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Gravettian hand stencils as sign language formatives

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Several Upper Palaeolithic archaeological sites from the Gravettian period display hand stencils with missing fingers. On the basis of the stencils that Leroi-Gourhan identified in the cave of Gargas (France) in the late 1960s, we explore the hypothesis that those stencils represent hand signs with deliberate folding of fingers, intentionally projected as a negative figure onto the wall. Through a study of the biomechanics of handshapes, we analyse the articulatory effort required for producing the handshapes under the stencils in the Gargas cave, and show that only handshapes that are articulable in the air can be found among the existing stencils. In other words, handshape configurations that would have required using the cave wall as a support for the fingers are not attested. We argue that the stencils correspond to the type of handshape that one ordinarily finds in sign language phonology. More concretely, we claim that they correspond to signs of an 'alternate' or 'non-primary' sign language, like those still employed by a number of bimodal (speaking and signing) human groups in hunter–gatherer populations, like the Australian first nations or the Plains Indians. In those groups, signing is used for hunting and for a rich array of ritual purposes, including mourning and traditional story-telling. We discuss further evidence, based on typological generalizations about the phonology of non-primary sign languages and comparative ethnographic work, that points to such a parallelism. This evidence includes the fact that for some of those groups, stencil and petroglyph art has independently been linked to their sign language expressions.

This article is part of the theme issue 'Reconstructing prehistoric languages'.

1. Introduction

Representations of human beings are scarce in Palaeolithic cave art. There are, of course, some depictions such as the 'hommes blessés' of Cougnac and Pech-Merle [1], the 'sorcerer' of Grotte du Sorcier [2], or the man of the 'Scène du Puits' in Lascaux [3], but their number is strikingly low compared to the abundance of game animals (such as bison, aurochs, horses, deer or mammoths) across many sites in Western Europe. However, there is an exception to such a pattern: hand stencils are some of the most representative images of Gravettian Palaeolithic art. In Europe alone, up to 619 hand stencils have been attested [4], but the phenomenon of hand stenciling in rock art also extends to other regions of the world, from Patagonia [5] to Borneo [6] and Timor-Leste [7]. However, there is a particularity in the Franco-Spanish region of Western Europe: several archaeological sites display hand stencils with missing fingers (figure 1).

Notable numbers of hand stencils with missing fingers can be specially observed in the French sites of Gargas [8], Cosquer [9], Tibiran [10] and the Spanish Maltravieso [11] and Fuente del Trucho [12,13]. Isolated mutilated hands also appear occasionally, as in the Grand Grotte of Arcy-sur-Cure [14], in Margot [15], in Altamira [16], in Chauvet [17] or in Erberua [18], among many others [4].

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Figure 1. Stencils in Gargas (photo © Y. Rumeau).

Such paintings are not the mere output of mindless doodling, rather, they require planning, carrying the pigment and lighting material into chambers of difficult access deep within the cave, and often times they seem to be placed in specifically chosen placements in the wall [8,13,19–23]. Furthermore, the blowing painting techniques employed are sophisticated, and often require the joint participation of several individuals for their production, since they require lighting, model placement and pigment application, as is obviously the case for hand stencils of infants and children which are sometimes attested to in inaccessible and/or dangerous sites (e.g. [13,19–21]).[1]

The traditional hypotheses about the stencils not displaying all the fingers revolve around the idea that fingers were really missing when performing the stencils, conjecturing that this might be due to either of two main reasons:

— Accidental (unintended) loss, which would be caused by frostbite, due to the harsh climate of the Ice Age [13,25,26], or by pathological loss of phalanges and fingers (caused by conditions such as acute arteritis, syphilitic arteritis, arteriosclerosis, embolism, diabetic gangrene, obstructive thromboangiitis, severe meningococcal infection, Lesch-Nyhan Syndrome or Raynaud's disease [27–30]).
— Deliberate mutilation, conceived as being for sacrificial offerings, magical and initiation rites, medical treatments or punishments [31–38].

