a higher figurativeness than settlements, this would provide more evidence that the forms of rock art motifs are not only shaped by their role of group identity marking, but also by their function of signs communicating content effectively to a certain audience. In general, it would be interesting to investigate the interplay between the two forces of identity marking and effective content communication, and how these two together can influence the shape of rock art forms.

Finally, our findings also contribute to identifying a plausible demography-driven pattern of change shared by multiple human communication media. Research in sociolinguistics and language evolution has shown the existence of a correlation between the degree of contact of a community of speakers (among other socio-demographic factors) and language complexity (Lupyan & Dale, 2010; Reali, Chater, & Christiansen, 2018). Languages spoken in societies of strangers (high-contact, large sized, loosely-knit communities with small amounts of socially-shared information) are more lexically and morphologically transparent, regular, and less redundant than languages spoken in societies of intimates (low-contact, small sized, tightly-knit communities with large amounts of socially-shared information; Trudgill, 2011). This is generally thought to be due to the large-scale learning by non-native adults taking place in societies of strangers, which would act as a selective filter for complexification (an example of this is the process of pidginisation; Wray & Grace, 2007). In other words, in high-contact communities, languages become easier for non-natives to understand and learn, whereas in small isolated communities, languages are more difficult for non-natives to understand and learn. In this study we don't explicitly investigate the transparency of the intended meanings of rock art motifs (for the reasons explained above); however, the higher recognisability and convergence of participants' descriptions for contact group motifs suggest that a correlation similar to the linguistic one exists between degree of contact of a community on the one hand, and transparency of meaning for

naïve observers of pictorial signs on the other. It may be the case that inter-group contact is a driver of clarity and understandability in human communication regardless of the specific medium used.

Acknowledgments

The authors thank Prof. Robert Layton for his precious advice on the Indigenous Australian context and his help in finding sources for building the dataset of Australian rock art motifs.

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Data availability

The rock art motif dataset and survey data that support the findings of this study are available from Figshare, https://figshare.com/s/6f702d0e4d3ae9414e1d

Code availability

The R code for the Bayesian models is available in the Supplementary Information (§A.2.2).

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4 Designing exhibition blueprints for research outreach[5]

"Outside in. There are two kinds of people in the world of relevance: insiders and outsiders. Insiders are in the room. They know it, love it, protect it. Outsiders don't know your door exists. They are uninterested, unsure, unwelcome. If you want new people to come inside, you need to open new doors – doors that speak to outsiders – and welcome them in" (Simon, 2016).

"We believe that universities and research institutes have a major responsibility to contribute to society through their public engagement, and that they have much to gain in return" (National Co-ordinating Centre for Public Engagement, 2010)

Abstract

Public engagement is increasingly urgent for academic research. In the broad sector of evolutionary studies, the area of biological evolution has a consolidated practice of public engagement, especially of exhibitions and displays in museums and science centres. In more recent years, the area of cultural evolution has also made good progress in media coverage and policy-makers outreach. However, cultural evolution is still underrepresented in exhibitions and public displays. Here we present the process and output of creating an exhibition blueprint based on findings in the cultural evolution of pictorial representations. The main aim of the blueprint is to translate that piece of academic research into an accessible and engaging experience for lay audiences. This paper also aims to provide researchers at their first experience of exhibition design with guidance in the initial stages of creating an exhibition blueprint.

4.1 Introduction

In the last two decades, public engagement has become an increasingly urgent imperative for academic researchers (Owen, Featherstone, & Leslie, 2016). Governmental and funders' policies have clearly expressed the expectation that the research community should value, support and reward public engagement initiatives (National Co-ordinating Centre for Public Engagement, 2010; Owen et al., 2016; RCUK, 2010). Research assessment now scrutinises not just the quality of the

[5] The paper is going to be submitted to *Evolution: Education and Outreach*.

research but also its impact on society, and public engagement is identified as a key route to realising impact (Research Council UK, n.d.). All major funding bodies in Europe and the US require applicants to outline the activities they will undertake to share knowledge, resources and skills with communities (Lok, 2010). Likewise, the Research Excellence Framework encourages researchers to submit impact case studies (Research Excellence Framework, 2019) where public engagement has come to play a crucial role (King's College London and Digital Science, 2015; National Co-ordinating Centre for Public Engagement, 2017; TNS-BMRB, 2016; Townsley, 2016; Watermeyer, 2012). Engaging with the public is considered of strategic importance for higher education not only because it can improve transparency of public money spend, but also because it can help strengthen relevance of research for the wider audience and responsiveness to their needs, and consequently build trust between universities and communities (Duncan & Spicer, 2010; National Co-ordinating Centre for Public Engagement, 2010).

In the broad sector of evolutionary studies, the research area of biological evolution has a consolidated practice of public engagement, including the development of educational tools for school children (Chanet & Lusignan, 2009; Cook, 2009; Kover & Hogge, n.d.; Passmore & Stewart, 2002; Pobiner, Beardsley, Bertka, & Watson, 2018; Scoville, 2019; University of California Museum of Paleontology, n.d.), a consistent stream of articles in newspapers, magazines, TV, and online news outlets (Horenstein, 2012), but above all a surprisingly long record of both permanent and temporary exhibitions and displays in museums and science centres around the world (Bloomfield, 2012; Ceci, 2009; Diamond & Evans, 2007; Dominici & Cioppi, 2012; Falchetti, 2012; Giusti, 2012; Harcourt-Smith, 2012; MacDonald & Wiley, 2012; Padovani, Buckler, Gualtieri, & Vescogni, 2013; Wycoff, 2008). In recent years, the research area of cultural evolution has made good progress in public engagement as well. In particular, it has started a fruitful dialogue with the audience of policy makers by proposing applications of research findings to social policy development (e.g. see The Evolution Institute, 2018), and it has received good media coverage (e.g. see as a few examples 'Beyond Today, Anti-vax', 2019; 'Fairy tales "thousands of years old"', 2016; Harkness, 2018; Kendal, 2014). Also, some core areas of cultural evolution, such as animal culture, the evolution of

technology and language evolution, were the topics of *Culture Evolves*, an exhibition held at the Royal Society on its 350th anniversary[6].

However, cultural evolution is still under-represented in museum exhibitions and public displays, notwithstanding its great potential for engaging stories, catchy objects, interactive exhibits, and topics that resonate with the audience's everyday life. This represents a missed opportunity. Firstly, from an educational perspective, museum exhibitions are effective learning tools for the understanding of evolutionary mechanisms, reasoning, and key terms (Giusti, 2006; Spiegel et al., 2012), and are considered the most appropriate places for engaging the public in evolutionary topics (Diamond & Kociolek, 2012). Secondly, there are also some very practical advantages in choosing museums as venues for research outreach: they can provide a ready-made and keen audience and a clear view of visitor profiles to aid the targeting of your engagement activity; their strong community links can help access some harder to reach groups; they often have clear frameworks for evaluating success and can suggest mechanisms of capturing data about engagement activities (National Co-ordinating Centre for Public Engagement, n.d.).

Here we present the process and output of creating the blueprint of an exhibition designed for disseminating research findings on the cultural evolution of graphical symbols. In particular, the blueprint responded to the topic of CG's PhD research project and its wider research area: how pictorial representation evolves in graphical communication and visual art, how cultural groups create shared visual languages and conventions, and how social contexts can affect the styles of representation of pictorial signs, in particular the processes of abstraction and figuration (Granito, Tehrani, Kendal, & Scott-Phillips, 2019). The blueprint is the output of an ESRC placement project at The Heritage Management Organisation[7] tutored by curator and content designer Rosie Wanek.

The main aim of the exhibition blueprint was to transform this piece of cultural evolution research into an accessible and engaging experience for a non-specialist audience. The blueprint is indeed going to be proposed to multiple potential host venues as a touring exhibition, and it will be further refined in collaboration with

[6] More information on *Culture Evolves* is available here: http://www.cultureevolves.org/caseStudy4.aspx.

[7] More information of The Heritage Management Organisation here: https://heritagemanagement.org/

their inhouse curatorial staff in order to adjust it to the institution's specific purpose, needs and spaces. Additionally, this paper also aims to help researchers working on germane topics or adopting similar theoretical frameworks or research methods, who are at their first approach with exhibition design: it will give them an idea of how to start and develop the process of translation of their research into an exhibition, what elements to consider, what challenges await; this will also create some common background with professionals in museum, libraries, science centres etc. and facilitate potential collaborations with them.

Firstly, we will outline the phase of research and analysis of the theme, potential venues and target audiences. This will then come together in the phase of content development, where we illustrate how we built our concept, narratives, structure and content package. Finally, we will provide a small toolkit to aid the creation of an exhibition blueprint for academics who are not familiar with the process.

Note that we will focus here on context analysis and content development only, whereas the later stages of experience design, budgeting and implementation are beyond the scope of this paper. This is because the crucial steps for learning how to translate research findings nto something that can spark visitor interest belong to those initial phases.

4.2 The research phase: themes, venues, audiences

Developing an exhibition concept is a dynamic and iterative process based on the interplay of three main factors: content, institution, and audience. The concept package has to be located in the sweet spot where these three elements overlap (Lord, 2014). This is why the first stage of the process was a research and analysis phase where we conducted extensive research on the theme selected for the exhibition, the venues and institutions that might potentially host it, their audiences and how the exhibition might address them.

These steps are presented here in a sequence, but they are actually carried out in parallel, since insights on theme, venues and audiences constantly feed back into each other. This is particularly true in the case of touring exhibitions, such as ours, whereas when the exhibition is co-designed with a single venue, the theme might be defined in collaboration with their practitioners to suit their specific remit and audience profile.

The output of this phase was the basis for later developing our concept and content package.

4.2.1 The research topics behind the exhibition

The research area that inspired the exhibition concept is the cultural evolution of pictorial representations in graphical communication and visual art. In particular, there are three main strands of research that underpin the exhibition concept. They have to do with how cultural groups create shared graphical languages and pictorial conventions, and how different contexts can affect the styles of representation of pictorial signs.

- **Variation in pictorial conventions**

Pictorial representation is a key human behaviour and ubiquitous in human culture. We find it in visual art, pictographic writing systems, road signs, graphic design, book illustrations, comics and animations, just to mention a few examples. Cultures around the world have made images to convey information about living kinds, objects and ideas for at least 75,000 years (Henshilwood et al., 2002).

However, there is a great deal of variation in the ways humans represent things in pictures. Representing a three-dimensional subject in a bi-dimensional picture always involves a selection of traits of the real thing as well as a choice of how to represent spatial relations (Willats, 1997). Such conventions of representation can vary depending on belief systems, ideologies, stereotypes, environment, available materials and technologies etc. (Gombrich, 1984; Layton, 1991). This is why pictorial styles vary greatly between cultures and historical periods.

- **The process of abstraction**

The archaeological record shows that many pictorial signs, especially in writing systems, were originally rather accurate depictions of things. Numerous writing systems, such as the Phoenician alphabet, cuneiform writing and Chinese pictograms, originated from representations of objects, people and animals (Garrod, Fay, Lee, Oberlander, & Macleod, 2007; Sacks, 2007; Tversky, 1995). An example of that is the letter *aleph* of the Phoenician alphabet Figure 22, which initially represented an ox head and eventually evolved into the Greek *alpha* and the Latin *A* (Clayton, 2013; Healey, 1990; Sacks, 2007)..

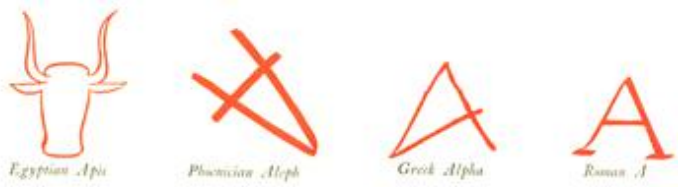


Figure 22 The Phoenician letter aleph initially resembled an ox head; it was probably based on the Egyptian hieroglyph Apis and over time it evolved into increasingly abstract shapes, such as the Greek letter alpha and eventually the Latin A (illustration from Clayton, 2019).

Experimental studies have investigated this evolutionary pattern. They have shown that pictorial signs used in graphical communication gradually evolve over time from figurative representations to abstract symbols through repeated use in a cultural group (Caldwell & Smith, 2012; Garrod et al., 2007). Over repeated interactions with same-group members, representations gradually reduce their level of detail and become extremely simplified lines and shapes, so much that they lose any resemblance to the things they originally depicted. Indeed, pictorial representations at their later stages of evolution are usually opaque for outsiders and typically need group-specific cultural information to be interpreted (Healey, Swoboda, Umata, & King, 2007).

- **Figurative *vs* abstract signs and the role of audience**

Being difficult to understand for outsiders, abstract symbols are not effective in contexts where pictorial representations are used for communication between different cultural groups or to a highly culturally diverse audience. For effective graphical inter-group communication, transparent figurative signs are needed. An experimental study has showed that pictorial representations, when produced in a context of contact between different groups, tend to retain figurativeness compared to the very abstract signs produced in isolated groups (Granito et al., 2019; see Figure 23 a and b). The same evolutionary patterns are found in Aboriginal Australian rock art, where rock art motifs from high-contact Aboriginal groups are more figurative than motifs from isolated groups (Granito et al., in preparation; see Figure 23 c and d). These results indicate that intergroup contact and diversity of the audience play an important role in the cultural evolution of pictorial representations, because the need to communicate with members with different cultural backgrounds causes pictorial signs to retain figurativeness and maintain accessibility to potentially any audience.

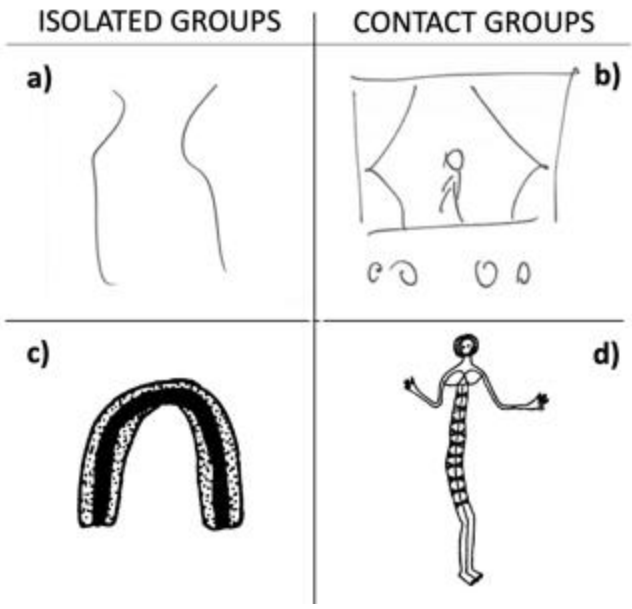


Figure 23 Top: Drawings for "actor" from the isolated (a) and contact (b) groups in the experiment in Granito et al. (2019); Bottom: Representations of a person in rock art motifs from Aboriginal isolated (c) and contact (d) groups (images from Arndt, 1962; Mountford, 1937).

4.2.2 From theory-oriented key messages to an audience-relevant theme

Based on the research context outlined above, we identified the key theoretical messages that we wanted to communicate through the exhibition experience and the main ideas we wanted the audience to engage with:

- The way we represent things in pictures is a convention of our cultural groups (Gombrich, 1984; Layton, 1991; Willats, 1997).
- Many pictorial signs were initially figurative and evolved into abstract symbols over time through repeated use in a cultural group (Caldwell & Smith, 2012; Garrod et al., 2007).
- Different cultural groups produce different abstract conventions over time, which are usually obscure to outsiders (Healey et al., 2007).
- For effective visual communication across different cultures, figurative and transparent signs are needed (Granito et al., 2019).

However, science-based contents are not usually interesting per se for the general audience. They tell stories that are not well known, and their significance to the public doesn't often lie in their inherent scientific value but in their relationship to contemporary issues which are close to the life of people (Bud, 2017). Therefore, our theoretical messages needed to be encapsulated into a unifying theme that would matter to audiences. A few potential candidates were identified: emoji,

pictographic writing systems, infographics and public information signage, public health campaigns, holy cards, propaganda visual materials, aeroplane emergency cards.

In selecting a theme, familiarity to the audience is not the only variable to consider. A theme needs to be relevant to people, that is it has to provide them with new information which adds meaning to their lives, it has to make a difference for them (Simon, 2016). Finally, we also assessed how well the candidate themes were able to exemplify our theoretical messages and which ones allowed to embed theoretical notions more accurately in the exhibition narrative.

We eventually selected emoji as a theme because it seemed to have the potential to meet all three criteria:

- **Familiarity**: Emoji is ubiquitous in our everyday digital communications; they are used by 95% of internet users and more than 10 billion emojis are sent every day (Brandwatch, 2018).
- **Relevance**: Emoji has the potential to be transformative for audiences; a show on emojis can give new insights and open new angles on a pervasive phenomenon of contemporary life by telling little-known stories on emoji ancestors, backstage of emoji development process, and emoji as a place of social activism and political campaigns.
- **Accuracy**: emoji allows to embed our theoretical content rather accurately in the exhibition narrative. For example, different emoji versions across brands give the opportunity to illustrate the idea of the conventionality of pictorial representations and their cultural variation. Emojis also vary over time: born as a graphical communication system for a Japanese audience, they were originally simpler stylised pictures; later on, as they spread globally, emoji designers had to deal with the problem of how to make them as transparent as possible for an increasingly large and diverse audience of users, and therefore opted for more figurative graphical solutions. Moreover, emoji has a strong link to the Japanese kanji characters, which are in turn based on Chinese writing; this offers the opportunity to display the process of abstraction in the evolution of Chinese pictograms. Finally, a comparison can be drawn between emoji and other attempts of graphical systems with a global aspiration; cases such as Neurath's Isotype, ISO symbols or Blissymbolics all engaged with the problem of universality and its consequences on abstraction/figurativeness of representation.

The selected theme was then researched broadly to have a general knowledge about the topic, as well as collect interesting stories, key characters, and potential objects. In particular, we investigated the following areas and produced a structured research piece:

- The origin of emoji: who invented them and why, their cultural ancestors and sources of inspiration
- Emoji change over time in form and meaning
- The design process of emoji and brand differences
- Emoji use in everyday conversations
- Emoji use in public campaigns
- Linguistic and socio-linguistic perspectives on emoji
- Societal impact of emoji and related issues of diversity and inclusion
- Previous attempts at universal graphical languages

We also identified some authoritative sources of quantitative and qualitative data on emoji (Emojipedia.org, Unicode.org, Emojination.org, Brandwatch.com) as well as key books such as Danesi (2016), Evans (2017) and Griffiths (2019).

4.2.3 Benchmarking similar exhibitions

In order to understand what stories on emoji have already been told in public displays and how, we searched for and analysed previous exhibitions on the same or similar themes. We mainly focussed on the prominent narratives, the kind of objects displayed, the interpretation strategies used, the audiences targeted.

We analysed three exhibitions:

- *The first emojis by Shigetaka Kurita* (MoMa, New York, 2016): This was a large digital installation projecting the very first set of emojis. It focussed exclusively on the figure of the first emoji designer, Shigetaka Kurita, and the immediate technological context in which emojis were created; it also highlighted the role of emojis as emotional cues in digital communication (MoMa, 2016)
- *The story of emoji* (KK Outlet, London, 2016): A small exhibition for promoting the launch of a book on the same name (Lucas & Fl@33, 2016). It concisely showed some key moments in the story of emojis and highlighted their relationship with emoticons and typography-based icons. Differently

from MoMa, it displayed present-day emojis and presented them in large-scale prints. It also invited contemporary artists to design new provocative emojis for the event.

- *Writing. Making your mark* (British Library, London, 2019): a large and rich exhibition on the origin and evolution on writing, focussing mainly on calligraphy and typefaces (British Library, 2019). A final section titled "The Future of Writing" was dedicated to emoji, however this only displayed two elements: a vox-pop video of approximately 5 minutes where a series of people from different backgrounds and age ranges express their opinions on whether or not emoji will replace writing at some point in the future; and an interactive multiple choice survey asking "How will we send birthday greetings in 50 years?" (card, email, text) and providing live results. The section felt rather disconnected from the previous historical ones; it was poorer in content and articulation and it treated emoji rather superficially, especially compared to the detail and attention given to materials in the other sections.

We concluded that there was room for an extensive exhibition on emoji that would cover the whole timespan from origins to present day and treat emojis as cultural objects worthy of substantial depth of analysis by telling stories previously unexplored or superficially presented, such as: why exactly emojis were designed and their relation to Japanese culture, the cultural sources that inspired them, how they became a global phenomenon, the process of emoji development and approval and its gatekeepers, the politics behind emoji. We envisaged a show that would locate emoji in a broader cultural context and bring up its relationship with deeply human needs and aspirations (e.g. communicating with pictures, emotional cues in conversations, utopia of universality).