Interesting as they are, we believe that such conjectures do not fit the patterns attested in the caves, nor the comparable ethno-archaeological records. As a matter of fact, European Palaeolithic caves display hand stencils of all sorts of individuals (babies, infants, adolescents and adults of both sexes [13,20,21,37,39–43]) which does not correspond either to the unintended loss or to the deliberate mutilation hypotheses. Such prevalences of pathologies across all segments of a population are not attested, not even among societies living in comparable climates. Likewise, the mutilation hypothesis seems to us not to be tenable. Actually, finger mutilations (as a *pars pro toto* aetiology of sacrificial offering) are not uncommon across human cultures, and are attested since Classical Antiquity (cf. [44,45]) but the mutilation of all the fingers of a hand (which would correspond to the most common configuration 'O' in Gargas, see figure 2) is unattested as a population-wide practice; and there may be good functional reasons for this, since the amputation of all the fingers would plainly be an impediment in a hunter–gatherer society such as those of the European Gravettians. Furthermore, attested voluntary mutilations (either for sacrifice [47], mourning [48], identity-marking [49], medical procedures [50], marriage [51] or even punishment [52]) typically start from the distal phalanx of the pinky finger (cf. [37,53]), *contra* the patterns attested in Gravettian hand stencils (see, for instance, figure 2, where the configuration with a missing pinky finger (E) is only attested once in Gargas). What is more, bent fingers in stencil paintings and pluridigital finger flutings are well attested in Gravettian caves[2] [1,8,13,19,54]. Besides, stencils such as those in Gargas or El Castillo can and have been replicated experimentally by folding the fingers [55–58]. Last, even if hand stencils (negative images of hands) are much more abundant than handprints (positive images of hands), some handprints are still attested in caves such as Chauvet [59] or Pech-Merle [1], and in these cases, no evidence of mutilated fingers is attested, since they present the five fingers uncut. We will, therefore, conclude that even if pathological loss and sacrificial amputation of fingers do exist (or have existed), losing (voluntarily or involuntarily) several fingers is still a very marked event among humans, and it does not fit well with the patterns attested in Gravettian stencils.

In turn, alternative interpretations of the significance of these paintings—starting with Leroi-Gourhan's assessment of the Gargas stencils in the late 1960s—conjecture that those forms could be meaningful: they represent hand configurations resulting from the deliberate folding of one or several fingers, which are intentionally projected as a negative figure onto the wall.

The issue, then, is what kind of signs these could be. Archaeological work talks loosely about conventional signs, pieces of an organized code system that could be associated with counting, hunting or with other important community occasions [46,60,61]. Here, we set out to specifically explore the hypothesis that the so-called mutilated hands represent the type of hand configuration that one ordinarily finds in the phonology of natural sign languages. In other words, that the handshapes in these cave walls are sign language formatives.[3] For this, we apply a decompositional analysis of handshapes which was designed for sign language phonetics (Ann's [63,64] 'Ease of Articulation Scores') to the study of the handshapes in Palaeolithic stencils. We examine the handshapes in the cave of Gargas (France)—the cave that displays the most and best preserved hand stencils—and compare them with the hand configurations which are (and are not) possible in natural sign languages, concluding that all the handshapes under the stencils correspond to handshapes available across natural (sign) languages. In a nutshell, there is not a single stencil whose corresponding gesture and finger disposal could not be produced as a manual gesture in the air, i.e. no gesture that requires the support of a wall to be articulable (§3). This provides support to the hypothesis that hand stencils are representations of hand gestures of an 'alternate sign language' [65] such as those employed by non-deaf communities like the Australian First Nations [65], or the American Indian nations of the Great Plains (Plains Indians Sign Language (PISL), cf. [66]), which besides their spoken languages, also employ alternate sign languages for rites, special community occasions, or as a *lingua franca*—even more so, given that there is evidence linking the origin of their parietal art to their sign languages, both for Australian