4.2.4 Outline potential venues

The aim of the venue outline was to have a better understanding of the expectations of the venues or types of venues that might be potentially interested in our blueprint pack, and consequently figure out how to approach our concept in a way that it would be more likely to be appealing for them.

We selected three potential venues. The first is the House of Illustration (London), the UK's only public gallery dedicated solely to illustration and graphic art. Founded by Sir Quentin Blake, it opened in July 2014 in King's Cross area. They

explore historic and contemporary illustration, and the work of both defining and emerging illustrators from all over the world (House of Illustration, 2019). This is a natural venue for an exhibition on emoji as a graphic design object.

The second venue is the Design Museum (London), the world's leading museum of contemporary design and architecture. It is the only institution in the UK that brings together the design industry, design education and the public. It is an international showcase for British designers, and a creative centre which promotes innovation and supports emerging design talents (Design Museum, 2019). This venue was selected because they host a collection of graphic design; they also have an inbuilt evolutionary approach to design that particularly suits our theoretical approach to the topic of emoji.

The third venue is Palace Green Library (Durham), founded in 1833 and occupying Durham World Heritage site buildings. Palace Green served as the University's main library for 150 years before specialising in archival and special collections in the 1980s. Today, visitors and researchers can explore both the University's treasures and collections from around the world (Palace Green Library, 2019). This venue was chosen because it has a clear connection to Durham University and it is often the venue for exhibitions and small displays based on research conducted at Durham.

For each of them, we created a profile focussing especially on mission and institutional purpose, decision-making process, programming remit/criteria, scale and purpose of spaces, style of exhibitions, and including any other element that would help us develop a suitable proposal. Information was collected through desk analysis, mainly by searching the institutions' websites, and conducting interviews with curators or heads of exhibitions (see Interview template, §A.1.1). Their profiles helped us identify what aspects of emoji would be more interesting for them and consequently how we could best approach shaping our concept (see Table 1).

Table 1 Left: Key features of mission, purpose and programming criteria of potential venues. Right: why and how emoji might be appealing for them as an exhibition theme.

Institution's profile	Why emojis are interesting for them
House of Illustration	
They look for examples of illustration as a vital art form	Emoji is vital for contemporary digital communication

They seek diversity of illustration fields	Emoji would be their first digital graphics display
They want to show underrepresented areas of illustration and communities of authors	- Emoji is arguably an underrepresented topic in museums and galleries. - Behind emoji design and approval process there are stories of conflict between undiverse decision-makers and underrepresented communities of authors and users
They prefer concepts with a sociological implication	Emoji has a strong socio-political aspect about issues of diversity and inclusion
Design Museum	
They aim to make the impact of design visible	- Emoji is considered by some the world "lingua franca" - Emojis contribute to shape/express our representation of self and others
They aim to connect design to people's lives	- Without emoji, digital communication would be full of misunderstandings - Emoji is a battlefield for fighting social causes related to personal and community identity
They aim to show the designer's role at the forefront of social, technological and environmental change	Emoji designers have a) revolutionised our communications and b) become activists in supporting social causes
They invite designers to "think in public"	Emoji design lends itself to a participatory bottom-up approach where designers and the audience get together
Palace Green Library	
Palace Green is in a transitional phase and the organisational strategy is under construction. Their main objective remains to support Durham research in producing impact.	The concept is based on research conducted at Durham university.

4.2.5 Identify your audiences

Once venues were profiled, we moved on to study their audiences in order to outline potential segments for the exhibition. In our case, venues were unable to share their official audience profiles (reports were unavailable or confidential). Therefore, we used a solid UK segmentation tool for cultural audiences, Culture Segments (Morris Hargreaves McIntyre, 2013a), in order to reconstruct the most likely profiles of the venues' audiences. Culture Segments was developed by the consultancy Morris Hargreaves McIntyre in collaboration with the British Museum, it has been applied internationally, and it has proven to be a powerful tool for developing successful exhibitions (e.g. see Morris Hargreaves McIntyre, 2013b).

Culture Segments is an audience segmentation system specific for culture and heritage organisations. Based on data from Audience Atlas, the most detailed existing survey of cultural audiences in the UK, Culture Segments provides the profiles of different types of people (i.e. audience segments) visiting British culture and heritage organisations. This system clusters the British cultural audience into eight segments, labelled as Expression, Essence, Stimulation, Affirmation, Entertainment, Perspective, Enrichment, and Release; a short description of all the segments is provided in A.3.1.

Compared to other segmentation systems, usually based on people's demographics, habits and attitudes, Culture Segments' distinctive feature is that it does not simply describe what audience segments do but especially why they do it; in other words, segments are defined by what people seek to get out of a cultural experience, what drives them, and how they want to be made to feel. Culture Segments is based on people's cultural values, beliefs and motivations, providing organisations with insights on the deepest audience needs their cultural offer should satisfy.

By comparing the information collected on each venue's overall offer (§4.2.4) with the profiles of the British cultural audiences identified in Culture Segments, we identified the most likely audience segments visiting each of our potential venues as follows:

House of Illustration:	Expression | Essence | Stimulation
Design Museum:	Expression | Essence | Affirmation | Entertainment
Palace Green:	Expression | Essence | Perspective | Enrichment

From this list of segments, we selected Expression and Essence as the most suitable potential targets for the exhibition. They are highly engaged segments, with high levels of spending and consumption for arts, culture and heritage. They are shared by all three potential venues and they are the most in-tune with the exhibition theme of emoji: they have an interest in contemporary culture and the digital, in discovering the unknown side of things, and they are risk-takers (Morris Hargreaves McIntyre, 2013a).

The remaining segments we identified for the three venues did not provide a good match with our theme. Enrichment and Perspective were excluded because of their preferences for more traditional cultural forms, history and heritage, and their orientation towards the past rather than the contemporary. For the Entertainment segment, culture and the arts are peripheral interests in their lives; their occasional participation in cultural events is usually for spectacular, entertaining or must-see events. Finally, Affirmation has a preference for large, mainstream events and activities as these are safe, low-risk investments of their time. These remaining segments were therefore not considered as a target for the exhibition.

The profiles of our selected targets, Expression and Essence, helped us identify useful principles and guidelines for shaping the exhibition offer.

4.2.5.1 Expression

4.2.5.1.1 Key traits

- Community: Expression has a strong sense of community. They enjoy feeling part of a group, connecting with others and sharing experiences. They want to feel part of something bigger. They like to be part of events and organisations, bring other people along and getting involved as supporters. They dislike exclusivity and don't disdain popular culture.
- Expressive: They are creative and active participants and wish to express themselves. For them, arts and culture are an occasion for self-expression and connection with like-minded individuals.
- Receptive and confident: They are open and receptive to new ideas and they pursue challenge, debate and intellectual stimulation.

4.2.5.1.2 Guidelines for the exhibition offer

To attract this segment, it will be crucial to show the relevance of the theme to their life philosophy: the key message for them will be that Emoji is not just cute

decorations for your texts, but an object with social impact, a place of social conflict where activists fight for the inclusion of underrepresented communities against new digital forms of cultural imperialism. This apparently unimportant little thing can be a way to build a better world together.

The exhibition should then highlight narratives about community themes and collective causes; for example, it might show interviews with members of Emojination, the prominent organisation supporting bottom-up campaigns for representation of underrepresented communities in the Emoji "vocabulary" (Emojination, 2019); or it might display materials from the numerous emoji campaigns run in the last few years.

The exhibition should also provide this segment with occasions to express their creativity together with others, especially if in support of a communal cause; for example, a digital interactive might provide an experience of emoji design, or the exhibition programme might include a workshop with a professional emoji designer helping participants create a new participative emoji supporting a social cause; the proposal might be submitted to Unicode with the assistance of Emojination.

Finally, Expression should be made feel they have been given voice, so talks with Q&A with Emojination founder Jennifer 8 Lee or with designers of "political" emoji such as Paul Hunt (author of the gender-neutral emoji) might be appealing for this segment as occasions to share their views.

4.2.5.2 Essence

4.2.5.2.1 Key traits

- Discerning and critical: for the Essence segment, culture is a fundamental element of their life and identity, it is who they are and what they do. They are likely to be cultural leaders, well-educated professionals who are highly active cultural consumers.
- Sophisticated: They are confident in their own tastes, inner-directed and self-sufficient, actively avoiding the mainstream. They pursue high quality productions.
- Challenge: culture is an essential source of self-fulfillment and challenge for them, and a means for experiencing life.

4.2.5.2.2 Guidelines for the exhibition offer

Essence might already be aware of emojis as objects of design (e.g. from the MoMA exhibition and the coverage it received on specialised media), and some might already be aware of the political implications of emoji. The key move to involve Essence will be to make them feel they can explore a previously uncharted territory, to reveal what is still unknown, a new deeper meaning, e.g. emojis' place in the cultural evolution of visual communication systems, or emojis as the latest product of the everlasting human challenge for creating universal languages.

Emojis should be presented as sophisticated cultural objects through high-quality content. The display should include rarely seen or unusual materials such as previous attempts at universal graphical languages (e.g. Blissymbols, ISO public signage…), unreleased early versions of emojis, or emojis rejected by Unicode. High-profile international experts might be involved in the programme of activities, such as linguist Vyvyan Evans, journalist Ed Griffith, or cognitive scientist Nicolas Fay; they might be speakers of Q&A talks or give specialised guided tours for a limited number of private views.

4.3 The development phase: concepts, narratives, objects

At this point, we had collected the most important research and analytical materials we needed in order to start developing our concept. We had a clear idea of the core theoretical notions we wished the audience to engage with (§4.2.1), substantial knowledge of the theme including a variety of stories, characters and objects (§4.2.2), an understanding of the purposes and requirements of the institutions that might potentially host the show (§4.2.4), and a sense of what might be appealing for our target audience (§4.2.5).

Now we combined all these parameters together in order to pin down the main ideas of the exhibition, organise them into a cohesive overall narrative and embed them in materials that could translate theoretical notions from "academese" into a language lay audiences can understand and appreciate (McKenna-Cress & Kamien, 2013). At this stage, we focussed only on the materials included in the exhibition (i.e. what goes in the galleries).

4.3.1 Storifying research content: structure and narratives

Out of all possible theme-related contents collected in our research piece (§4.2.2), we firstly selected the phenomena (objects, characters, stories, events etc.)

that could better exemplify our theoretical notions and had the potential to appeal to our target audiences. We laid these elements out in space, considering their relationship to one another, their relative importance to the whole, and how their individual parts added up to create a narrative. This can be done using a mood board, where contents can be gradually shuffled around to group or ungroup things as we identify recurring topics and shared storylines. This is the start of a conceptual floor plan (McKenna-Cress & Kamien, 2013).

The elements on the board then need to be organised in sections based on a compelling organising principle (Higgins, 2016); these sections are the "seeds" of the final exhibition sections. There are a number of strategies to do that. Information architects suggest some primal schemes we are all familiar with, such as chronological and numerical order, alphabetical systems, locations and directions, categories, opposites, or easy-to-understand thematic schemes like "the five senses" (Shedroff, 1999; Wurman, 1997). For the most part, these classification arrangements will be immediately transparent to visitors. On the other hand, other more original systems are possible that may trigger curiosity and reduce the risk of boredom, but they will also be more intellectually challenging.

Which strategy to choose mainly depends on the nature of the material the exhibition deals with; for example, a socio-historical theme may suit a historic time line which will produce a sequential plan. Considering the potential complexity of the exhibition's key messages, we went for a chronological-thematic organisation of materials that would not require too much effort of interpretation and would therefore allow visitors to spend their time and energy engaging themselves in other aspects. As shown below, our sections stand for different stages in the history of emoji, in chronological order, with each stage developing around a core topic: 1) how and why emoji were created, 2) how they became a global phenomenon, 3) the impact of emoji on contemporary society.

Around the phenomena arranged in our preferred scheme, we then built a narrative. The story form is ideal for shaping exhibition contents (Allen, 2004). Stories are the most fundamental way humans learn and make sense of the world (Bruner, 2009), they generate personal connections between visitors and content and can teach without preaching (Bedford, 2001). For its power to trigger both emotional and cognitive change in visitors, the story form has become the predominant tool for exhibition design.

For our narrative, we looked for a "story arc" with a beginning, middle and end, where a problem is presented for which characters seek a solution, obstacles frustrate them but they eventually reach a harmonic conclusion, happy or sad or simply in balance (Goodman, 2015). In our overarching narrative, we tell the story of how emoji designers undertook the challenge of capturing big ideas (e.g. emotions, human activities, abstract concepts…) in extremely small graphics, first in a Japanese context and then for a universal audience, and how emoji eventually became a place for social activism where big ideas are fought for.

Such a narrative is brought to life and made relevant to visitors by smaller stories embedded in the main one. They can illuminate multiple sides of the problem, point to possible directions for solving it or often place more obstacles in the way, and finally show the conclusion. Ideally, these stories should be human and personal in some way, even in the case of a science exhibition (McKenna-Cress & Kamien, 2013). The resulting Chinese boxes narrative structure encapsulates our theoretical content and makes it accessible for a non-specialist audience.

We drafted three key messages composing the overarching story of emoji and we articulated the key messages in sub-stories. During this process, it is useful to always keep in mind what theoretical contents we are conveying with these stories. The output of this step is the exhibition structure:

Section 1 – Origins of emoji (why and how they were born, who created them, what their ancestors were)

Key message:

Emoji solved a communication design problem: how to encode complex ideas and emotions in the small space of a digital graphics for a Japanese audience.

Key stories:

- At the dawn of mobile communication, Japanese tech brand DoCoMo wanted users to be able to express complex ideas and emotions in the small space of a text message.
- Shigetaka Kurita, the first emoji designer, created a set of graphical signs inspired by Japanese cultural influences, such as the Tokyo '64 Olympics graphics, manga's graphical morphemes manpu, Japanese emoticons Kaomoji, and Japanese kanji characters.

- That was not just a present-day challenge. The legendary hero Cangjie solved a similar problem: he invented the Chinese (later to become also Japanese) writing system creating pictograms that captured the essence of all things and encoded a whole idea in a single character.

Underlying theoretical notions: creating a graphical system for a local audience

- Graphical codes are based on generalisation and abstraction
- Graphical codes need to balance conciseness and expressivity: they need to be simple and compressed but also clear and understandable; how much shared background there is among audience members plays a crucial role in that balance.
- In closed contexts, graphical systems evolve from figurative to abstract; divergent systems evolve in different cultures, which are mutually hard to understand.

Section 2 – Emoji for the global world (the shift from Japan to a global audience, and how emoji changed to fulfil a universal aspiration to become the world language)

Key message: To overcome the babel of different emoji systems born after Kurita's, digital character consortium Unicode created a global standard for emoji with the aspiration to transform it into a universal language

Key stories:

- After Kurita's, many carriers designed their own emoji set. The babel of different emoji systems made communication across carriers highly problematic, especially if extended to a global audience. Unicode's standard codes and meanings for emoji tried to solve this problem.
- Other people in the past tried to solve a similar problem of communicating across linguistic barriers by creating a standard graphical code for the world, with different outcomes: the cases of Isotype, Blissymbols and ISO
- The universal aspiration of Unicode standards might stay a utopia, because emojis have a life of their own: emojis can still vary in design across brands, and in meaning across people and cultures

Underlying theoretical notions: creating a "universal" graphical system

- Different groups develop different local graphical systems

- Local systems are inadequate for inter-group/global communication and need to adopt transparent signs based on standards aiming to prevent local change
- A universal language is a utopia because language change cannot be completely stopped: local groups will still continue to create local conventions

Section 3 – Emoji and society (how Emoji has become a place of representation, where activists fight for their social campaigns)

Key message:

Under-represented communities petition against biased and undiverse Emoji to see themselves acknowledged. Emoji becomes a place for reclaiming diversity and inclusiveness and fighting stereotypes and taboo.

Key stories:

- Emoji used to depict a white male heterosexual world, for historical reasons and for biases in designers and the Unicode board
- People and communities who did not feel represented campaigned for their causes, also supported by public organisations
- Many campaigns succeeded, and emojis multiplied exponentially. But others are still being fought and Emoji has now become a place of social activism.

Underlying theoretical notions: the expressivity boom

- Systems of representations cannot map the world 1:1, they are based on a selection of what is represented and how
- Graphical codes result from the interplay between expressivity/semantic richness and simplicity of use; when the former prevails, codes becomes less agile.

4.3.2 Storytelling through objects and exhibits

Such stories can be communicated to the visitor through a variety of interpretation devices. The traditional ones are collection items, oral histories, photographs, scientific data, and archival materials, but they can also centre on more artistic approaches (e.g. artworks, performances, installations, creative-imaginative exhibits). They can also be supported by interactives, digital or analogue, that explain ideas hands-on and by stimulating multiple sensory channels

(for more examples of kinds of objects and exhibits that can be used in different types of exhibitions, see Lord, 2014).

Initial input for interesting objects and exhibits comes from the research phase, but more ideas will come across as key messages and stories are refined. The output of this step is a content package, which can be presented as a series of slides; each slide contains an object/exhibit with brief notes about what story(ies) that item is telling; for the core objects, the slides can include how each of them is relevant to the theoretical framework. Later on, considerations on how the visitor might engage with the item and get the story we want to convey can also be added (see slide template, §A.3.5).

It is important to note that the two steps of identifying stories and collecting objects for the content package did not happen in a strictly linear sequence. Rather, it is an iterative process. The stories we wanted to tell guided us in searching for objects and, in turn, objects we found would open new interesting storylines.

Here we present a selection of the key items we chose for illustrating the stories of Section 1 – Origins of Emoji and a scheme showing their ideal spatial arrangement (Figure 24). For the complete content package, see §A.1.1.

<u>Part 1 – The problem</u>

Main story: The challenge of creating clearly understandable and emotion-carrying graphical signs in the very limited space of a character.

Theoretical angle: Graphical codes need to balance expressivity and simplicity.

1990s DoCoMo pager advert

キャラ メーラー (literally "Character mailer"), pagers were all the rage in 1990s Japan and DoCoMo was a major producer

	*Newspaper article*: "Japan Teens Flip for Private Pagers", T. Lippit, *International Herald Tribune*, April–1995 The pager craze in Japan.
	*1995 DoCoMo Pocket Bell with heart icon* DoCoMo Pocket bell was the most popular pager among teenagers because it was the only one with the heart symbol, which injected sentiment (and cuteness) into texts. DoCoMo wanted more emotion icons for their new models.
	*First DoCoMo i-mode mobile phone* DoCoMo also provided i-mode, an information service on travel, entertainment, weather forecasts, news. Texts and emails had a character limit, so DoCoMo wanted single-character icons to replace whole words and save space. Emoji were originally designed for this.

	*Double video-interview*: Kurita and graphical language evolution expert (e.g. Kenny Smith, Simon Kirby, Monica Tamariz, Nicolas Fay…) Kurita explains the challenge of designing clear and emotional emojis in a 12x12 pixel grid, and how he solved it. In parallel, the language evolution expert explains how codes need to find the sweet spot between being expressive and keeping it simple.

Part 2 - Sources of inspiration

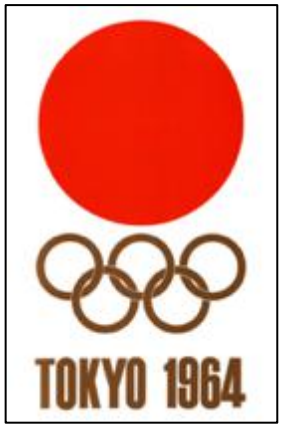
Main story: Previous Japanese "designers" solved the same problem of representing complex ideas in little space; they were sources of inspiration for Kurita

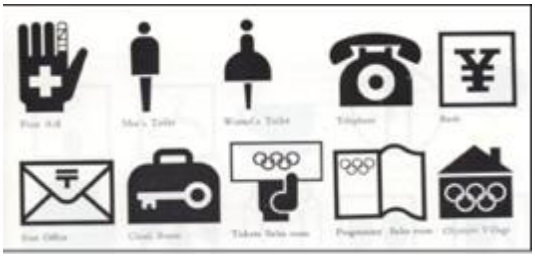
Theoretical angle:

- Graphical codes need to balance expressivity and simplicity
- Iconic origin of writing systems and their evolution towards abstract symbols
- Figurative style of signs for multi-cultural audiences

A. Kaomoji	
(ﾉ*ｪ*)ﾉ (♡-_-♡) (−_−)♡ (*ω*♡) (ღ˘⌣˘ღ) (*•ω•*)♡ └(•‿•)┘♡	*Selection of kaomoji* 'Kaomoji' (kao = face + moji = character) was a popular Japanese emoticon style made up of Japanese characters and punctuations; they were used to express emotion,

	complex actions, objects, and even whole stories in texts messages
	*Kaomoji masks* Kaomoji are part of Japanese everyday life
	*Kaomoji sweets* Kaomoji are part of Japanese everyday life
	*Kaomoji emoji* Kaomoji inspired some of Kurita's emoji
B. Manga manpu	
	*Selection of manga manpu* Manpu are manga's graphical shorthand to draw "big ideas" (emotions and states of mind) in the little space of a comic frame.

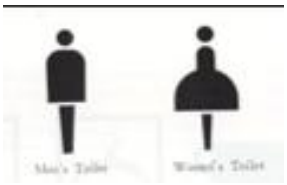
	*Manpu in Japanese advert* Manpu are a popular and versatile Japanese code which spreads from manga to other forms of visual culture to convey complex ideas (e.g. pain) simply but clearly.
	*Emoji with manpu* Kurita's emojis for emotions and states of mind were significantly inspired by manga visual conventions; they can be difficult to understand for a non-Japanese audience
C. Tokyo '64 Olympics graphics	
	*Poster of Tokyo '64 Olympic games* 1964 Tokyo Olympics accommodated an onslaught of foreign visitors and international sports teams



Tokyo Olympics pictograms for sports and public signage

Foreigners would not understand signage written in Japanese, so the committee had graphic designers represent useful concepts and information in simple and accessible icons.

Japan was the first host country in the modern Olympic era to use a non-alphabetic script.



Tokyo Olympics toilet signage

The international toilet icon was designed in Japan for the 1964 Olympics

Photograph of Tokyo Olympics showing toilet signage

The Tokyo games of 1964 pioneered the use of symbols rather than text to help foreign visitors find their way.

Emoji inspired by Tokyo Olympics graphics

'64 Tokyo Olympics graphics inspired Kurita's work

D. Kanji

Main story:

Cangjie was trying to solve a similar problem as Kurita's at a different time and place, and found a similar solution

Theoretical angle:

First emoji set and first Chinese pictograms are both simple pictograms capturing a variety of ideas in little space; designed for a specific cultural context, they retain both iconic and symbolic traits, and can be hard for non-Japanese

Creation of kanji

Portrait of Cangjie

Cangjie is the legendary hero creator of Chinese writing; he solved a similar problem as Kurita

	*Video animation: the legend of Cangjie* According to the legend, the emperor asked Cangjie to invent characters for writing to replace the existing knot-based information coding system. Inspired by an animal footprint, which a hunter can easily recognise by difference with any other, he created Chinese pictograms by drawing the essential features of all things.
	*The first kanjis (diagram from Garrod et al., 2007* A kanji represents a whole idea in the small space of a single character. Originally, many kanji were iconic, i.e. they resembled their objects.
	*Ox bone with ancient kanji characters* Many kanji were originally iconic, they "captured the essence of things"

Evolution of kanji

Evolution of kanji diagram (diagram from Garrod et al., 2007)

Over the centuries and with repeated usage, kanji became more and more abstract, until they reached the present form.

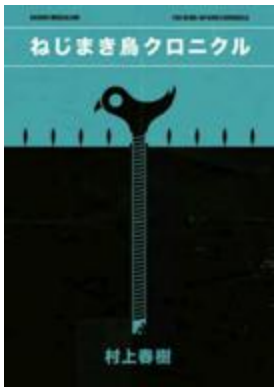
Book: Maspero, G. (1846-1916), *Recueil de travaux relatifs à la philologie et à l'archéologie égyptiennes et assyriennes;*

Not only kanji, but most writing systems evolved from pictograms to abstract symbols; they evolved in different ways in different cultural contexts.

Kanji to Japan

Copy of Kojiki

Japan imported kanji. The first Japanese text was the Kojiki, on the myths of creation of Japanese islands.

	*Present-day Japanese kanji board* Kanji are part of Kurita's cultural background. From kanji, he took the ability to express complex ideas like "secret" and "love" in a single character.
	*Book*: Murakami, H. *The Wind-Up Bird Chronicle* Kanji are part of Kurita's cultural background.
	*Digital interactive: "How symbols evolve"* A double player Pictionary-style drawing game. Two visitors play at the same time with two interconnected tablets on either sides of a wall divider: they are given three confusable concepts and they have to depict those concepts so that their partner can identify them quickly as possible. Each pair will have a time limit. Pairs gain points for correct guesses and receive penalties for wrong guesses. This is a simplified version of the experimental task in Fay, Garrod, Roberts, & Swoboda (2010).

	All pairs' scores and final-round drawings (arranged by concept) are publicly displayed on a screen. This will illustrate two fundamental aspects of the evolution of graphical symbols: the change over time from figurative to abstract representations and the cross-cultural variation of graphical conventions. Upon participants' consent, data from this interactive display will be used for research purposes. At the end of the game and/or next to the interactive display, visitors will be asked "Can you create universal symbols? Sign up for *Icons for the world*!". They will be able to sign up for a session of an educational activity which simulates the evolution of graphical symbols in contexts of cultural contact as well as the designers' procedure of cross-cultural testing of icons aimed at a global audience (for more on the activity, see A.3.2.1, slide 37).

<u>Part 3 - The outcome</u>

Main story: Kurita's solution to the communication design problem

Theoretical angle:

- Each symbol has a long history of semantic and graphical change
- Design tools influence the shape of graphical representations
- Balancing out expressivity and simplicity

A. Kurita's sketches

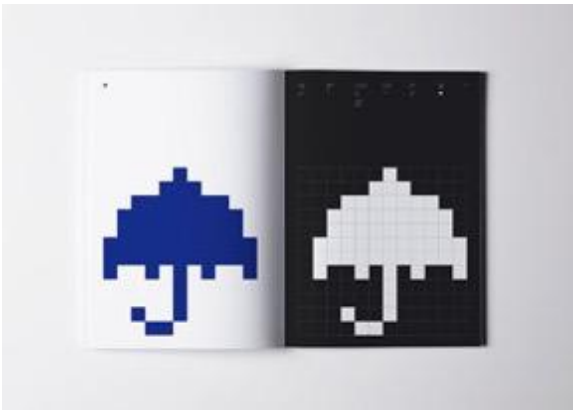
Original sketches for the first emoji set

Kurita had a list of words/ideas and sketched an emoji for each of those.

"I was working with the sense of creating a new alphabet. It was an attempt to create texts rather than a sense of making pictures." (S. Kurita)

Kurita quotation

Kurita always envisioned emoji as symbols — something close to letters, that wouldn't feel out of place if you slipped them into a sentence.

B. Pixel drafts	
 	*Pixel drafts* Kurita had to transfer his paper sketches onto a 12x12 pixel grid. He had little space and curves were tricky to draw. He also had to make sure the minute emoji would be recognisable from a distance. [Right hand page: the grid and how the icon was drawn; left hand page: emoji in full colour; up in the top left it is depicted at one-to-one scale, showing how the designer had to consider its small viewing proportions]
"An underlying grid is such a graphic design trick. Most of these identity guidelines coming out today are made up after the fact, they're not necessary, but here it was truly the framework for developing the illustrations. It was the architecture, and it's a quintessential exercise in reductive design" (J. Reed)	*Reed quotation* The grid determined the stylised structure of the first emoji
"[A 12x12 grid] means you can't centre an object, and curves (see the umbrella symbol) are a tricky exercise. The technical limitations meant they had to be so simple" (H. Smyth)	*Smyth quotation* Emoji had to be simple to fit the grid

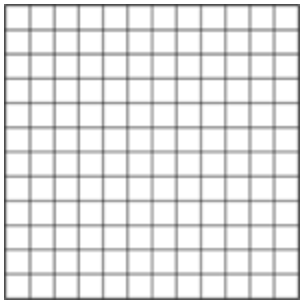
C. Explore the first set

Maxi touch screen with the complete first set

This is the outcome of Kurita's work. Each emoji has a story behind.

Visitors are invited to select, enlarge and see more information for each emoji. The info includes a) their meaning, b) previous famous representations of the same thing in the history of cultures.

D. Create



Digital interactive exhibit: "Draw a pixel emoji"

A 12x12 pixel touch-screen offers the experience of designing a pixel emoji in the same tech conditions of Kurita. Visitors are asked to draw a thing/idea using the grid. The drawing goes on Instagram for people to guess what it is.

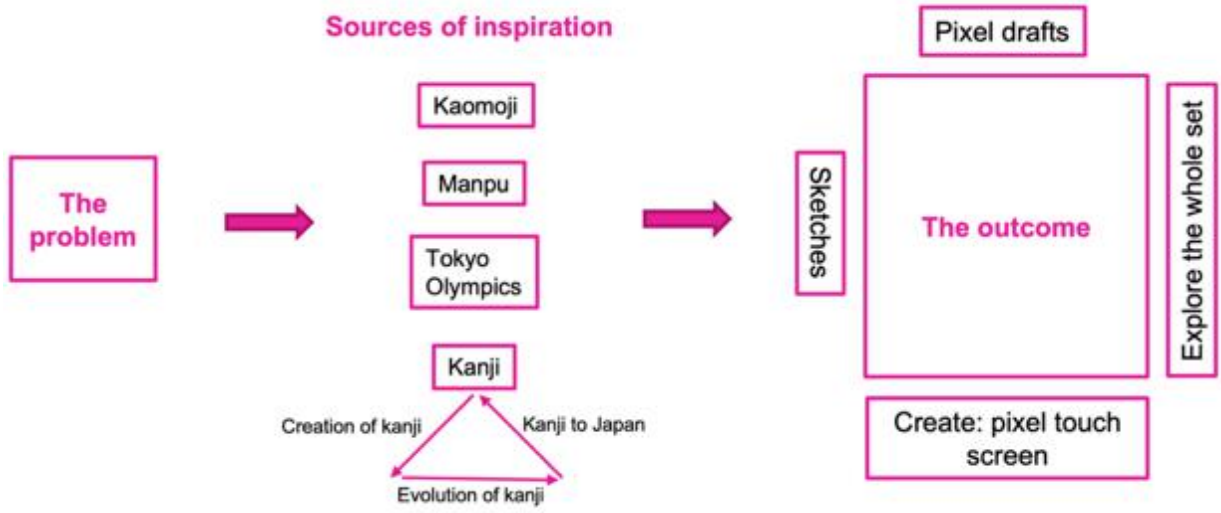
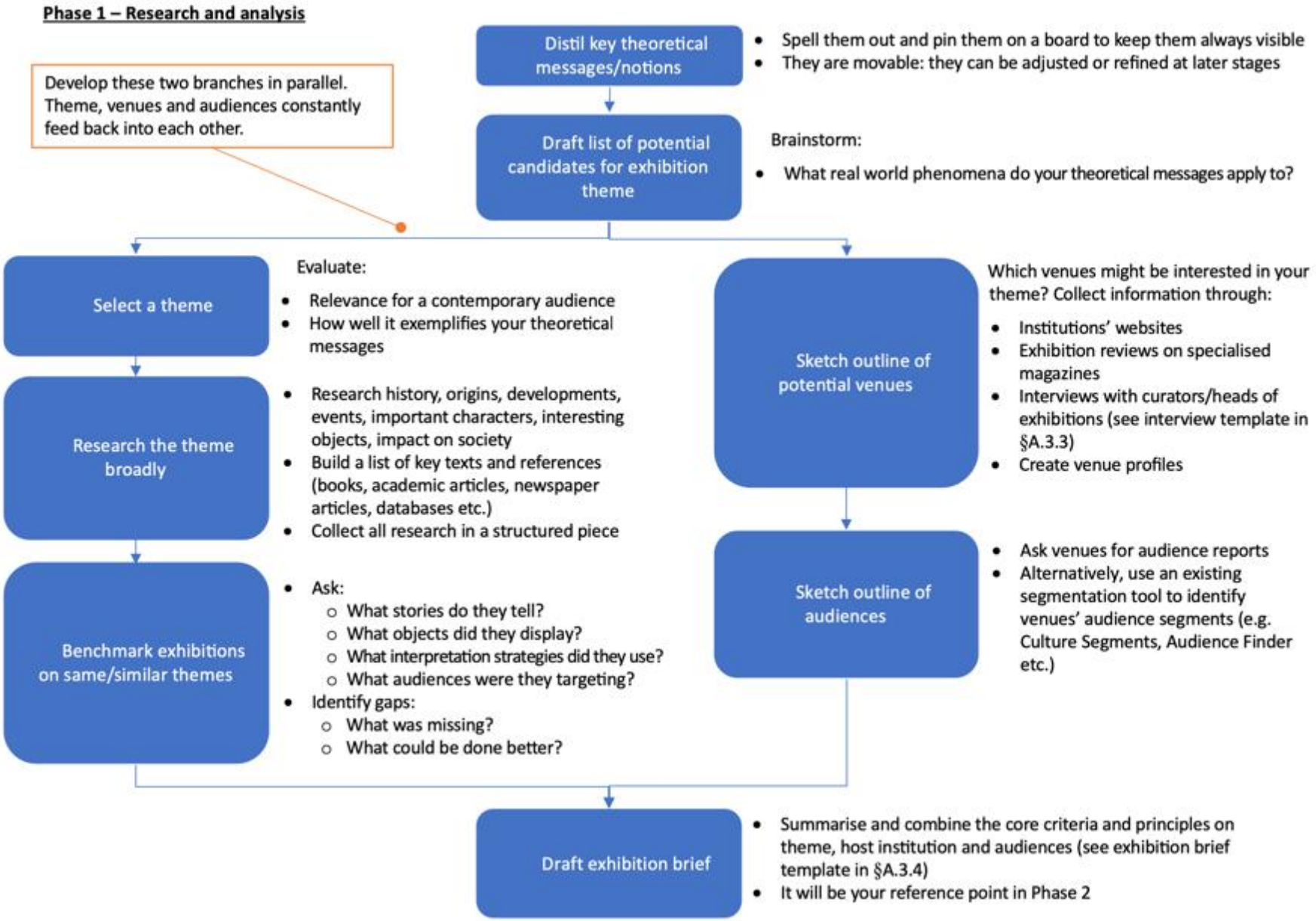


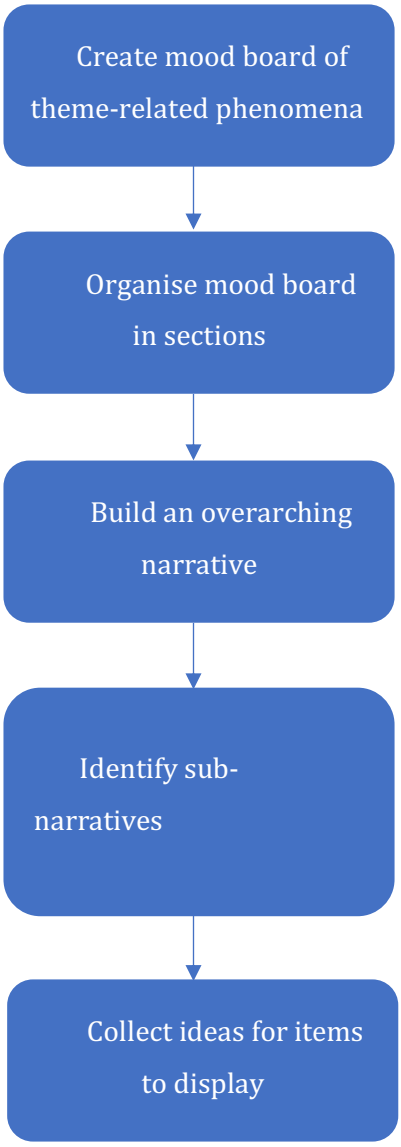
Figure 24 Spatial arrangement of Section 1 "Origins of Emoji"

4.4 Toolkit and tips for developing an exhibition blueprint

To help researchers at their first attempt with exhibition design, here we provide a flow-chart of the essential steps and tips to carry out the research/analysis phase and the content development phase. Some tips will also refer to templates (provided in appendixes A.1.1, A.3.4, A.3.5) that will provide more detailed guidance for some specific tasks. Finally, we discuss some of the main challenges in the process of which to be aware.


Phase 1 – Research and analysis
Develop these two branches in parallel. Theme, venues and audiences constantly feed back into each other.
Distil key theoretical messages/notions
Spell them out and pin them on a board to keep them always visible
They are movable: they can be adjusted or refined at later stages
Draft list of potential candidates for exhibition theme
Brainstorm:
What real world phenomena do your theoretical messages apply to?
Select a theme
Evaluate:
Relevance for a contemporary audience
How well it exemplifies your theoretical messages
Research the theme broadly
Research history, origins, developments, events, important characters, interesting objects, impact on society
Build a list of key texts and references (books, academic articles, newspaper articles, databases etc.)
Collect all research in a structured piece
Benchmark exhibitions on same/similar themes
Ask:
What stories do they tell?
What objects did they display?
What interpretation strategies did they use?
What audiences were they targeting?
Identify gaps:
What was missing?
What could be done better?
Sketch outline of potential venues
Which venues might be interested in your theme? Collect information through:
Institutions' websites
Exhibition reviews on specialised magazines
Interviews with curators/heads of exhibitions (see interview template in §A.3.3)
Create venue profiles
Sketch outline of audiences
Ask venues for audience reports
Alternatively, use an existing segmentation tool to identify venues' audience segments (e.g. Culture Segments, Audience Finder etc.)
Draft exhibition brief
Summarise and combine the core criteria and principles on theme, host institution and audiences (see exhibition brief template in §A.3.4)
It will be your reference point in Phase 2

Phase 2 – Concept development



- Select objects, characters, events, stories from the research piece
- Group together phenomena that might be experienced together
- Spell it out and pin it on a board to keep it visible throughout the process

The output is a structure like this:

Section 1

- Key story
  - Smaller stories
  - Theoretical significance: what theoretical

- Use slides to help you (see slide template in §A.3.5)
- Ideas for items to display might open other stories not previously considered: you can go back and adjust those

4.4.2 Main challenges

4.4.2.1 Dumbing it down?

To the academic expert dealing with exhibition design, the simplification of a complex idea may sometimes feel like leading visitors to unfounded conclusions or forcing research topics into insufficiently accurate representations (McKenna-Cress & Kamien, 2013). However, an exhibition as a learning context is very different from a lecture; most potential visitors will not have the expertise to get the details and technicalities of a research topic, nor will they be interested in them but in their implications to their everyday lives and their significance in the contemporary world.

Still, visitors can profit from exposure to well-thought-out material if it is made relevant and engaging, and presented in an accessible way. They might not be able to explicitly grasp the whole set of theories, findings and debates underpinning the exhibition concept, but they will start reflecting on topics, problems and solutions, potential causes and possible effects. The goal of the academic expert in this context should not be to teach specific technical notions and analyse arguments, but to open spaces for reflections and invite people to carry their own enquiries (Allen, 2004).

4.4.2.2 Not a linear argument

For those who are accustomed to thinking, writing and teaching in terms of key arguments and supporting reasons, it might be difficult to abandon linear reasoning when articulating the key messages of an exhibition into exhibits and objects. It might be tempting for them to think of an exhibition as a book and of a content package as a presentation, projecting the schemes of a formal learning setting where a teacher can regulate students' progress guiding them from an introduction to a conclusion (McKenna-Cress & Kamien, 2013).

However, visitors do not engage with exhibitions linearly but in rather unpredictable ways. They may read intended conclusions before introductions or explore a sequence of exhibits in unexpected orders. If an exhibit has a boring or complex or confusing component, visitors have no way of assessing whether or not the reward of engaging with it will be worth the effort, so they are very likely to simply skip the exhibit altogether and move to more attractive sections. In the exhibition environment, visitors can follow their interests and impulses and it is extremely difficult to get them to follow a narrowly constrained agenda involving sequential steps (Allen, 2004).