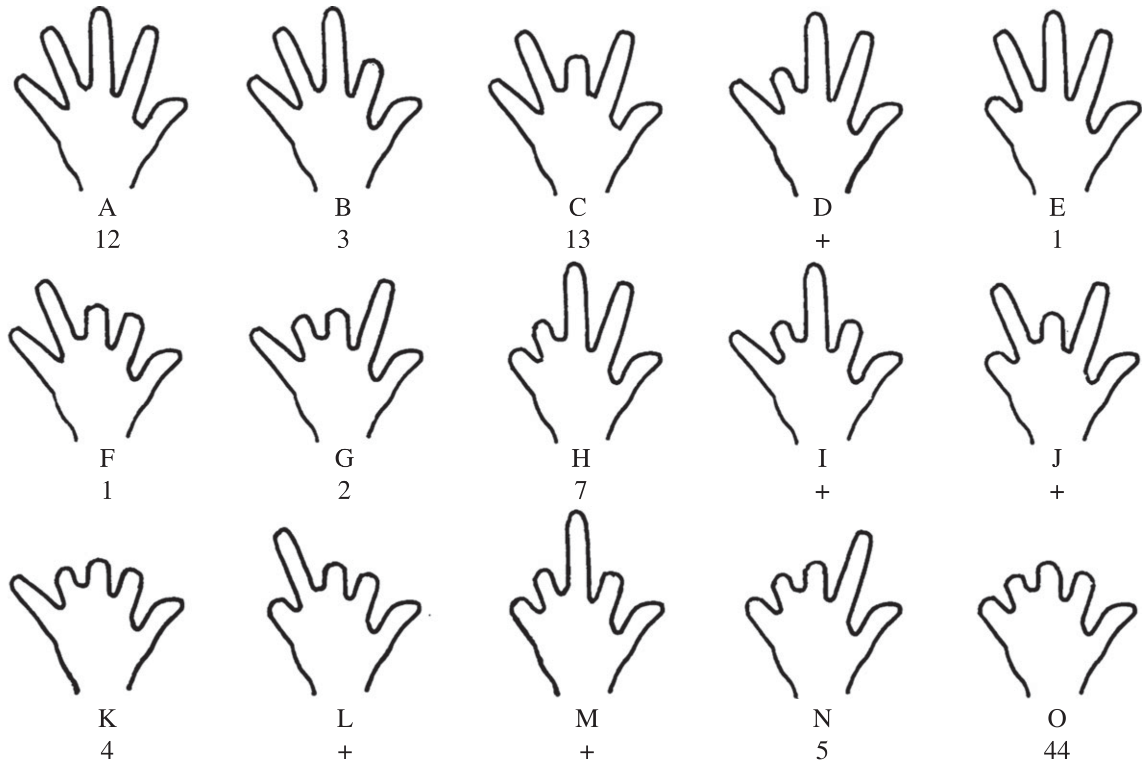

Figure 2. Array of handshapes corresponding to Gargas stencils (from Leroi-Gourhan [46, p. 109]). The numbers below represent the number of appearances in Gargas. Configurations identified by a cross are not attested.

nations (cf. [67–69]) and for Plains Indians (cf. [70–75]). As we will discuss in §4, the patterns attested in Gravettian hand stencils abide by universal patterns and constraints that rule the phonology of (alternate) sign languages.

2. Methods

Functional constraints play a relevant role in the shaping of natural languages (see [76–78]). In the realm of phonetics and phonology, Ohala [79], Westbury & Keating [80], Hayes & Steriade [81] and others propose that the sound patterns attested across languages are effectively arranged in order to facilitate the ease of articulation and distinctness of contrasting forms in perception. In a similar fashion, within the sign language literature, researchers underline the correlation between ease of articulation and ratio of occurrence of specific handshapes, such that within a given language a handshape which is difficult to articulate will be rare, while a handshape which is easy to articulate will be common [63,82,83]. In particular, Ann [63,64] proposes a decompositional algorithm for determining whether a handshape is easy, hard or impossible to articulate, based on the physiology of the hand and forearm. She proposes the following three biomechanic criteria, assigning them variable scores depending on the difficulty they bring about for articulation:

1. *The Independent Extensor Criterion* (IEC): whether a finger has an independent extensor, in addition to a tendon of the common extensor (the thumb, index and pinky have independent extensors and the middle and ring do not). If it does have it, it is assigned a value of 0, if it does not, a 1 (that is, higher values represent increases in difficulty).[4]
2. *The Profundus Criterion* (PC): whether all members of the set <middle, ring, pinky> act together (which is motivated by the physiology of the flexor digitorum profundus). If they do = 0; if they do not = 1.
3. *The Muscle Opposition in the Configuration of Selected Fingers Criterion* (MOC of SFC): handset configurations which require only one muscle group show no evidence of opposition between muscle groups, while configurations which require two muscle groups could, in principle, show some amount of opposition (where a configuration requiring both extensors and flexors has maximal opposition). It assigns different values to different configurations of handshapes: curved = 3; extended = 2; bent = 1; closed = 0.

The Ease of Articulation Score (EAS) of a handshape will then be calculated with the following formula:

$$(\text{IEC} + \text{PC}) \times (\text{MOC of SFC}) = \text{EAS}.$$

EAS values then reflect the ease of articulation of handshapes, which Ann [63,64] clusters within the following thresholds: 0: easy; 2: articulable; greater than or equal to 4: unarticulable.

We employ this metric of sign language phonetics to analyse the handshapes under the stencils in Gargas (figure 2), assuming as in the dedicated experimental archaeology literature that such stencils were produced with the palm against the wall.

3. Results

The results of the EAS analysis of the handshape configurations in figure 2 show a clear pattern. This is summarized in table 1, where we provide the IEC, PC and MOC of SPC values for each handshape and their occurrences in Gargas.

There is in table 1 a last possible configuration which is not represented in figure 2 by Leroi-Gourhan [46]. We call this configuration ‘P’ and that would correspond to the extension of ring and middle fingers, while folding the index and pinky. Its EAS is 4 and it has no occurrences in the data.

As is patent, all the articulable handshapes are present among the stencils (except D), but none of the unarticulable handshapes is represented in the cave (those with an EAS $\geq$ 4, i.e. configurations I, J, L, M and P). These are handshapes that are unarticulable *in the air*, but they are perfectly articulable

Table 1. IEC, PC and MOC of SPC values and EAS score for each handshape type and their corresponding appearances in Gargas (according to Leroy-Gourhan, [46]. See figure 2). Values greater than or equal to 4 are unarticulable.

configuration	IEC	PC	MOC of SPC	EAS	appearances (Gargas)
A	0	0	2	0	12
B	0	0	2	0	3
C	0	1	2	2	13
D	0	1	2	2	0
E	0	1	2	2	1
F	0	1	2	2	1
G	0	1	2	2	2
H	0	1	2	2	7
I	1	1	2	4	0
J	1	1	2	4	0
K	0	1	2	2	4
L	1	1	2	4	0
M	1	1	2	4	0
N	0	0	2	0	5
O	0	0	2	0	44
P	1	1	2	4	0

against the support of a cave wall. For instance, configuration L is unarticulable, given that the ring finger does not have an independent extensor, and fully extending it to leave it in linear continuity with the back of the hand while the middle and pinky fingers are curled is anatomically inviable. But such a restriction disappears against a (cave) wall; the wall itself can play the function of the extensor, helping to raise the finger.

In a nutshell, the handshapes present in Gargas correlate with handshapes that can be produced as signs.[5] In the next section, we discuss the possibility that they may be signs of alternate sign languages, as modern populations employing this type of language such as the Australian First Nations or the Plains Indians also engage in stenciling and petroglyphing their hands, and the origin of such art has been independently linked to their sign language gestures.