To be effective learning tools, each exhibit should be highly motivating for visitors at every step of interaction in order to sustain involvement and willingness to explore throughout the show (Allen, 2004). Furthermore, the exhibition sections should be structured in such a way that every part speaks for itself and tell its own story. While the former is mainly achieved through the design of the visitor experience and other elements that are beyond the scope of this paper (e.g. interpretive texts, built environment, digital technologies etc.), the latter aspect is dealt with at the stage of the conceptual structuring. For example, in Section 1 – Part 2 "Sources of Inspiration", we iterated the same core idea (i.e. how "big ideas" can be encapsulated in small graphical spaces) in every subpart (i.e. kaomoji, manpu, Tokyo Olympics, kanji) so that each of them would tell the same story through materials of

different kinds, and would do so independently from each other or from the order they are seen. This should increase the likeliness of visitors getting the intended message by attending any one of them. Also, in order to illustrate the relation of the materials in each subpart with the protagonist of our story (emoji), each subpart also includes a sample of Kurita's emoji inspired by the subpart's materials (e.g. the manpu sub-part also includes the set of manpu-inspired emojis), anticipating the big full set of emoji shown in Part 3; this is because we could not take for granted that the connection between Kurita's various sources of inspiration and the outcome of his work would be apparent to visitors when walking from Part 2 to Part 3. In conclusion, we aimed to tell a complete story within each sub-part.

4.4.2.3 Representations of power and controversial topics

Tackling issues which have political implications can be tricky when developing an exhibition concept and content package. How the political content is represented can determine how the audience will receive the show, it can trigger reactions from the third parties involved as subjects represented in the exhibition (e.g. corporations, communities, social groups) and it can obviously have serious consequences for the reputation and public perception of the host institution.

In these cases, curators should ensure that a plurality of voices and points of view are represented (Arnold, 1998). For example, Section 3 "Emoji and society" focusses on the conflict between the UNICODE board on one side, responsible for standardisation and approval of emoji, and communities that feel underrepresented in emoji on the other. UNICODE board members are the gatekeepers of emoji, a structure of power with initially unclear procedures for emoji approval and not entirely transparent partnerships with a few selected corporations and country committees (Warzel, 2015). The board has long been in conflict with discriminated communities on issues of sexism, gender equality, racial diversity, inclusiveness. While their transparency of decision-making has improved in the last few years (UNICODE, 2019), there are still unresolved issues. For example, the blood drop accepted as "emoji period" left many unsatisfied (Miller & Maharaj, 2019). Being this an ongoing debate, our choice was to give voice to all stakeholders involved; UNICODE personalities, campaign leaders, and samples of underrepresented communities are all given space in video-interviews accompanying the display of contentious emoji.

Still, it is important to remember that, even when applying a policy of pluralism of perspectives, there will always be the possibility of a mismatch between

curatorial intentions in treating political content and visitors' reactions (Arnold, 1998). This is mainly due to two factors. One is curator biases: as curators, we select what stories are told and what materials are displayed out of all possible ones; we also decide the ways objects are displayed, juxtaposed and described, and how the visitor is allowed to interact with them (Macdonald, 2010). Our biases and unreflected-upon assumptions can never be completely erased from this process, and they inevitably give the exhibition message a 'point of view', which can be noticed by the attentive visitor. As Foucault argued, the production and distribution of knowledge are always political processes where dynamics of power are involved (Foucault, 1977, 1979).

The second factor is visitors' biases. When visiting an exhibition, people will make assumptions on the ideological position of the host institution and the political agenda behind a show. These assumptions are sometimes based on the visitor's own political opinion on the exhibition topic, but oftentimes they are also grounded in how visitors perceive the institutional identity of the venue, on the basis of their previous exhibitions, their general reputation or even on cues from the venue's built environment (Arnold, 1998). In the end, they are likely to point out (e.g. in online visitor reviews or guestbook comments) gaps or missing voices, or to accuse the institution or the curators of sanitising controversial topics.

As the first set of biases is inevitable, and the second can be difficult to predict and counteract, what curators can do is to acknowledge their role and position in the process of knowledge representation, as it is best practice in most social sciences (Haraway, 1988; Rose, 1997).

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5 Conclusions

These studies contribute to addressing Gombrich's riddle of style presented in the introduction: "Why is it that different ages and different nations have represented the visible world in such different ways?" (Gombrich, 1960). They showed that one of the factors that concur to shaping styles of pictorial representation in a cultural group is the degree of contact or isolation of that group in relation to other groups. Chapter 2 provided experimental evidence of this causal relationship by simulating group contact and isolation with laboratory micro-societies performing drawing tasks. Chapter 3 provided empirical evidence that the relationship holds in real world scenarios by analysing an ethno-archaeological dataset, comparing rock art motifs from highly interconnected and isolated indigenous communities of Australia. Chapter 4 provided a qualitative application to a type of pictorial representation which has come to play a fundamental role in digital communication nowadays, i.e. emoji.

Overall, these studies showed that group contact or isolation can act on two aspects of pictorial representations: semantic transparency and stylistic form, and suggested that the two are related. On the level of semantic transparency, our findings suggested that pictorial representations produced in contact groups are easier to understand for outsiders than those produced in isolated groups. In the experiment presented in Chapter 2, for example, participants' drawings produced in contact groups were easy to interpret for naïve observers, whereas drawings were semantically opaque when produced in the absence of intergroup contact (i.e. in the isolation and control conditions).

On the level of stylistic form, our results showed that pictorial representations produced in contact groups tend to be more figurative whereas those produced in isolated groups tend to be more abstract. Chapter 2 showed that naïve observers were more likely to judge as recognisable representations of objects drawings produced by contact groups compared to those produced by isolated groups. In line with this findings, Chapter 3 showed that rock art motifs coming from high-contact indigenous Australian communities were more likely to be judged by non-native observers as inter-subjectively recognisable depictions of objects, and to elicit converging descriptions of their subjects, when compared to motifs produced in

isolated communities. This indicated that pictorial representations produced in contexts of contact enable different observers to recognise as their subjects the same or very similar things, whereas representations produced in isolated contexts either "do not look like anything" at all or enable different observers to identify different subjects in an idiosyncratic way.

In Chapter 4, a qualitative analysis of the evolution of emoji revealed a pattern of change consistent with the previous quantitative results. In particular, it revealed a major shift in the style of representation of emoji in correspondence with the spread of emoji in digital communications worldwide. While emoji were rather schematic and abstract when they were first introduced in Japan for the specific Japanese audience, they became figurative when they were extended to a global audience. Emoji designers had to deal with the problem of how to make them as transparent as possible for an increasingly large and diverse audience of users, and therefore opted for figurative graphical solutions.

Combined with previous experimental findings, it can be concluded that in general, over repeated interactions within cultural groups, pictorial signs evolve towards stylistic abstraction and semantic opacity. However, contact with different cultural groups can slow down or limit the process and cause pictorial signs to retain stylistic figurativeness and semantic transparency. Our findings suggest that this happens under the push of inter-group understandability. In contexts of between-group contact, pictorial representations need to be accessible to two or more different audiences with different cultural habits; figurative strategies of representation, where depictions of subjects are inter-subjectively recognisable, allow us to keep higher levels of external interpretability.

Overall, these findings parallel research in sociolinguistics and language evolution that shows that in high-contact communities, languages become easier for non-natives to understand and learn, whereas in small isolated communities, languages are more difficult for non-natives to understand and learn (Lupyan & Dale, 2010; Reali et al., 2018; Trudgill, 2011; Wray & Grace, 2007). It may then be the case that a similar demography-driven pattern of change exists across multiple communication media, and that inter-group contact is a driver of clarity and understandability in human communication in general.

Recent work on the relationship between demography and cultural complexity predicts that population size affects a population's ability to invent and maintain complex culture (Collard et al., 2011, 2013; Derex et al., 2013; Derex & Boyd, 2015;

Henrich, 2004; Kempe & Mesoudi, 2014; Kline & Boyd, 2010; Powell et al., 2010; but see, for a criticism to this approach (Collard et al., 2016; Querbes et al., 2014; Vaesen, 2012; Vaesen et al., 2016a, 2016b). The rationale behind this correlation is that smaller populations have lower rates of invention due to having fewer inventors, and when inventions do emerge they are more likely to be lost in smaller groups because of random loss or incomplete transmission (Richerson et al., 2009).

Based on this literature, it might be expected that larger populations produce more complex pictorial representations than smaller populations. However, our findings do not seem to reflect this pattern. On the one hand, our contact conditions (where the overall effective population size of sign users was larger than in isolated conditions) do produce more graphically complex pictorial representations than isolated groups.[8] But, on the other hand, the control condition of the experimental study presented in Chapter 2 (where effective population size was three times larger than in the isolation condition) produced the same kind of simple pictorial representations as isolated groups. This suggests that effective population size might not necessarily play a role in the graphical complexity of pictorial representations.

This might be due to the fact that different selective forces are in action in the evolution of pictorial representation and the evolution of technology. While in technological domains higher complexity is supposed to improve performance, in pictorial communication graphical complexity per se is not necessarily a success factor. For example, in our experimental context, successful pictorial representations were those which were able to strike the right balance between understandability (i.e. they were easy to interpret for their target audience) and compressibility (i.e. they were quick to produce). This supports the idea that the effect of demography on cultural complexity might be domain-dependant (Acerbi et al., 2016).

[8] The studies presented in Chapter 2 and 3 did not measure the graphical complexity of pictorial representations; however, based on previous studies adopting similar methods and including measures of graphical complexity (e.g. Caldwell & Smith, 2012), it is reasonable to assume that abstract experimental drawings and abstract Aboriginal motifs are graphically simpler than figurative ones.

It might well be that, in domains where the aesthetics and display of skill in pictures play a major role, the relationship between population size and complexity will still hold. Some art historians, for example, have hypothesised that decoration might evolve in a similar way as technology; (Gombrich, 1984) saw the evolution of decorative style as a cumulative process driven by the aim of patrons or artists of displaying power or skills to seek prestige. Decorative artists would compete over skills by showing off their mastery in the manipulation of materials and shapes. In this view, decorative artists would imitate the most skilled masters from the previous generation, those producing the most complex designs. In larger populations, where there are more chances to find skilled individuals, and learners can access more models to copy, decorative designs would become increasingly graphically complex; in smaller groups, instead, the accumulation of random error would lead to the simplification of patterns. Muthukrishna et al. (2014) attained similar results in a transmission chain experiment with participants reproducing a target geometrical design with a digital editing tool; larger groups generated increasingly effective editing skills and graphically complex images, whereas in smaller groups there was no improvement in skills nor increase in image complexity.

However, differences between decorative arts and technology give good reasons also not to expect the demography-complexity correlation to hold for decorative styles. The goal of decorative arts, and therefore the measure of success of decorative pieces, varies over time and space; pattern complexity might not always be the criterion for selecting which masters to imitate. As Gombrich (1984) also notes, the artistic criterion on which the competition over skills is judged changes from period to period (e.g. complexity, elegance, simplicity, etc.). Cumulative change in decorative arts might then be pulsating (Kroeber, 1957): competition triggers the search for originality, leading to gradual change towards increasingly better ways to fulfil the local artistic objective; eventually, for audience fatigue or for running out of further formal possibilities, a style reaches exhaustion, the artistic objective changes, and the process starts all over again. If decorative style evolves in pulses and the success criteria changes at every pulse, we would not expect graphical complexity to always increase by cumulative change, nor to always correlate with population size. Graphical complexity might be just one of the local goals in art history. Future research might investigate the evolution of decoration in relation to skill and in comparison with technological design.

Furthermore, our findings might have important implications for the archaeology of pictorial representations. Archaeologists have usually relied on distributions of specific types of artefacts and motifs across sites to reconstruct characteristics of the social contexts that produced them, including population-level structures of interaction (Barton et al., 1994; Braun & Plog, 1982; Conkey, 1985; Francis et al., 1993; Gamble, 1982; Jochim, 1983; Ucko & Rosenfeld, 1967; Wiessner, 1983; Wobst, 1977). However, the distributional approach is not always feasible because of the frequent gaps in the archaeological record. It might therefore be useful to also take into consideration more general stylistic features, like figurativeness of representation, to infer information about their demographic context of production or use. Considering the abstract or figurative nature of pictorial representations might be valuable to reconstruct group interactions in historic periods for which material evidence is scarce.

These studies also make a contribution to the experimental methodology of Cultural Evolution and experimental semiotics. In Chapter 2, an experimental paradigm was adopted where laboratory micro-societies simulated cultural isolation or cultural contact. This paradigm is not just applicable to pictorial representations but can become a model for investigating the effects of group contact on other cultural items.

Finally, to make this research accessible to a non-specialised audience, its core topics and findings were translated into an outreach project in the form of an exhibition blueprint. The concept design mainly focussed on the evolution of abstraction and the role of the audience in determining the style of pictorial representations. However, the history of emoji also offered the opportunity to include further related topics such as the notion of conventionality of pictorial representations and their cultural variation, the problem of universality of representations and its consequences on style. The blueprint is going to be proposed to a number of venues, including the House of Illustration, the Design Museum and Durham Palace Green.

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A Appendices

A.1 Chapter 2 Appendix

A.1.1 Supplementary Methods

A.1.1.1 A note on stimuli

The lists of stimuli words used in the drawing game did not include any distractor. Distractors were not needed because our procedure made guessing the last few concepts on the list not trivial for participants. This was for a combination of reasons: 1) when a wrong answer was given, the right answer was not revealed, which made it impossible to exclude words from the set of potential answers to the following trials. 2) Even in later rounds of the game, when accuracy would improve, it was still extremely unlikely for participants to proceed by elimination considering that each participant had to deal with the whole list of 12 words in each round and that the average memory span for individual words is about 5 or 6 (Baddeley, 2000). Participants would have needed to remember the last 9 or 10 words to have some chances to guess the last two. 3) This was made even harder by the fact that the words were confusable and that confusable words came sometimes in triplets or sets of 4.

A.1.1.2 Bayesian models: structure, priors and chain convergence

1. **Transparency model**

The code of the Transparency model is the following:

```
m1 <- map2stan(
      alist(
        Correct ~ dbinom (Total_trials, p),
        logit(p) <- a +
        + a_Concept[Concept]
        + a_Questionnaire[Questionnaire]
        + a_Drawing[Drawing]
        + b_List*List
        + b_KindConcept*Kind_of_Concept
        + b_Contact*Contact
        + b_Control*Control,
        a ~ dnorm(0,10),
        a_Concept[Concept] ~ dnorm(0, sigma_concept),
        a_Questionnaire[Questionnaire] ~ dnorm(0, sigma_questionnaire),
        a_Drawing[Drawing] ~ dnorm(0, sigma_drawing),
        b_List ~ dnorm(0,10),
        b_KindConcept ~ dnorm(0,10),
        b_Contact ~ dnorm(0,10),
```

```
    b_Control ~ dnorm(0,10),
    sigma_concept ~ dcauchy(0,1),
    sigma_drawing ~ dcauchy(0,1),
    sigma_questionnaire ~ dcauchy(0,1)
    ),
  data = surveydata, warmup = 1000, iter = 4000, chains = 3
  )
```

Concept, Questionnaire and Drawing are included as random variables generating varying intercepts (varying intercepts priors). List (A, B) and Kind of Concept (abstract, concrete) are covariates which are included as fixed variables. The fixed factor Condition (Isolation, Contact, Control) has been recoded into dummy variables, where Isolation is the baseline: Isolation (0,0), Contact (1,0), Control (0,1).

The parameters for contact, control, kind of concept, list of concepts, and the mean intercept were assigned normal distributions (mean=0, SD=10). The varying intercept parameters for drawing, concept, and questionnaire were assigned normal distributions with mean at 0 and SD as a hyperparameter, sigma, which takes a half-Cauchy distribution (0, 1) (McElreath, 2016).

We ran 3 Markov chains of 4000 iterations (with 1000 warmup), all of which converged (R^=1).

The model gave this output:

```
                    Mean StdDev lower 0.89 upper 0.89 n_eff Rhat
a                  -1.36   0.41      -2.01      -0.70  1620    1
b_List             -0.12   0.45      -0.82       0.60  1933    1
b_KindConcept       0.46   0.44      -0.22       1.17  1737    1
b_Contact           1.75   0.20       1.44       2.07  2896    1
b_Control          -0.21   0.20      -0.53       0.11  2863    1
sigma_concept       1.00   0.18       0.74       1.26  9000    1
sigma_drawing       1.06   0.06       0.96       1.14  2031    1
sigma_questionnaire 0.24   0.10       0.08       0.38   969    1
```

2. Style model

The code of the Style model is the following:

```
m1 <- map2stan(
  alist(
    Figurativeness ~ dbinom (TotalTrials, p),
    logit(p) <- a +
      + a_Concept[Concept]
    + a_Drawing[Drawing]
    + b_List*List
    + b_KindConcept*KindOfConcept
    + b_Contact*Contact
    + b_Control*Control,
    a ~ dnorm(0,10),
    a_Concept[Concept] ~ dnorm(0, sigma_concept),
    a_Drawing[Drawing] ~ dnorm(0, sigma_drawing),
    b_List ~ dnorm(0,10),
    b_KindConcept ~ dnorm(0,10),
    b_Contact ~ dnorm(0,10),
```

```
    b_Control ~ dnorm(0,10),
    sigma_concept ~ dcauchy(0,1),
    sigma_drawing ~ dcauchy(0,1)
  ),
  data = styleratings, warmup = 1000, iter = 4000, chains = 3
)
```

Concept, and Drawing are included as random variables generating varying intercepts (varying intercepts priors). List (A, B) and Kind of Concept (abstract, concrete) are covariates which are included as fixed variables. The fixed factor Condition (Isolation, Contact, Control) has been recoded into dummy variables, where Isolation is the baseline: Isolation (0,0), Contact (1,0), Control (0,1).

The parameters for contact, control, kind of concept, list of concepts, and the mean intercept were assigned normal distributions (mean=0, SD=10). The varying intercept parameters for drawing, concept, and questionnaire were assigned normal distributions with mean at 0 and SD as a hyperparameter, sigma, which takes a half-Cauchy distribution (0, 1) (McElreath, 2016).

We ran 3 Markov chains of 4000 iterations (with 1000 warmup), all of which converged (R^=1).

The model gave this output:

```
               Mean StdDev lower 0.89 upper 0.89 n_eff Rhat
a             -1.73   0.38      -2.32      -1.11  2755    1
b_List        -0.34   0.41      -0.99       0.30  3181    1
b_KindConcept -1.04   0.42      -1.73      -0.39  2941    1
b_Contact      1.71   0.20       1.41       2.03  3457    1
b_Control     -0.09   0.21      -0.41       0.25  3969    1
sigma_concept  0.92   0.19       0.62       1.18  5313    1
sigma_drawing  1.69   0.09       1.55       1.83  2772    1
```

A.1.2 Supplementary Results

A.1.2.1 Additional models

Drawings were produced in populations of participants who repeatedly interacted with each other: 6 populations in the isolation condition (the 6 isolated mini-groups), 2 populations in the contact condition (the interacting mini-groups in the 2 iterations of the contact condition), and 2 in the control condition (the large groups in the 2 iterations of the control condition). Drawings produced within the same population are not independent. We addressed this by running two additional models including the cluster variable “population” as a random variable generating a varying intercept (McElreath, 2016: 355-ff). In the new models, the effect of condition was essentially the same as in the original models.

A.1.2.1.1 Additional Transparency model

The additional Transparency model (here named New) was:

```
New <- map2stan(
         alist(
           Correct ~ dbinom (Total, p),
           logit(p) <- a +
             a_Concept[Concept] +
             a_Questionnaire[Questionnaire] +
             a_Drawing[Drawing] +
             a_Population[Population] +
             b_List*List +
             b_KindConcept*KindConcept +
             b_Contact*Contact +
             b_Control*Control,
           a ~ dnorm(0,10),
           a_Concept[Concept] ~ dnorm(0, sigma_concept),
           a_Questionnaire[Questionnaire] ~ dnorm(0,
   sigma_questionnaire),
           a_Drawing[Drawing] ~ dnorm(0, sigma_drawing),
           a_Population[Population] ~ dnorm(0, sigma_population),
           b_List ~ dnorm(0,10),
           b_KindConcept ~ dnorm(0,10),
           b_Contact ~ dnorm(0,10),
           b_Control ~ dnorm(0,10),
           sigma_concept ~ dcauchy(0,1),
           sigma_drawing ~ dcauchy(0,1),
           sigma_questionnaire ~ dcauchy(0,1),
           sigma_population ~ dcauchy(0,1)
           ),
         data = surveydata, warmup = 1000, iter = 4000, chains = 3
         )
```

The model gave the following output (note that the 600+ parameters for Drawing were not displayed here for ease of reading):

```
                    Mean StdDev lower 0.89 upper 0.89 n_eff Rhat
a                  -1.44   0.46      -2.14      -0.71  1117 1.00
a_Concept[1]       -0.93   0.43      -1.64      -0.28  1473 1.00
a_Concept[2]        0.31   0.44      -0.39       1.00  1186 1.00
a_Concept[3]        0.98   0.43       0.27       1.61  1422 1.00
a_Concept[4]       -0.07   0.43      -0.78       0.61  1353 1.00
a_Concept[5]        0.87   0.43       0.18       1.53  1323 1.00
a_Concept[6]       -0.13   0.44      -0.82       0.57  1329 1.00
a_Concept[7]        0.09   0.43      -0.55       0.81  1518 1.00
a_Concept[8]        0.37   0.43      -0.28       1.10  1309 1.00
a_Concept[9]       -0.53   0.44      -1.21       0.17  1557 1.00
a_Concept[10]      -0.06   0.43      -0.75       0.62  1341 1.00
a_Concept[11]      -0.03   0.43      -0.70       0.67  1426 1.00
a_Concept[12]      -0.76   0.44      -1.46      -0.06  1335 1.00
a_Concept[13]      -1.36   0.44      -2.08      -0.68  1492 1.00
a_Concept[14]       1.04   0.43       0.40       1.77  1545 1.00
a_Concept[15]      -0.30   0.43      -0.99       0.38  1337 1.00
a_Concept[16]      -1.33   0.45      -2.01      -0.60  1754 1.00
a_Concept[17]       1.47   0.43       0.79       2.16  1407 1.00
a_Concept[18]       0.08   0.43      -0.60       0.75  1442 1.00
a_Concept[19]      -1.57   0.45      -2.32      -0.88  1474 1.00
a_Concept[20]      -0.22   0.43      -0.89       0.45  1532 1.00
a_Concept[21]       1.16   0.43       0.44       1.80  1394 1.00
a_Concept[22]       1.64   0.43       0.97       2.33  1565 1.00
a_Concept[23]       0.25   0.42      -0.38       0.95  1405 1.00
a_Concept[24]      -0.95   0.45      -1.67      -0.25  1535 1.00
```

a_Questionnaire[1]	0.04	0.15	−0.19	0.29	1974	1.00
a_Questionnaire[2]	−0.06	0.16	−0.31	0.18	1563	1.00
a_Questionnaire[3]	0.08	0.16	−0.14	0.36	1426	1.00
a_Questionnaire[4]	−0.04	0.15	−0.27	0.20	2674	1.00
a_Questionnaire[5]	−0.02	0.15	−0.27	0.21	3182	1.00
a_Questionnaire[6]	0.01	0.15	−0.24	0.23	3297	1.00
a_Questionnaire[7]	−0.03	0.15	−0.27	0.23	2745	1.00
a_Questionnaire[8]	−0.03	0.15	−0.25	0.22	2508	1.00
a_Questionnaire[9]	−0.03	0.15	−0.28	0.20	3098	1.00
a_Questionnaire[10]	−0.01	0.15	−0.25	0.22	3207	1.00
a_Questionnaire[11]	0.13	0.18	−0.10	0.42	919	1.00
a_Questionnaire[12]	−0.03	0.15	−0.28	0.20	3414	1.00
a_Questionnaire[13]	0.09	0.16	−0.15	0.35	1982	1.00
a_Questionnaire[14]	−0.11	0.17	−0.36	0.13	1227	1.00
a_Questionnaire[15]	0.05	0.15	−0.17	0.31	3112	1.00
a_Questionnaire[16]	0.12	0.17	−0.11	0.40	1052	1.00
a_Questionnaire[17]	−0.14	0.18	−0.42	0.10	1058	1.00
a_Questionnaire[18]	−0.01	0.15	−0.24	0.23	3587	1.00
a_Population[1]	0.19	0.35	−0.36	0.72	2063	1.00
a_Population[2]	−0.19	0.36	−0.76	0.35	2226	1.00
a_Population[3]	0.12	0.36	−0.44	0.65	2838	1.00
a_Population[4]	−0.11	0.35	−0.62	0.43	3144	1.00
a_Population[5]	−0.13	0.28	−0.54	0.31	2387	1.00
a_Population[6]	0.20	0.29	−0.20	0.68	2298	1.00
a_Population[7]	−0.41	0.30	−0.88	0.05	2143	1.00
a_Population[8]	0.06	0.27	−0.36	0.49	2512	1.00
a_Population[9]	−0.07	0.27	−0.49	0.37	2763	1.00
a_Population[10]	0.35	0.29	−0.08	0.80	1625	1.00
b_List	0.03	0.52	−0.77	0.88	1303	1.00
b_KindConcept	0.45	0.44	−0.28	1.10	942	1.00
b_Contact	1.76	0.40	1.14	2.34	1674	1.00
b_Control	−0.20	0.39	−0.78	0.42	2022	1.00
sigma_concept	1.00	0.18	0.72	1.25	3480	1.00
sigma_drawing	1.05	0.06	0.96	1.14	1717	1.00
sigma_questionnaire	0.16	0.10	0.00	0.28	347	1.01
sigma_population	0.40	0.19	0.12	0.67	1313	1.00

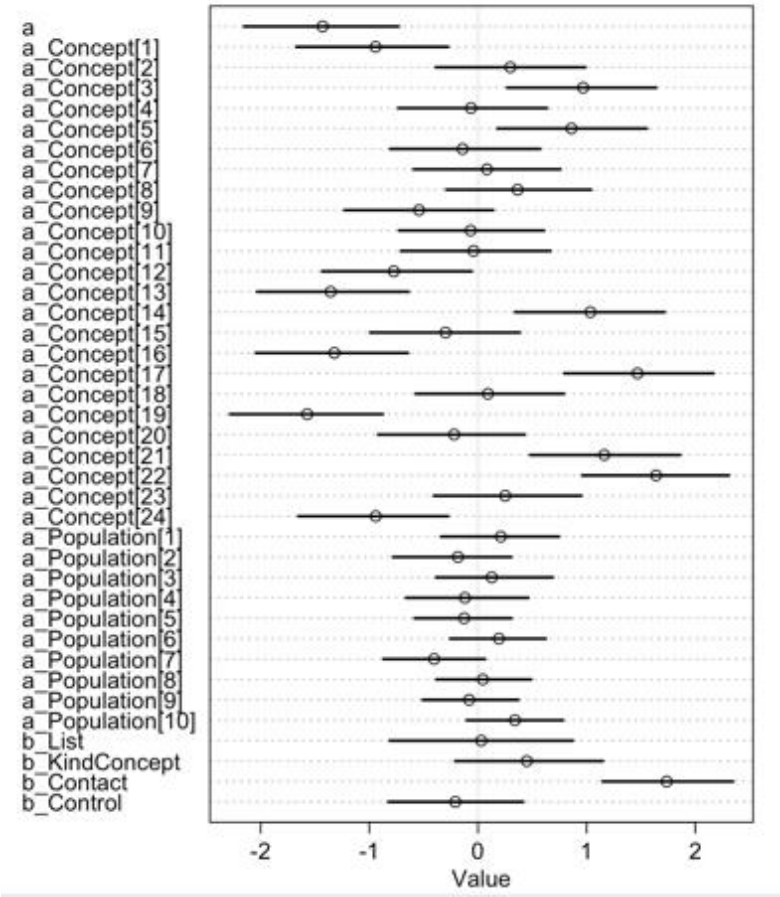


Figure 25 Posterior means and 89% highest density intervals for the additional transparency model.

After accounting for the variance due to "population", in the new model the effect of the condition was essentially the same as in the original model, only with a larger variance (see Table 2 and Figure 26). Similarly to the original model, in the new model there is a positive effect of contact against the baseline category isolation ($\beta_{contact}$ mean = 1.76, SD = 0.40, HPDI = 1.14 to 2.34), whereas there was no clear effect of control over isolation in the log-odds of correct interpretation ($\beta_{control}$ mean = - 0.20, SD = 0.39, HPDI = -0.78 to 0.42). Comparing the median estimates for the posterior probability distributions between conditions, we find that the probability of correct interpretation for drawings from the contact condition is 38% higher than the isolation condition (HPDI = 18% to 54%) and 40% higher than the control condition (HPDI = 20% to 59%), whereas there was a very small difference in probability between control and isolation (-3% in the control condition, HPDI = -14% to 1%). Figure 26 (left) illustrates the predicted effect of the conditions on the probability of correct interpretation according to the new model, and confirms the

trend that was already shown in the original model (Figure 26 right), which is consistent with our hypothesis: drawings coming from the contact condition were more likely to be interpreted correctly than drawings coming from the isolation or control conditions, which had instead similar low interpretation accuracy.

Table 2 Comparison of estimates between the new model and the old model

New model

	Mean	StdDev	lower 0.89	upper 0.89	n_eff	Rhat
a	-1.44	0.46	-2.14	-0.71	1117	1.00
b_List	0.03	0.52	-0.77	0.88	1303	1.00
b_KindConcept	0.45	0.44	-0.28	1.10	942	1.00
b_Contact	1.76	0.40	1.14	2.34	1674	1.00
b_Control	-0.20	0.39	-0.78	0.42	2022	1.00
sigma_concept	1.00	0.18	0.72	1.25	3480	1.00
sigma_drawing	1.05	0.06	0.96	1.14	1717	1.00
sigma_questionnaire	0.16	0.10	0.00	0.28	347	1.01
sigma_population	0.40	0.19	0.12	0.67	1313	1.00

Old Model

	Mean	StdDev	lower 0.89	upper 0.89	n_eff	Rhat
a	-1.37	0.39	-1.97	-0.71	1319	1
b_List	-0.11	0.43	-0.80	0.58	1586	1
b_KindConcept	0.46	0.43	-0.25	1.12	1318	1
b_Contact	1.76	0.20	1.45	2.07	2779	1
b_Control	-0.20	0.20	-0.51	0.11	2832	1
sigma_concept	1.00	0.17	0.73	1.25	9000	1
sigma_drawing	1.06	0.06	0.97	1.15	1897	1
sigma_questionnaire	0.23	0.10	0.06	0.39	611	1

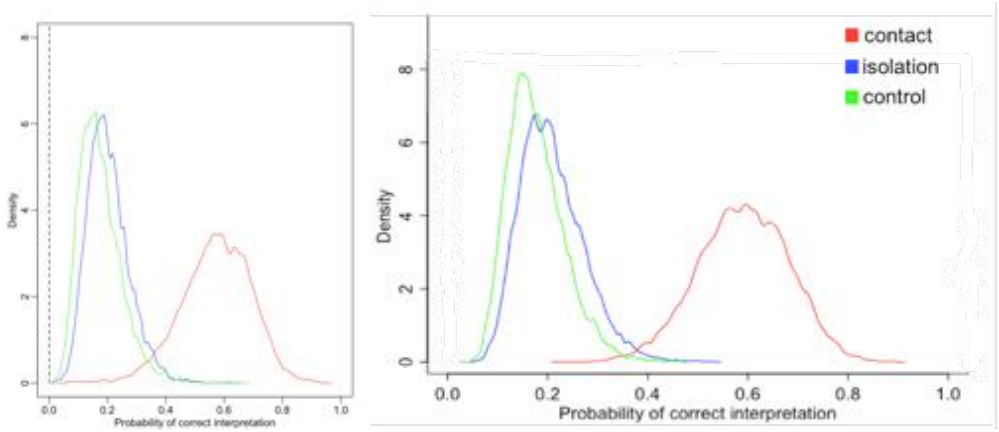


Figure 26 Posterior probability distributions from the new model (left) and old model (right).

A.1.2.1.2 Additional Style model

The additional Style model (here named NewStyle) was:

```
NewStyle <- map2stan(
  alist(
    ProportionFigurative ~ dbinom (TotalTrials, p),
    logit(p) <- a +
    + a_Concept[Concept]
    + a_Drawing[Drawing]
    + a_Population[Population]
    + b_List*List
    + b_KindConcept*KindOfConcept
    + b_Contact*Contact
    + b_Control*Control,
    a ~ dnorm(0,10),
    a_Concept[Concept] ~ dnorm(0, sigma_concept),
    a_Drawing[Drawing] ~ dnorm(0, sigma_drawing),
    a_Population[Population] ~ dnorm(0, sigma_population),
    b_List ~ dnorm(0,10),
    b_KindConcept ~ dnorm(0,10),
    b_Contact ~ dnorm(0,10),
    b_Control ~ dnorm(0,10),
    sigma_concept ~ dcauchy(0,1),
    sigma_drawing ~ dcauchy(0,1),
    sigma_population ~ dcauchy(0,1)
  ),
  data = surveydata, warmup = 1000, iter = 4000, chains = 3
)
```

The model gave this output (note that the 600+ parameters for Drawing were not displayed here for ease of reading):

```
                  Mean StdDev lower 0.89 upper 0.89 n_eff Rhat
a                -1.73   0.63      -2.70      -0.74  2800    1
a_Concept[1]      0.53   0.46      -0.21       1.26  5351    1
a_Concept[2]      0.30   0.46      -0.40       1.04  4407    1
a_Concept[3]     -0.16   0.47      -0.88       0.60  5337    1
a_Concept[4]      0.87   0.47       0.08       1.58  4807    1
a_Concept[5]     -1.42   0.53      -2.24      -0.58  6222    1
a_Concept[6]     -0.77   0.48      -1.53      -0.03  5144    1
a_Concept[7]     -0.23   0.48      -0.99       0.54  5218    1
a_Concept[8]     -0.49   0.46      -1.26       0.22  4171    1
a_Concept[9]      0.64   0.47      -0.08       1.40  4667    1
a_Concept[10]    -0.19   0.46      -0.92       0.56  4815    1
a_Concept[11]     0.85   0.47       0.12       1.61  4977    1
a_Concept[12]     0.06   0.47      -0.64       0.83  4858    1
a_Concept[13]     0.96   0.46       0.28       1.75  4662    1
a_Concept[14]     0.15   0.47      -0.56       0.93  4577    1
a_Concept[15]    -0.81   0.49      -1.62      -0.05  5828    1
a_Concept[16]     0.75   0.46       0.01       1.49  4241    1
a_Concept[17]     1.41   0.47       0.67       2.14  4336    1
a_Concept[18]    -0.26   0.46      -1.03       0.44  4452    1
a_Concept[19]     0.71   0.47      -0.04       1.44  4655    1
a_Concept[20]     0.27   0.45      -0.45       0.96  4561    1
a_Concept[21]    -1.76   0.57      -2.63      -0.84  6501    1
a_Concept[22]    -0.48   0.47      -1.20       0.28  4648    1
a_Concept[23]    -0.80   0.51      -1.59       0.02  6000    1
a_Concept[24]    -0.16   0.46      -0.90       0.58  4218    1
a_Population[1]   0.14   0.74      -1.01       1.30  6265    1
a_Population[2]  -0.11   0.74      -1.19       1.13  5694    1
a_Population[3]  -0.40   0.76      -1.59       0.74  5916    1
a_Population[4]   0.39   0.77      -0.74       1.65  5102    1
a_Population[5]   0.72   0.57      -0.18       1.60  3409    1
a_Population[6]   0.50   0.58      -0.37       1.42  3133    1
```

a_Population[7]	-1.03	0.60	-2.01	-0.16	3188	1
a_Population[8]	-0.49	0.57	-1.38	0.40	4573	1
a_Population[9]	-0.58	0.58	-1.52	0.28	4520	1
a_Population[10]	0.83	0.58	-0.05	1.75	4171	1
b_List	-0.45	0.74	-1.61	0.69	3296	1
b_KindConcept	-1.02	0.42	-1.70	-0.36	3696	1
b_Contact	1.74	0.80	0.47	2.97	5072	1
b_Control	-0.03	0.82	-1.33	1.20	4091	1
sigma_concept	0.92	0.18	0.64	1.20	5832	1
sigma_drawing	1.61	0.08	1.47	1.74	3020	1
sigma_population	0.91	0.34	0.42	1.36	2663	1

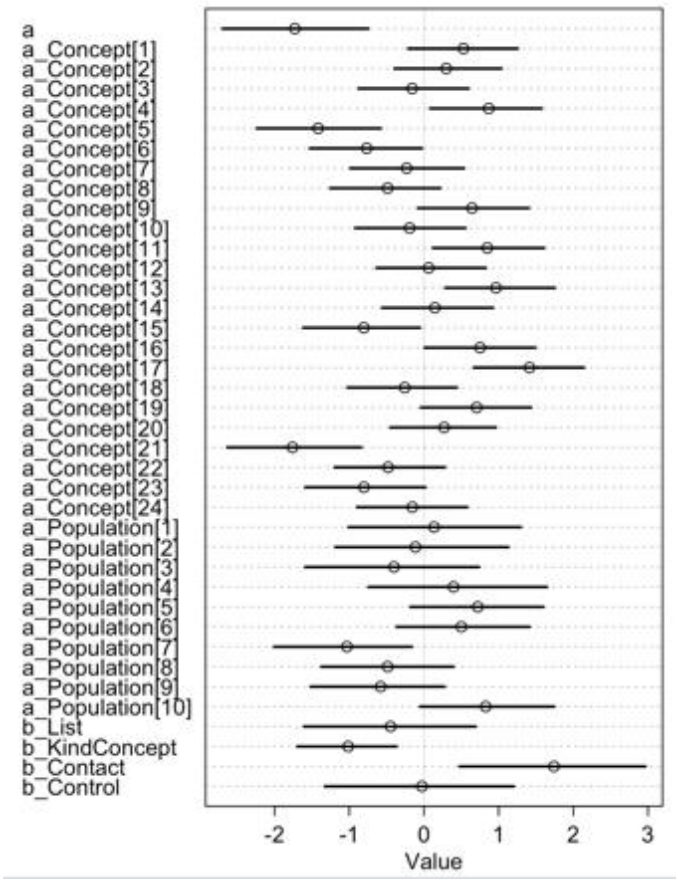


Figure 27 Posterior means and 89% highest density intervals for the additional style model.

After accounting for the variance due to population, in the new model the effect of the condition was essentially the same as in the original model, but with a larger variance (see Table 3 and Figure 28). Similarly to the original model, in the new model there is a positive effect of contact against the baseline category isolation ($\beta_{contact}$ mean = 1.74, SD = 0.80, HPDI = 0.47 to 2.97), whereas there was no clear effect of control over isolation in the log-odds of a drawing being figurative ($\beta_{control}$ mean = -0.03, SD = 0.82, HPDI = -1.33 to 1.20). Comparing the median estimates for the posterior probability distributions between conditions, we find that the probability of figurativeness for drawings from the contact condition is 34% higher than the isolation condition (HPDI = 1% to 65%) and 33% higher than the control condition (HPDI = 4% to 67%), whereas there is essentially no difference in

probability between control and isolation (-0.2% in the control condition, HPDI = -21% to 29%). Figure 28 (left) illustrates the predicted effect of the conditions on the probability of figurativeness according to the new model, and confirms the trend that was already shown in the original model (Figure 28 right), which is consistent with our hypothesis: drawings coming from the contact condition were more likely to be figurative than drawings coming from the isolation or control conditions, which had instead similar low probabilities of figurativeness.

Table 3 Comparison of estimates between the old and new model

New model

	Mean	StdDev	lower 0.89	upper 0.89	n_eff	Rhat
a	-1.73	0.63	-2.70	-0.74	2800	1
b_List	-0.45	0.74	-1.61	0.69	3296	1
b_KindConcept	-1.02	0.42	-1.70	-0.36	3696	1
b_Contact	1.74	0.80	0.47	2.97	5072	1
b_Control	-0.03	0.82	-1.33	1.20	4091	1
sigma_concept	0.92	0.18	0.64	1.20	5832	1
sigma_drawing	1.61	0.08	1.47	1.74	3020	1
sigma_population	0.91	0.34	0.42	1.36	2663	1

Old Model

	Mean	StdDev	lower 0.89	upper 0.89	n_eff	Rhat
a	-1.74	0.39	-2.35	-1.13	2479	1
b_List	-0.35	0.41	-0.99	0.31	3109	1
b_KindConcept	-1.03	0.43	-1.71	-0.37	2881	1
b_Contact	1.71	0.20	1.38	2.02	3486	1
b_Control	-0.10	0.21	-0.43	0.23	4079	1
sigma_concept	0.93	0.18	0.63	1.19	5143	1
sigma_drawing	1.69	0.09	1.55	1.82	2720	1

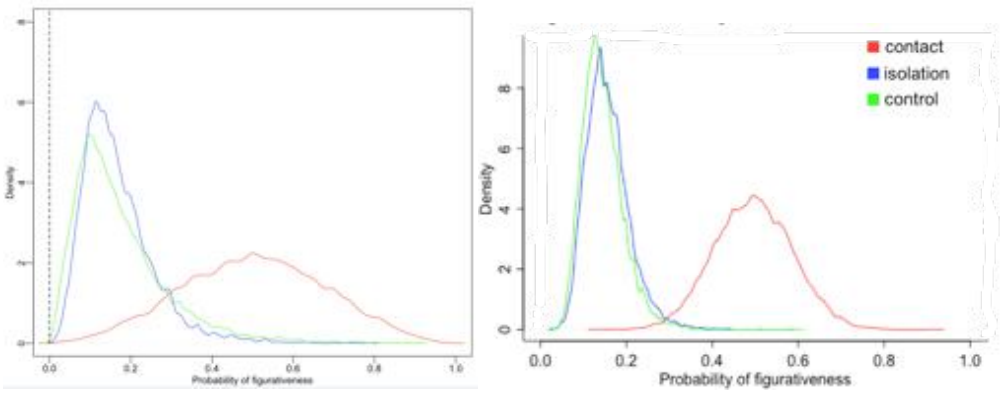


Figure 28 Posterior probability distributions from the new model (left) and old model (right).