4. Discussion and conclusion

Since Stokoe's [84] seminal work, sign language linguists have shown that, as in spoken languages, sign languages have sublexical structure that is systematically organized and constrained in a form analogous to phonological systems in the oral modality. It is widely acknowledged that the parameters of handshape, place of articulation, movement and orientation play a significant role at the phonological level in a similar way to the spoken language properties of place of articulation, manner and voicing, and that they underlie the basic feature geometry of sign language phonology (for a recent overview, see [85]; also [86,87]).

Admittedly, the hand stencils of the Gravettian period offer limited data for the hypothesis that they represent some sort of sign language: they only provide static handshapes.[6] The other important parameters of sign language phonology (particularly place of articulation and movement) are not directly expressed by the existing forms. Still, handshape is a crucial parameter in sign language phonology, with specific constraints that can be exploited as potential evidence for the presence of an underlying sign language.[7]

The special status of hand configurations in sign language articulation is made manifest by recent research focused on the differences between gesture and (linguistic) sign [88]. One important property of linguistic signs in relation to gestures is their stability, which appears to be grounded on Saussurean arbitrariness. In a nutshell, handshapes across different sign languages present a higher degree of arbitrariness in the composition of the sign in comparison to other components of signs such as motion or location. For instance, Schembri *et al.* [89] examine adherence to standards of form in event descriptions by studying signers of three historically unrelated sign languages (Australian Sign Language, Taiwan Sign Language and ASL). They find that signers of the same sign language use the same handshape forms to describe the events, and they differ from the handshapes used by signers of the other sign languages. By contrast, signers of all three languages used the same motion forms and the same location forms to describe the events. In other words, there is variability across signers of different languages in handshape, but not in place or motion. Schembri *et al.* also entertained the hypothesis that location and motion (but not handshape) reflect influence from gesture, and tested the hypothesis by asking English speakers who knew no sign language to use their hands rather than speech to describe the same events. Hearing non-signers, when asked to use only their hands to communicate information, invent gestures that resemble signs with respect to motion and location, but not with respect to handshape. Emmorey *et al.* [90] explored categorical perception for two parameters—hand configuration and place of articulation—in ASL signers and in hearing non-signers. They found that the ASL signers displayed categorical perception for hand configuration but not for place of articulation. The non-signers perceived neither parameter categorically. Finally, a recent neuroimaging study by Emmorey *et al.* [91] shows that production of both lexical signs and classifier constructions that require different handshapes engage left hemisphere language regions, while production of classifier constructions that require different locations or different motions, do not. In other words, if we have to look somewhere for an unequivocally linguistic dimension in the phonology of a sign language, hand configuration looks like the best option.

An important contribution of the pioneering work of Leroi-Gourhan [92] was showing that the animal and sign representations in the cave were not randomly distributed, but present correlations in terms of groupings of motives and spatial localization which imply some coherent patterning. Assuming that the hand stencils found in the Franco-Spanish caves are part of a closed semiotic system (as the recurrent hand patterns and their localization seems to suggest), handshapes afford, within the context of sign language phonology, a number of practical advantages over other parameters in sign language phonology that can be put to use in representing and identifying a linguistic sign. Representing movement or place of articulation (body location) would have been a much more difficult task, and