A.1.2.2 Frequentist models

Beside the Bayesian models presented in the main text, here we provide the equivalent models run with the traditional frequentist approach. The code is available upon reasonable request.

To estimate the effect of the experimental conditions on the transparency of drawings and their style of representation, response accuracy and figurativeness were analysed by item using logistic regression models fitted with generalised linear mixed-effects regression with a binomial family and a logit link (lme4 package, Bates, Maechler, Bolker, & Walker, 2015; R version 3.3.2, R Core Team, 2016). Condition was introduced as a fixed factor; we included as covariates or random factors the other variables that might account for some variance in the data (see below).

To compare our full models to reduced models including only the random factors and excluding the fixed factor, we compared their AIC values.

The significance of predictors' coefficients (p values) was obtained from their Z-distributed ratio to their standard errors. The effect sizes of significant coefficients were estimated with their odds ratio, reported as OR (how many times greater a drawing's odds of being correctly interpreted/being figurative are, when varying the predictor, Field, Miles, & Field, 2012; for a published example, Chudek, Heller, Birch, & Henrich, 2012). Note that in R the summary of fixed effects returns tests based on a factor's contrasts, comparing all levels to a baseline level, which we set at isolation for ease of interpretation.

Are drawings from the contact condition more likely to be interpreted correctly than drawings from the isolation and control condition?

Yes. Our analysis regressed binary response accuracy on (1) the fixed factor condition (i.e. whether the drawing had been produced in the contact, isolation, or control conditions), (2) the covariate kind of concept (i.e. whether the drawing represented an abstract or concrete concept), (3) the covariate list of concepts (i.e. list A or list B). We specified as a random factor the concept represented in the drawing (N=24); we also specified questionnaire as a random factor (N=18) since – for practical necessities – drawings were sorted in different questionnaires taken by different sets of participants. The model was corrected for overdispersion by introducing an item-level random factor (Browne, Subramanian, Jones, & Goldstein, 2005; Harrison, 2014).

This model had a lower AIC than the corresponding reduced model, which indicated a better fit (AIC_{full} =2692.6, $AIC_{reduced}$=2729.6).

As shown in §A.1.3.1, in this model there was a significant effect of the contact condition against the baseline category isolation. Specifically, the odds of a drawing being correctly interpreted were 5.73 times greater if it came from the contact rather than the isolation condition. Multiple pairwise comparisons revealed that the contact condition also significantly differed from the control condition, where the odds of a drawing being interpreted correctly were much lower: the odds ratio for correct interpretation of control over contact drawings were 0.143. The odds of correct interpretation of control and isolation drawings did not significantly differ. Response accuracy was not confounded by the covariates kind of concept (p=.226) or list (p=.759).

Are the drawings from the contact condition more likely to be figurative than the drawings from the isolation and control condition?

Yes. Our analysis regressed figurativeness on (1) the fixed factor condition (i.e. whether the drawing had been produced in the contact, isolation, or control experimental conditions), (2) the covariate kind of concept (i.e. whether the drawing represented an abstract or concrete concept), (3) the covariate list of concepts (i.e. to which of the two lists used in the Pictionary game the represented concept belonged). We specified the concept represented in the drawing as a random factor (N=24). The model was corrected for overdispersion by introducing an item-level random factor (Harrison 2014, Browne 2005).

This model had a lower AIC than the corresponding reduced model, which indicated a better fit (AIC_{full} = 2465.8, $AIC_{reduced}$= 2568.5).

As shown in §A.1.3.1, in this model there was a significant effect of condition on figurativeness. Contact condition was different from isolation condition (p<.001); specifically, the odds of a drawing being figurative were 5.48 times greater if it came from the contact rather than the isolation condition ($CI_{.95=}$[3.768 - 8.043], p<.001). Multiple pairwise comparisons revealed that the contact condition also differed from the control condition, where the odds of a drawing being figurative were much lower: the odds ratio for being figurative of control over contact drawings were .166 ($CI_{.95}$=[0.106 - 0.260], p<.001). Finally, the odds of a drawing being figurative did not differ between control and isolation conditions ($CI_{.95}$=[0.615 - 1.344], p=.630.).

Although not related to our hypotheses, we also report an effect of kind of concept, with concrete concepts having significantly lower odds of being figurative than abstract concepts (OR=.360, $CI_{.95}$=[0.173 - 0.736], p=.004). Style category was not confounded by the covariate list of concepts (p=.345).

Overall, the pattern of results of the frequentist models mirrors the pattern of results of the Bayesian models shown in the main text.

A.1.3 Supplementary Tables

A.1.3.1 Supplementary table 1 - Summary of the frequentist models

Models	Predictors	Coefficients	SE	z-values	Coefficients CI	Odds Ratios	Odds Ratios CI
Transparency model	Condition is Contact	1.745***	.161	10.804	1.409, 2.088	5.726	4.093, 8.069
	Condition is Control	- .201	.162	−1.241	- .545, .137	.818	.580, 1.147
	Kind of Concept is Concrete	- .458	.378	1.210	- .318, 1.235	1.581	.727, 3.438
	List of Concepts is B	.119	.387	−0.306	- .912, .671	.888	.402, 1.956
	N	648					
Style model	Condition is Contact	1.701***	.193	8.820	1.326, 2.085	5.479	3.768, 8.043
	Condition is Control	- .096	.199	−0.482	-.486, 296	.909	.615, 1.344
	Kind of Concept is Concrete	-1.021**	.354	−2.886	-1.755, - .307	.360	.173, .736
	List of Concepts is B	- .334	.353	−0.947	-1.063, .384	.716	.345, 1.468
	N	648					

Logistic regression coefficients and their standard errors, 95% CI, Odds Ratios and their 95% CI. The Transparency model regresses response accuracy onto the listed predictors, whereas the Style model regresses figurativeness onto the listed predictors. Condition encodes whether a drawing came from the contact, isolation or control experimental conditions, the baseline in this model being isolation; Kind of Concept encodes whether the drawing represents an abstract or a concrete concept; List of Concepts encodes whether a drawing is representing a concept coming from list 1 or 2. N is the number of observations on which the statistical inference was based.

A.1.3.2 Supplementary table 2 - Pair composition over the 36 rounds of the isolation condition

	Group 1	Group 2	Group 3
Home Block 1			
Game 1	A-B	D-E	G-H
Game 2	C-A	F-D	I-G
Game 3	B-C	E-F	H-I
Game 4	A-C	D-F	G-I
Game 5	B-A	E-D	H-G
Game 6	C-B	F-E	I-H
Home Block 2			
Game 7	B-C	E-F	H-I
Game 8	A-B	D-E	G-H
Game 9	C-A	F-D	I-G
Game 10	B-A	E-D	H-G
Game 11	C-B	F-E	I-H
Game 12	A-C	D-F	G-I
Home Block 3			
Game 13	C-A	F-D	I-G
Game 14	B-C	E-F	H-I
Game 15	A-B	D-E	G-H
Game 16	C-B	F-E	I-H
Game 17	A-C	D-F	G-I
Game 18	B-A	E-D	H-G
Home Block 4			
Game 19	A-C	D-E	G-H
Game 20	B-A	F-D	I-G
Game 21	C-B	E-F	H-I
Game 22	A-B	D-F	G-I
Game 23	C-A	E-D	H-G
Game 24	B-C	F-E	I-H
Home Block 5			
Game 25	B-A	E-F	H-I
Game 26	C-B	D-E	G-H
Game 27	A-C	F-D	I-G
Game 28	B-C	E-D	H-G
Game 29	A-B	F-E	I-H
Game 30	C-A	D-F	G-I
Home Block 6			
Game 31	C-B	F-E	I-H
Game 32	A-C	D-F	G-I
Game 33	B-A	E-D	H-G
Game 34	C-A	F-D	I-G
Game 35	B-C	E-F	H-I
Game 36	A-B	D-E	G-H
Final stage: Individual drawing			

A.1.3.3 Supplementary table 3 - Pair composition over the 36 rounds of the contact condition

	Group 1	Group 2	Group 3
Home Block 1			
Game 1	A-B	D-E	G-H
Game 2	C-A	F-D	I-G
Game 3	B-C	E-F	H-I

Game 4	A-C	D-F	G-I
Game 5	B-A	E-D	H-G
Game 6	C-B	F-E	I-H
Travel Block 1			
Game 1	B-D	H-A	F-G
Game 2	I-B	E-H	C-F
Game 3	D-I	A-E	G-C
Game 4	B-I	H-E	F-C
Game 5	D-B	A-H	G-F
Game 6	I-D	E-A	C-G
Home Block 2			
Game 1	B-C	E-F	H-I
Game 2	A-B	D-E	G-H
Game 3	C-A	F-D	I-G
Game 4	B-A	E-D	H-G
Game 5	C-B	F-E	I-H
Game 6	A-C	D-F	G-I
Travel Block 2			
Game 1	C-H	I-F	E-B
Game 2	D-C	A-I	G-E
Game 3	H-D	F-A	B-G
Game 4	C-D	I-A	E-G
Game 5	H-C	F-I	B-E
Game 6	D-H	A-F	G-B
Home Block 3			
Game 1	C-A	F-D	I-G
Game 2	B-C	E-F	H-I
Game 3	A-B	D-E	G-H
Game 4	C-B	F-E	I-H
Game 5	A-C	D-F	G-I
Game 6	B-A	E-D	H-G
Travel Block 3			
Game 1	A-G	E-C	H-F
Game 2	D-A	I-E	B-H
Game 3	G-D	C-I	F-B
Game 4	A-D	E-I	H-B
Game 5	G-A	C-E	F-H
Game 6	D-G	I-C	B-F
Final stage: Individual drawing			

A.1.3.4 Supplementary table 4 - Pair composition over the 36 rounds of the control condition

	Pairs
Home Block 1	
Game 1	H-C
Game 2	C-F
Game 3	B-C
Game 4	B-F
Game 5	E-G
Game 6	C-D
Home Block 2	
Game 7	A-D
Game 8	B-E
Game 9	H-A

Game 10	D-G
Game 11	I-B
Game 12	A-C
Home Block 3	
Game 13	B-D
Game 14	F-H
Game 15	G-H
Game 16	G-A
Game 17	C-G
Game 18	E-H
Home Block 4	
Game 19	F-G
Game 20	E-I
Game 21	F-I
Game 22	I-C
Game 23	E-F
Game 24	H-I
Home Block 5	
Game 25	G-B
Game 26	G-I
Game 27	A-B
Game 28	D-F
Game 29	A-E
Game 30	I-A
Home Block 6	
Game 31	I-D
Game 32	D-E
Game 33	D-H
Game 34	C-E
Game 35	F-A
Game 36	H-B
Final stage: individual drawing	

A.2 Chapter 3 Appendix

A.2.1 Example of coding

For motif 1, we had a list of answers (see Table 4). We split this list in 3 clusters, including 27, 2 and 1 items respectively. Therefore, for this motif we obtained the vector <27, 2, 1>, which had an entropy value of 0.389.

Table 4 List of responses for motif 1 and how they were split in clusters

Responses	Clusters
Snake	
Snake	
Snake	
Worm	
Snake	
That is a snek	
Snake	
Snake	
Snake	
Animal	
Snake	
Snake	
Snike	
Worm	
Snake	
A snake	
Snake	
A snake	
A snake	
A snake	
Snake	

Snake	
Snake	
A snake	
Snake	
Snake	
Snake	
Snake	
Snake	
Snake	

A.2.2 Bayesian models: structure, priors and chain convergence

A.2.2.1 Recognisability model

The code of the Recognisability model is the following:

```
m1 <- map2stan(
  alist(
    Recognisability ~ dbinom (30, p),
    logit(p) <- a +
      + a_Item[Item]
      + a_Site[Site]
      + a_questionnaire[questionnaire]
      + b_AnthropomorphicContent*AnthropomorphicCntent
      + b_Area*Area,
          a ~ dnorm(0,10),
          a_Item[Item] ~ dnorm(0, sigma_Item),
          a_Site[Site] ~ dnorm(0, sigma_Site),
          a_questionnaire[questionnaire] ~ dnorm(0, sigma_questionnaire),
          b_AnthropomorphicContent ~ dnorm(0,10),
          b_Area ~ dnorm(0,10),
            sigma_Item ~ dcauchy(0,1),
            sigma_Site ~ dcauchy(0,1),
            sigma_questionnaire ~ dcauchy(0,1)
  ),
  data = d, warmup = 1000, iter = 4000, chains = 3, control=list(adapt_delta=0.8)
)
```

Item, Site and Questionnaire are included as random variables generating varying intercepts (varying intercepts priors). Anthropomorphic content (0,1) is a covariate which is included as a fixed variable. The fixed factor Area was coded as Western Plateau = 0, Timor Sea = 1.

The parameters for anthropomorphic content, culture area and the mean intercept were assigned normal distributions (mean=0, SD=10). The varying intercept parameters for item, site and questionnaire were assigned normal distributions

with mean at 0 and SD as a hyperparameter, sigma, which takes a half-Cauchy distribution (0, 1) (McElreath, 2016).

We ran 3 Markov chains of 4000 iterations (with 1000 warmup), all of which converged (R^=1). The model gave this output:

```
                         Mean StdDev lower 0.89 upper 0.89 n_eff Rhat
a                       -0.72   0.39      -1.32      -0.10  1981    1
b_AnthropomorphicContent  0.26   0.20      -0.06       0.58  2297    1
b_Area                    1.98   0.42       1.33       2.66  2169    1
sigma_Item                1.10   0.09       0.96       1.23  3125    1
sigma_Site                0.55   0.23       0.19       0.91   863    1
sigma_questionnaire       0.40   0.23       0.03       0.69  1343    1
```

A.2.2.2 Entropy model

The code of the Entropy model is the following:

```
m2 <- map2stan (alist(
  entropyvalue ~ dnorm (mu, sigma),
  mu <- a + a_Item[Item] + a_SiteN[SiteN] + a_SurveyN[SurveyN] + b_Human*Human +
b_Area*Area,
  a ~ dnorm(0,10),
  a_Item[Item] ~ dnorm (0, tau_Item),
  a_SiteN[SiteN] ~ dnorm(0, tau_SiteN),
  a_SurveyN[SurveyN] ~ dnorm(0, tau_SurveyN),
  b_Human ~ dnorm(0,10),
  b_Area ~ dnorm(0,10),
  tau_Item ~ dcauchy(0,10),
  tau_SiteN ~ dcauchy(0,10),
  tau_SurveyN ~ dcauchy(0,10),
  sigma ~ dcauchy (0,10)
),
data = data, warmup = 1000, iter = 11000, chains = 3,
control=list(adapt_delta=0.99))
```

Item, Site and Questionnaire are included as random variables generating varying intercepts (varying intercepts priors). Anthropomorphic content (0,1) is a covariate which is included as a fixed variable. The fixed factor Area was coded as Western Plateau = 0, Timor Sea = 1.

The parameters for anthropomorphic content, culture area and the mean intercept were assigned normal distributions (mean=0, SD=10). The varying intercept parameters for site and questionnaire were assigned normal distributions with mean at 0 and SD as a hyperparameter, tau, which takes a half-Cauchy distribution (0, 1) (McElreath, 2016).

We ran 3 Markov chains of 11000 iterations (with 1000 warmup), all of which converged (R^=1). The model gave this output:

```
             Mean StdDev lower 0.89 upper 0.89 n_eff Rhat
a            2.78   0.14       2.56       3.00  4182 1
b_Human      0.24   0.08       0.12       0.37  7117 1
b_Area      -1.74   0.16      -1.98      -1.50  4609 1
tau_Item     0.32   0.13       0.11       0.51   118 1
tau_SiteN    0.20   0.09       0.06       0.33  3193 1
tau_SurveyN  0.13   0.11       0.00       0.24  3200 1
sigma        0.30   0.14       0.07       0.50   107 1
```

A.3 Chapter 4 Appendix

A.3.1 Culture Segments

Pen portraits of the segments identified as audiences of our potential venues (from Morris Hargreaves McIntyre, 2013)

Essence

Essence is the segment in which culture is not what people do, but who they are. Culture is like oxygen to Essence and they couldn't imagine life without it. Likely to be well-educated professionals who are highly active cultural consumers, they are leaders rather than followers. Confident and discerning in their own tastes, they will act spontaneously according to their mood and pay little attention to what others think. Rather than a social activity or form of entertainment, culture is an essential source of self-fulfillment and challenge, a means for experiencing life. They are inner-directed and self-sufficient, actively avoiding the mainstream.

Expression

Expression is the segment that most enjoys shared and communal experiences. They are very busy, cramming as much as possible into their lives and making the most of their free time. They like to feel part of events and organisations, bring other people along and getting involved as supporters. They are self-aware and most in-tune with their creative and spiritual side. They have a wide range of interests, from culture, to community to nature. Open to new ideas, they pursue challenge, debate and intellectual stimulation through their cultural engagement. Arts and culture offer a means of self-expression and connection with like-minded individuals who share their deeply held values about the world.

Stimulation

Stimulation is the segment that is most attracted to unusual, spectacular and experiential cultural events. They like culture that introduces big ideas but they like to consume it socially with friends. They are an active group who live their lives to the full, looking for stimulating experiences and challenges to break away from the crowd. They are open to a wide range of experiences, from culture to sports and music, but they like to be at the forefront in everything they do. They like to be the ones in the know amongst their peer group.

Affirmation

Affirmation is the segment that is most consciously committed to increasing its cultural intake. They believe culture improves their lives and want to see themselves, and want others to see them, as the kind of people who engage in cultural activity. They appreciate guidance on what they can add to their repertoire. They tend to look for larger, well endorsed, non-specialist events and activities, provided by trusted names, as this offers a low risk means of satisfying their needs. The arts and culture also provides this segment with a means of affirming their self-identity and validating themselves with their peer

Entertainment

Entertainment is the segment that tends to see culture as one of many leisure activities. They are most attracted to strongly branded, large scale, spectacular, entertaining or must-see events featuring well-known names. Arts and culture compete against a wide range of other leisure interests. This segment looks for escapism and thrill in their leisure activities. They are largely socially motivated to attend, looking to pass the time in an entertaining, enjoyable way with friends and family. They tend to stick to the tried and tested rather than take risks.

Perspective

Perspective is the segment that is most focused on their own intellectual and cultural interests. However, these interests are often very personal and home-oriented, so they are content, fulfilled and culturally self-sufficient, unless our offer connects with their agenda and broadens their horizons. They are optimistic and while this means they are highly contented, their horizons can become somewhat narrow. They are not actively seeking new experiences in arts and culture. Instead, their desire to learn and make their own discoveries can lead them into cultural engagement that gives them new perspectives.

Enrichment

Enrichment is the segment that most appreciates and admires culture that is acknowledged for its excellence and which has stood the test of time. They choose cultural activities that fit with their interest in nature and heritage and lets them experience nostalgia and awe and wonder. The Enrichment segment likes to spend their leisure time close to the home. They have established tastes and value traditional art forms. They know what they like and their visits to cultural

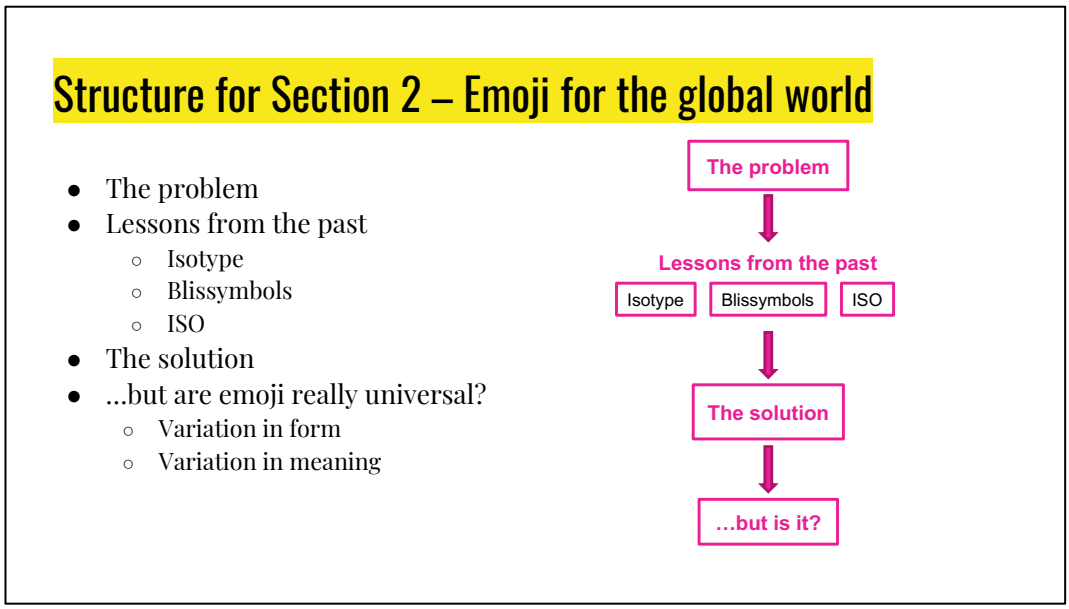
organisations are very much driven by their own interest and not those of others, or what is considered to be new or fashionable. Culture enriches their lives.

Release

Release is the only segment defined by a stage in life: when work and family take priority and drastically reduces time for relaxation, entertainment and socialising with friends. They miss this and aspire to do more of it. The Release segment needs encouragement to view culture as a social activity and an alternative means of taking time out from their busy lives. Arts and culture can offer them a release - an antidote to stress - and a means of staying connected to things that are current and contemporary - keeping them in the loop.

A.3.2 Exhibition content package: Sections 2 and 3

A.3.2.1 Section 2 – Emoji for the global world



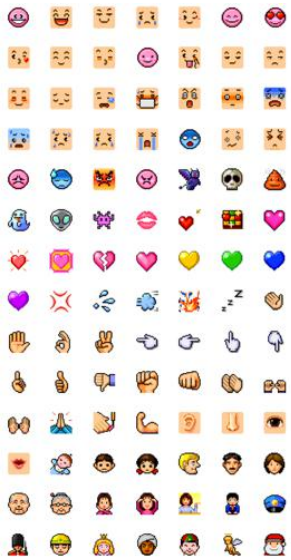
The problem

The babel of different emoji systems: carriers “speak” different languages; the risk of miscommunication is high

- Theoretical angle: a context of multiple language communities (dialects) trying to communicate with each other

Soft Bank set (animated)

- Emoji become animated; faces gain skin colour



KDDI Type D1 (animated)

- KDDI uses low resolution pixel art to create animated and multi-colour emojis; new emojis are added; faces gain contour

Goomoji (Google Gmail)

- Google used colour codes for types of emotions and types of objects

Emoji babel video animation

- Animation with an example of how emoji would mis-translate from one carrier to another. Texting with emojis from different carriers was like two speakers talking different languages.

Lessons from the past

Other designers dealing with a similar problem created standardised graphical codes to communicate with anyone in any place

- Theoretical angle: Local systems are inadequate for inter-group/global communication and need to adopt transparent signs based on standards

Isotype

Photographs of Otto and Marie Neurath, and G. Arntz

- A team of social scientists and designers wanted to create a graphical system for communicating scientific information clearly to anyone in the world



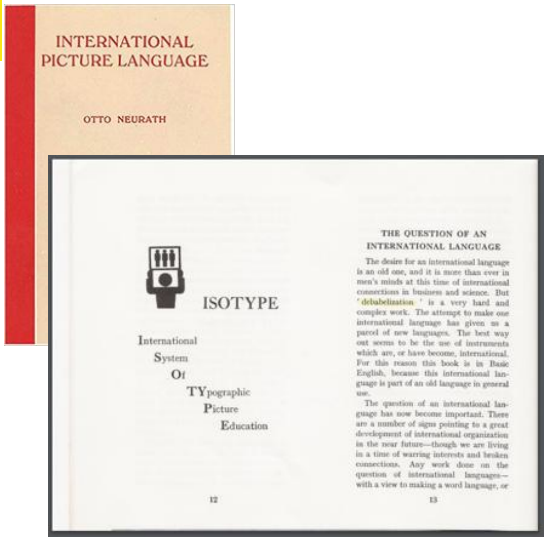
O. Neurath's quotation

- They wanted to create universal pictures which would be easy to understand regardless of verbal languages

"…pictures, whose details are clear to everybody, are free from the limits of language; they are international. WORDS MAKE DIVISION, PICTURES MAKE CONNECTION" (International Picture Language, p.18)

Book: *International Picture Language* (O. Neurath)

- Isotype is a graphical system aimed at communicating complex information clearly to anyone in the world 'Isotype' is Greek for 'the same sign', which summarises the essence of the system, i.e. standardization.

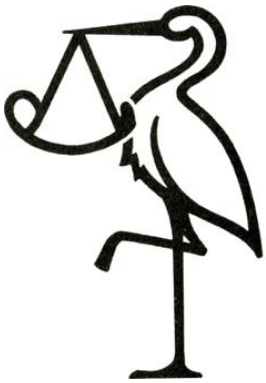


Isotype rules illustrated/1

- Rule 1: One chief organisation sets the rules for forms and colours
  That is, it sets a standard.

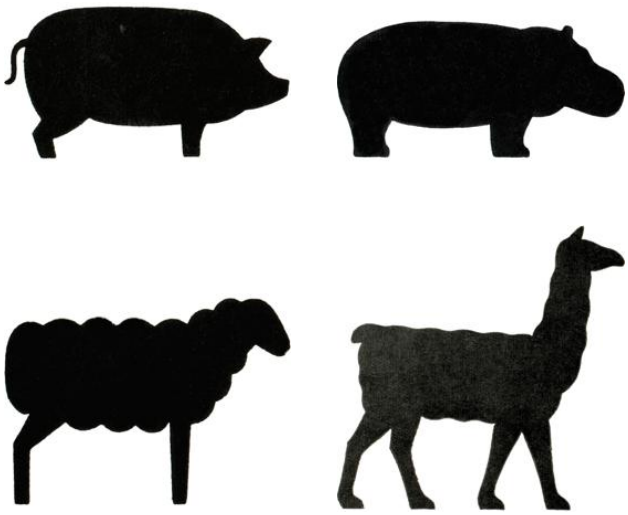
Isotype rules illustrated/2

- Rule 2: pictures must be clear in themselves, without the help of words



Isotype rules illustrated/3

- Rule 3: Pictures must be different from one another



Isotype rules illustrated/4

- Rule 4: Pictures must be simple and nice to look at

Isotype rules illustrated/5

- Rule 5: Pictures must be archetypes

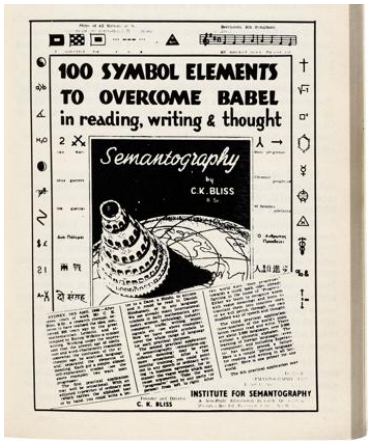
Isotype 'Picture Dictionary' (1930-1940)

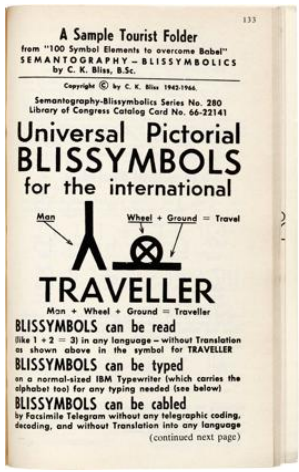
- The Isotype project produced a dictionary of icons

Blissymbols

Book: *Semantography*, C. Bliss (1942)

- Bliss designed a pictographic writing system intended for travellers to overcome linguistic barriers and be able to communicate easily anywhere in the world



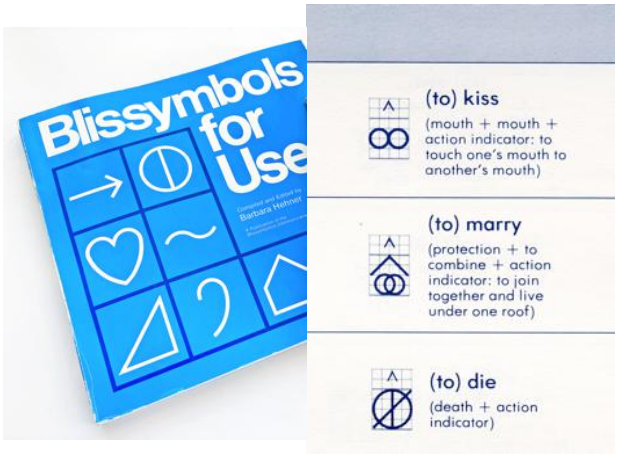


Documentary: *The Symbol Man*

- The documentary shows how Blissymbolics works and explains how it is rooted in a specific vision of how the world works

Handbook of Blissymbols

- Blissymbolics is based on a set of standardised pictograms following established design and combination rules

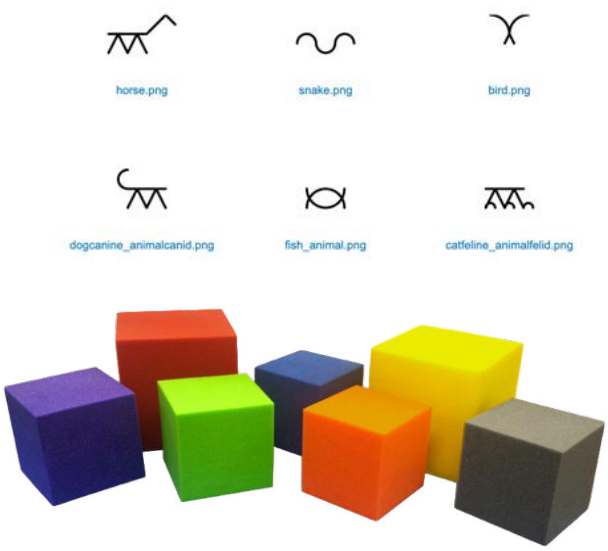


Bookmark and postcard

- Bliss considered Blissymbols as a revolutionary system in the history of writing

Interactive: Blissymbols dictionary (selection) + soft printed blocks

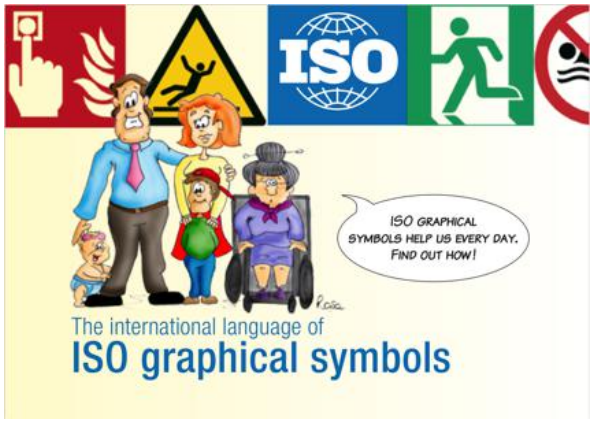
- Bliss designed a dictionary of standard pictograms to be combined in sentences. The dictionary is printed on the wall and on the soft blocks' faces. Visitors can compose sentences with the blocks and take a selfie.



ISO

ISO graphical symbols booklet

- ISO (International Organization for Standardization) provides people all over the world with a coherent set of public information and safety graphical symbols to help overcome language barriers



ISO comic booklet

- ISO symbols are the same anywhere in the world; a technical committee, ISO/TC 145 Graphical symbols, has defined internationally accepted requirements for designs, colours, content and shapes of graphical symbols

ISO 7001: public information symbols

- Each symbol has a fixed code and has been tested in multiple countries

The solution: a universal standard

Unicode standardises emoji by assigning a meaning, a fixed numerical code and providing design guidelines

Digital interactive: Unicode Standard searchable chart

- The Unicode Consortium sets standardised codes for the representation of text in digital form. It assigns a number to each character of the world's writing systems to ensure we all see the same characters when texting each other. Google and Apple asked Unicode to do the same for emoji characters.

  Visitors can explore *The Unicode Standard* chart and see if their writing system are present.

Mark Davis's letter to Unicode

- M. Davis (Unicode) proposed that the Unicode Consortium take a look at Japan's popular picture-writing symbols

L2/06-369

Source: Mark Davis
Date: 2006-11-01
Subject: Symbols

==========

There are a number of symbol sets that are in widespread use, but currently can only be mapped to private use characters on input. The UTC should consider whether or not it would be useful to encode these, or some subset.

Symbol fonts use in mobile environments

DoCoMo's:
http://www.nttdocomo.co.jp/service/imode/make/content/pictograph/list/index.html and
http://www.nttdocomo.co.jp/service/imode/make/content/pictograph/list/list02.html ,

KDDI's:
http://www.au.kddi.com/ezfactory/tec/spec/pdf/typeC.pdf and
http://www.au.kddi.com/ezfactory/tec/spec/pdf/typeD.pdf ,

Vodafone:
http://developers.vodafone.jp/dp/tool_dl/download.php?docid=120 .

Symbol Fonts installed on a large percentage of personal computers

Webdings
Wingdings
Wingdings 2
Wingdings 3
others tbd...

Video interview with Mark Davies (Unicode co-founder)

- He tells the story of how brands approached Unicode and persuaded them to include emoji in the Unicode standard

Announcement: emoji in Unicode

- Unicode accept emoji in their standard

UNICODE

NEWS, ANNOUNCEMENTS, RELEASE INFO, AND CALENDAR UPDATES FROM THE UNICODE CONSORTIUM

TUESDAY, OCTOBER 12, 2010

Unicode Version 6.0: Support for Popular Symbols in Asia

The newly finalized Unicode Version 6.0 adds 2,088 characters, with over 1,000 new symbols.

A long-awaited feature of Unicode 6.0 is the encoding of hundreds of symbols for mobile phones. These emoji characters are in widespread use, especially in Japan, and have become an essential part of text messages there and elsewhere. Unicode 6.0 now provides for data interchange between different mobile vendors and across the internet. The symbols include symbols for many domains: maps and transport, phases of the moon, UI symbols (such as fast-forward) and many others.

LINKS OF INTEREST

What is Unicode?
The Unicode Consortium
Archived Announcements

BLOG ARCHIVE

- 2019 (12)
- 2018 (36)
- 2017 (46)
- 2016 (34)
- 2015 (35)

Unicode 6.0: List of emoji with codes and names

- The Unicode Consortium assigns a name (i.e. a standard meaning) and a numeric code to each emoji for the release of Unicode version 6.0.

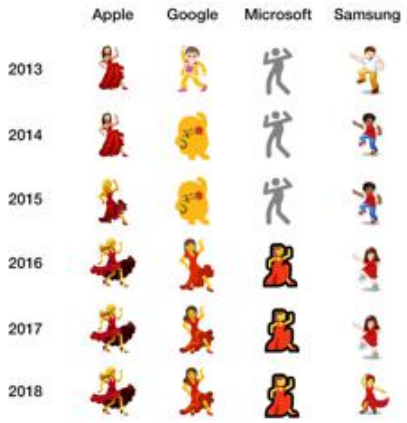
Unicode design guidelines + example

- Unicode gives design guidelines for standard emoji, e.g. which direction they should face

"Direction (whether a person or object faces to the right or left, up or down) should also be maintained where possible, because a change in direction can change the meaning: when sending "crocodile shot by police", people expect any recipient to see the pistol pointing in the same direction as when they composed it" (Unicode® Technical Standard #51)

Evolution of emoji across brands over time

- While the shape of the character can vary as long as it represents the standard meaning, Unicode suggests designers should maintain the same "core" shape, based on the shapes used mostly commonly in industry practice. Emoji across brands started gradually converging towards the same form



Educational activity "Icons for the world"

- An educational activity for adults and children run in hourly slots. Sign-up spots will be available in multiple places along the exhibition.
- Participants will play a Pictionary-style drawing game in groups. After a few rounds spent playing in the same closed group, players will then be repeatedly shuffled into new groups (this is a simplified version of the task in Granito, Tehrani, Kendal, Scott-Phillips 2019).
- The aim is to draw "icons for the world". The game simulates the evolution of graphical symbols in contexts of cultural contact as well as the design procedure of testing icons aimed at a global audience.

...but are emoji really universal?

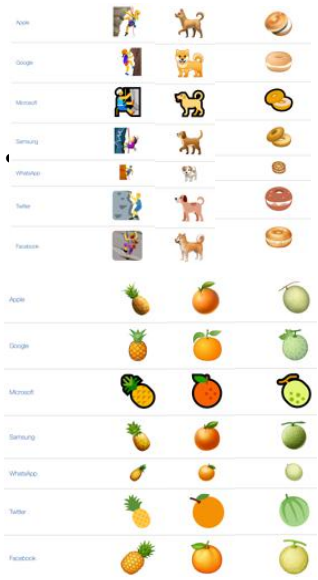
The universal aspiration of Unicode standard emoji might stay a utopia: emoji still vary in form and meaning

- Theoretical angle: languages evolve in their own ways through usage

Variation in form

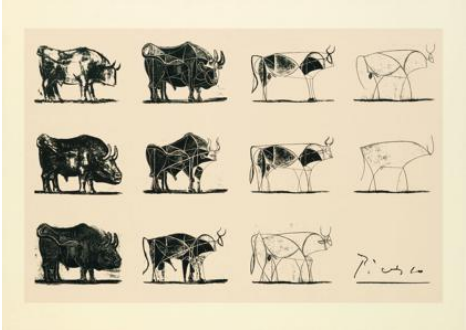
Emoji versions across brands

- The brands and services that implement emoji—smartphone manufacturers, messaging apps, chat clients—can interpret and design their standard meanings slightly differently, often to reflect their corporate image



Picasso's bulls

- There is more than one way to represent the same thing, and each has a different "feeling"



Video interview with emoji designer Colin Ford

- He talks about the multiple ways a certain thing can be represented, and how brands choose their emoji style

Variation in meaning

Ekman's universal faces of emotion

- A few emoji faces correspond to universal expressions of emotion identified by psychologists

Emoji faces with cultural nuances

- However, most emoji faces have different meanings in different cultures

In some cultures, this is an upset face

in China, this does not mean happiness, but implies distrust, disbelief, or even that someone is humouring you.

In China, the angel emoji, which in the West can denote innocence or having performed a good deed, is used a sign for death, and may be perceived as threatening.

Folded hands, person bowing and see-no-evil monkey

- Many emoji mean different things in different cultures

"Folded hands" have been commonly used as a high five, a prayer, Indian "namaste" but it actually came from "please" or "thank you" in Japanese culture that brought the emojis to Unicode in 2010.

The "person bowing", known as a "dogeza" in Japan which is used to express a sincere apology or a deep favour that many have misinterpreted as "person doing push ups", "excited", "cute person", "lying down for massage"

Commonly used in the West as expressing embarrassment, it actually means a wise person. The See-No-Evil monkey has hands covering his eyes, as part of the proverb "see no evil, hear no evil, speak no evil".

Examples of Emoji Slang

- Emoji can take on a completely different meanings than the institutional Unicode one. The have a life of their own once users use them.

penis

bum

Cuddles, hugs

opposition to Brexit

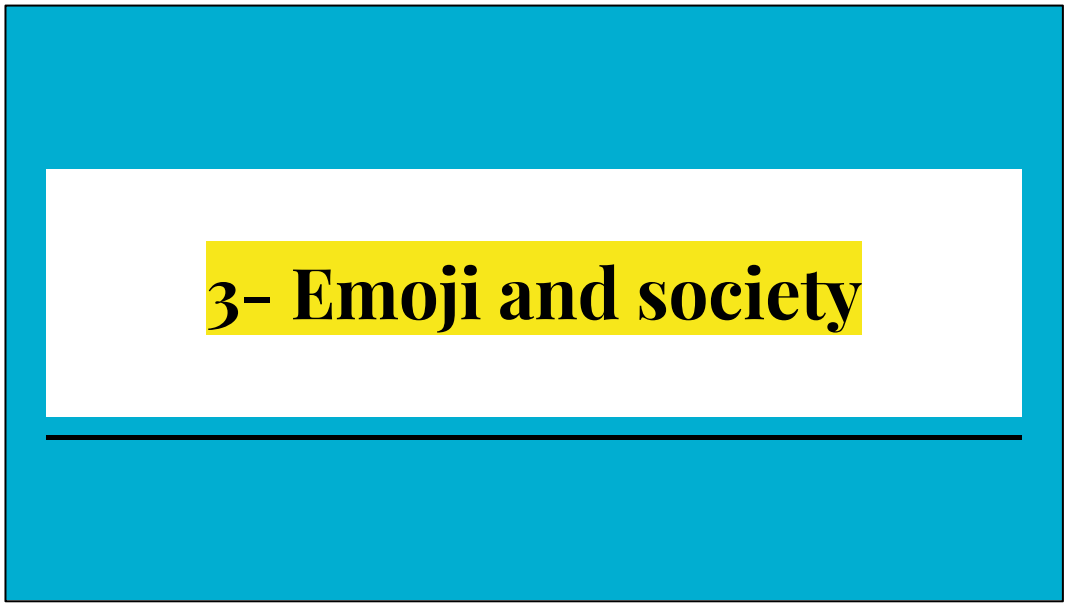
used to express an exasperated "I don't even know what to think anymore"

To be fabulous; to feel chill; it can also indicate that you are not bothered about something someone said about you

girls' night out, but also sex workers.

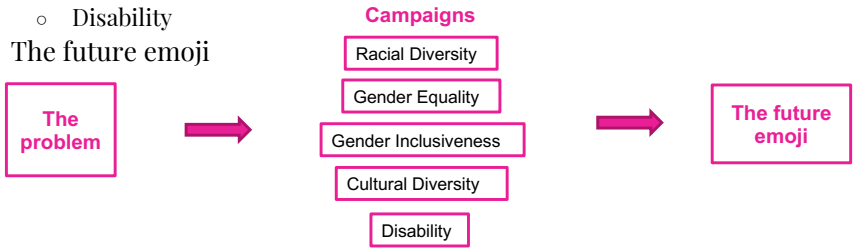
tattoo needle

This emoji is supposed to indicate someone running so hard they leave a trail of smoke behind them, but it now often serves as a symbol for vaping.



Structure for Section 3 – Emoji and society

- The problem
- Campaigns
  - Racial diversity
  - Gender Equality
  - Gender Inclusiveness
  - Cultural diversity
  - Disability
- The future emoji



The problem

Emoji are initially undiverse and biased: they depict a white male heterosexual world; users are unsatisfied

- Theoretical angle: initially, emoji were semantically poor, they depicted a narrow world

Wallpaper by Carla Gannis

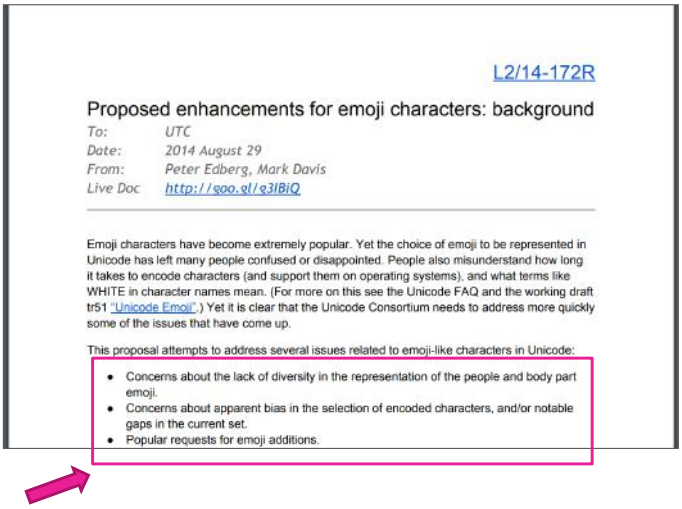
- Before 2015, emoji depicted a white male heterosexual humanity

Interview with Jennifer Lee (Emojination)

- She talks about power dynamics in the Unicode board and the issue of representation of minorities

Edberg and Davis' note to Unicode

- Users are not satisfied by the range of existing emoji



L2/14-172R

Proposed enhancements for emoji characters: background

To: UTC
Date: 2014 August 29
From: Peter Edberg, Mark Davis
Live Doc http://goo.gl/q3IBiQ

Emoji characters have become extremely popular. Yet the choice of emoji to be represented in Unicode has left many people confused or disappointed. People also misunderstand how long it takes to encode characters (and support them on operating systems), and what terms like WHITE in character names mean. (For more on this see the Unicode FAQ and the working draft tr51 "Unicode Emoji".) Yet it is clear that the Unicode Consortium needs to address more quickly some of the issues that have come up.

This proposal attempts to address several issues related to emoji-like characters in Unicode:

- Concerns about the lack of diversity in the representation of the people and body part emoji.
- Concerns about apparent bias in the selection of encoded characters, and/or notable gaps in the current set.
- Popular requests for emoji additions.

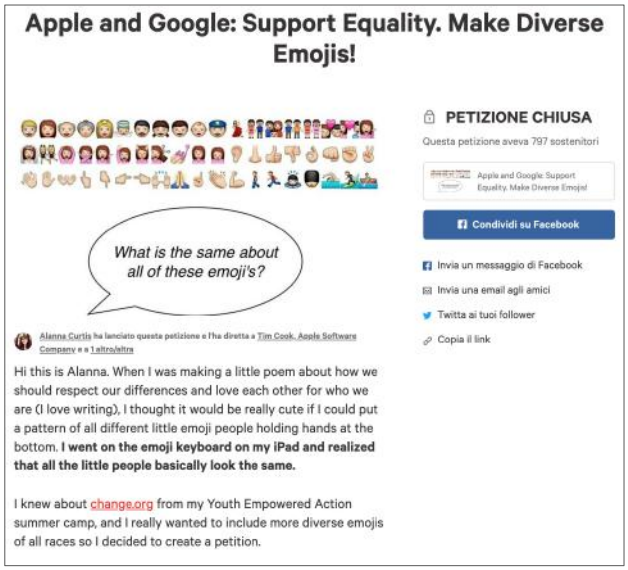
Racial diversity

People petition for a recognition of racial diversity in emoji humans

- Theoretical angle: emoji start increasing expressivity and become a more fine-grained representation of the world

Petition for racial diversity by Alanna Curtis

- People see emoji as a place to start social fights and claim the right to representation of under-represented groups



Apple and Google: Support Equality. Make Diverse Emojis!

What is the same about all of these emoji's?

PETIZIONE CHIUSA

Questa petizione aveva 797 sostenitori

Condividi su Facebook

Invia un messaggio di Facebook
Invia una email agli amici
Twitta ai tuoi follower
Copia il link

Alanna Curtis ha lanciato questa petizione e l'ha diretta a Tim Cook, Apple Software Company e a 1 altro/altra

Hi this is Alanna. When I was making a little poem about how we should respect our differences and love each other for who we are (I love writing), I thought it would be really cute if I could put a pattern of all different little emoji people holding hands at the bottom. **I went on the emoji keyboard on my iPad and realized that all the little people basically look the same.**

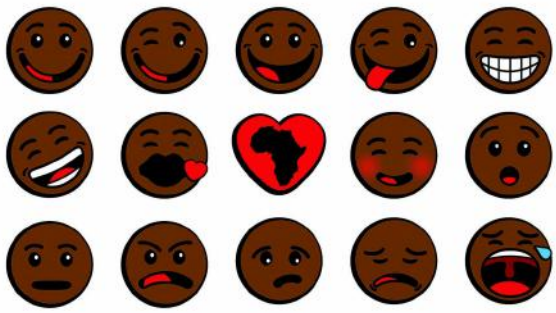
I knew about change.org from my Youth Empowered Action summer camp, and I really wanted to include more diverse emojis of all races so I decided to create a petition.

Miley Cyrus's tweet on racial diversity in emoji

- Vips support emoji campaigns and they go viral on social media

Oju Africa black smileys

- Oju Africa launched a set of "Afro" emoji



Skin tone palette

- Unicode accepts the petition and introduces skin colour palettes

Quickfire interviews

- Multiple short interviews about what people of colour think of the skin colour update: do they like it? Do they find it unnecessary?

Tinder's petition for interracial couples: tweet + video

- Tinder submits a proposal to Unicode for inter-racial couple emojis

Touch screen + live survey: Couples' emojis

- Unicode accepted Tinder's proposal for inter-racial couples.
  Visitors can tap their couple type; the survey results show how many couples are inter-race or same-race

Gender equality

People petition for an equal representation of women

- Theoretical angle: emoji keep increasing expressivity

Wallpaper: Emoji feminism

- Emoji had gender equality issues

NY Times op-ed by A. Butcher

- Emoji had a sexist representation of work

OPINION

Emoji Feminism

By Amy Butcher

March 11, 2016

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RECENTLY, upon notice that she'd received tenure, I texted a close friend to offer my congratulations. Later, I knew, we'd meet for drinks and celebration, but the day was early and I was thrilled, imagining her pleasure in her hard-won achievement.

I AM SO EXCITEDDDDDDD, I wrote, and as with any message of sincere and unparalleled sentiment, I thought to include emojis: the party hat, the airborne confetti, the two tumblers of light beer clinking. I sent these enthusiastically. Then I sent them again.

YOU DID IT! I wrote, following up with a unicorn. My friend was a rare and beautiful beast, yes — bounding over the mountainsides of academia.

But when she didn't respond — she was busy, I reasoned, what with being a now tenured unicorn — I began to wonder: *Why* a unicorn? Was she not, after all, a woman — a medieval environmentalist, a scholar whose work involved saints and conflicts and the power of places? She taught a class titled "Castles & Cathedrals" that had a waiting list as long as an Ohio winter.

Why, just months earlier, she'd spent a whole Saturday in a Panera Bread, translating Latin, hoping to find a firsthand account of anything remotely involving dolphins.

She was markedly a woman. She was by no means a unicorn. Where was the emoji for her?

I began to scroll through the emojis on my phone. Yes, there were women's faces, and tiny women's bodies. But for the women actually engaged in an activity or profession, there were only archetypes: the flamenco dancer in her red gown, the bride in her flowing veil, the princess in her gold tiara. There was a set of ballet dancers complete with bunny ears and black leotards, their smiles indicating that, gosh, they were so grateful to God and everyone, really, for this opportunity to pose for Playboy. There was a woman getting her hair cut, and another with her arm out, Valley Girl, osmosis ditz, as if to say, *Tenure? What is tenure? That sounds like an injury! Ow-i!*

Interview to the Google team which designed women at work emoji

- They talk about their reasons for proposing women at work, cultural stereotypes and how the “women at work” emoji were born

Women at work emoji

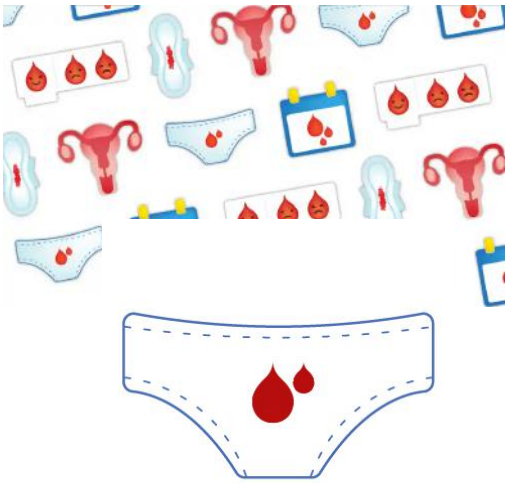
- Unicode accepts the proposal and includes women at work

Interview with Lucy Russel (Plan International UK)

- She explains why we need a period emoji, what is period shame and why it happens

Contest of period emoji

- Plan International UK launched a contest to choose the period emoji to submit to Unicode; the winner was the period pants



Blood drop emoji

- Plan International proposal was rejected. A drop of blood was included instead. Unicode justifications are unknown.

Quickfire interviews with women + M. Davies (Unicode)

- Davies explains Unicode's reasons behind the choice of the blood drop emoji. In parallel, women express their opinions: What do they think of the drop of blood as a period emoji? Are they satisfied?

Gender inclusiveness

People petition for a more inclusive, non-binary representation of gender

- Theoretical angle: emoji expressivity is booming

Interview with Paul Hunt, designer of gender-neutral emoji

- He talks about why gender-neutral emojis were needed, and how he designed a gender-neutral representation of a person

Gender-neutral emoji

- Unicode accepted the propos for gender-neutral emoji

Quickfire interviews

- Opinions from the LGBTQ community about the gender-neutral emoji

Cultural diversity

People petition for having cultural traditions represented in emoji

- Theoretical angle: emoji expressivity is booming

Interview with R. Alhumedhi, proponent of hijab emoji

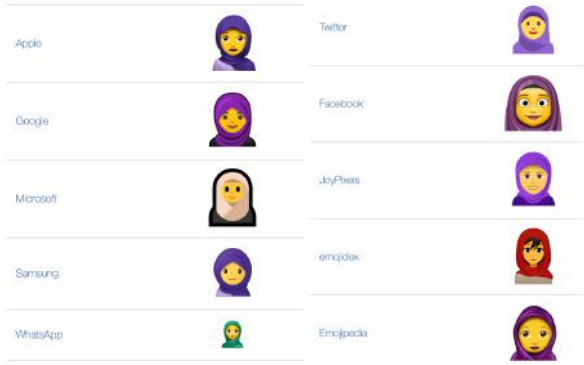
- She explains why she wanted a hijab emoji and how that would help Muslim women

Prototypes of headscarf emoji

- Hundred million Muslim women were not represented in emoji

Headscarf emoji

- Unicode accepted the proposal and included the headscarf emoji

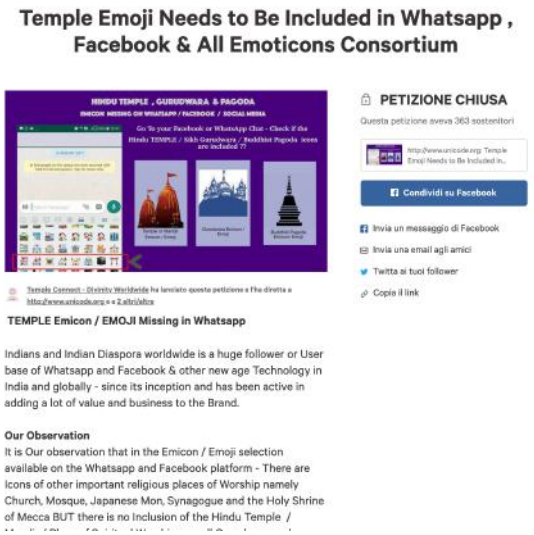


Quickfire interviews

- Opinions: What do Muslim women think of the headscarf emoji? Do they feel represented? What about the veil style?

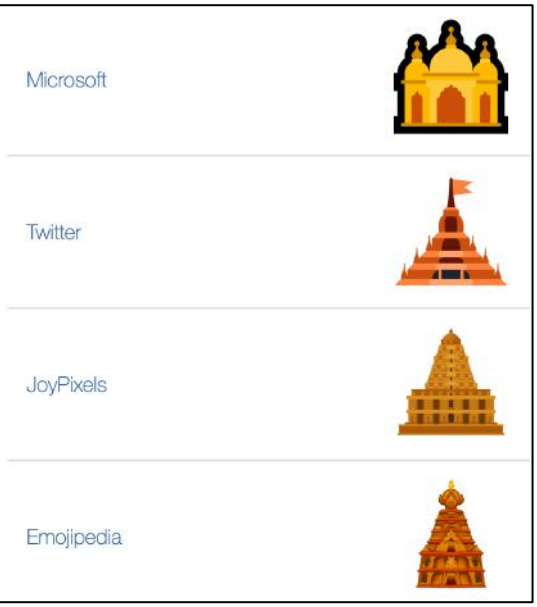
Petition for a Hindu temple emoji

- While other religious temples were included in emoji, Hindu temples weren't



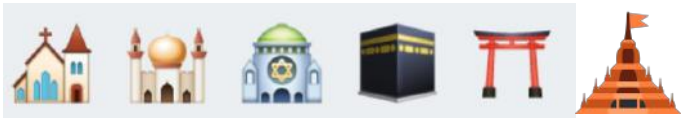
Hindu temple emoji

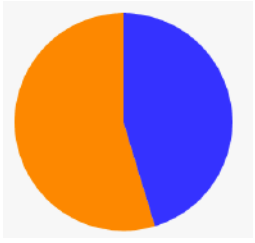
- Unicode accepted the proposal and included a Hindu temple emoji



Live Survey: "Are your beliefs represented? Y/N"

- By participating in the live survey, visitors can have an idea of how good a job Emoji is doing in representing world's religions





Disability

People petition for a having disabilities represented in emoji in a varied and positive way

- Theoretical angle: emoji expressivity might limit usability

Interview with P. Talbot (Scope)

- He explains why disability inclusive emoji are needed

Prototypes of disability emojis

- So far, there has been one generic icon (person on wheelchair) for disabilities; new emoji have been proposed for representing a variety of disabilities in a positive way

Disability emojis

- Unicode added a set of emoji fo specific disabilities

Quickfire interviews

- Opinions: What do disabled people think of the new emojis? Do they feel represented? Do they use them and how?

Carla Gannis, "The Garden of Emoji Delights" (or ad hoc work)

- Emoji are gradually changing to represent a diverse world

The future emoji

Emoji seem to be growing with no limitation

- Theoretical angle: will emoji sacrifice compressibility for expressivity? Will there be a limit?

Prototypes for new emojis by Emojination

- More emojis are going to be submitted every year

Audience contribution

- What emoji would you like to have, and why? Sketch your emoji and pin it on our wall

Call to action – QR code (or similar technology)

- Would you like to submit an emoji proposal? Download the help package (it includes guidelines and template documents for the submission to Unicode); in collaboration with Emojination

A.3.3 Interview template for curators/heads of exhibitions of potential venues

Programming

1. How do you go about programming for your organisation?
2. Could you give me an overview of the decision-making process?
    a. What are your timelines for decision making?
    b. Who are the decision makers?
3. Do you have formalised criteria for selection? How do you evaluate what projects are appropriate and what are to be excluded? Are there specific things you look at?
4. What materials/documents do you need to assess a proposal?
5. Are there things/approaches/outputs that you always expect to have as part of your exhibitions? E.g. accompanying event, producing a leaflet or catalogue, audio guide, children's interpretation activities...

Audience

How do you define your audiences?

Budgets and resources

1. How is the organisation funded?
2. Could you give me an overview of the types of resources you have in house and what you have to look for externally? [E.g. technicians, conservation, framing services, AV hardware and maintenance, marketing, showcases, building walls…
3. What in-house curatorial staff do you have? How do they develop their collaboration with external curators for shows that are proposed to them?
4. when you are working with external partners/proposals, how are your in-house curators involved in the process of developing the exhibition?
5. Do you expect to work your collections into all their exhibitions?

Space/location

1. Are there considerations on infrastructures that impact on how you deliver your shows and what they can achieve?
2. What spaces do you programme for temporary exhibitions?
    a. What's their scale?
    b. What's the architectural nature?
    c. What's their position within the building?
    d. What facilities do they have, e.g. do they have environmental controls?
3. Do you have floor plans of their galleries that you can possibly share with us?

A.3.4 Exhibition brief template

Institutional purpose and content

[For each venue, list their main programming criteria and requirements and how the theme you selected meets them]

Venue 1	
Why did you select this venue?	
Institutional purpose (programming criteria, requirements, mission…)	How your theme is relevant to their purpose

Institutional purpose and audiences

[For each venue, list their audience segments; then list the segments you selected as the exhibition's target; also specify the segmentation system used to profile them]

Venue 1	segment 1 | segment 2 | segment 3…
Venue 2	segment 1 | segment 2 | segment 3…
…	…
Exhibition target audiences	Segment 1 | segment 2 | segment 3…
Segmentation system	

Audiences and content

[For each target audience, list their most salient traits (needs, interests, motivations) and general principles of what the exhibition should offer to fulfil them (kind of stories, kinds of objects, style of interpretation, mode of engagement, ideas for programme of activities, educational activities etc.)]

Segment 1	
Who are they? Needs and interests	What should the exhibition offer?

A.3.5 Content package slide template

Name of item

[Object, photograph, video, audio, book, analogue interactive, digital interactive etc.]

1. What story does it tell?
2. What theoretical notion does it stand for?
3. Mode of engagement: is it an interactive? Is it digital or analogue? Are there any parts to highlight and how? Is it illustrated by a video/audio description?