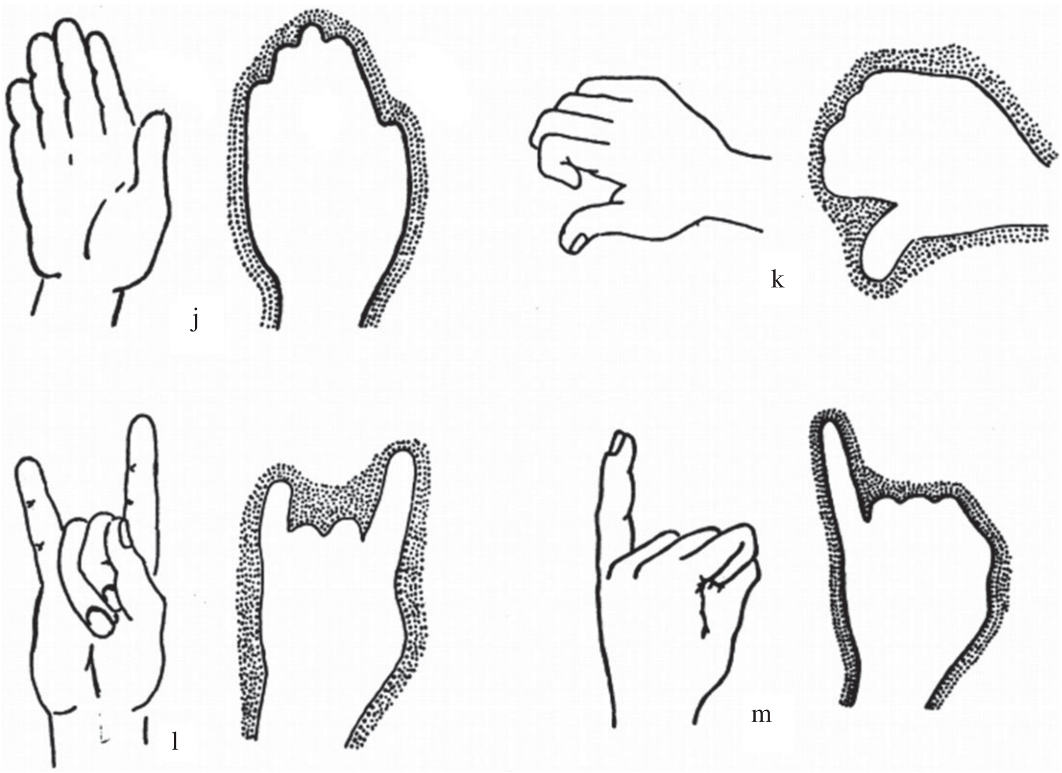

Figure 3. Correspondence between attested hand stencils in central Queensland (Australia), and alternate sign language handshapes employed in northwest central Queensland and recorded by Roth [68, p. 37]. Handshjape j corresponds to the sign for 'fish', k for 'here/in this spot', l for 'bad person (or thing)' and m for 'small caterpillar/grub'.

in any case, such a representation would have necessarily included handshape too. A useful phonological feature of the handshape is its relative stability in the signing gesture: the number and the choice of selected fingers do not change (the 'Selected Finger Constraint', [82]); only aperture features can change within a stem [85, p. 172]. The handshape may also be at the source of handshape–location correlations: signs with a 'marked' handshape are more frequently produced in the region of the head and the neck than at the trunk and arm ([87,93,94] for ASL, 75%).[8] This should make it possible, at least in some instances, to infer location from handshape. Also, one-handed signs are much more likely to occur in the region of the head and the neck than two-handed signs. Brentari [85,96] also shows that handshape, syllabicity and morphological boundaries go together to a large extent, so the minimal meaningful units in sign languages tend to correspond to specific handshape configurations. The higher degree of iconicity of sign languages as opposed to spoken languages may also enhance the identifiability of particular classes of signs through handshape, such as classifier signs.

The hypothesis that hand stencils represent formatives of a sign language may look like an unexpected one. The primary sign languages we are most familiar with (say ASL, British Sign Language, Hong Kong Sign Language, but also newly emerging languages like Nicaraguan Sign Language, see [97]) are found in signing communities which are almost totally constituted by deaf people, and evolve in a social context in which spoken language is hegemonic and sign language is employed by a distinctive minority. Sign language is usually transmitted there outside the family context, through schools or other purposeful socializing and educational environments, which seem completely at odds with our understanding of the ordinary life of human groups of the Upper Palaeolithic.

Another context in which sign languages develop is in stable and small-scale communities in which there is a high incidence of deafness due to genetic factors. These signed languages have been called 'village' or 'rural' sign languages [98,99]. Martha's Vineyard' Sign Language is a familiar instance of this class [100], as are the more recently described Al-Sayyid Bedouin Sign Language [101,102], and several others. It is unlikely though (but not impossible) that the special hand stencils in the Western European region correspond to a genetically determined high incidence of deafness. Although the relatively small size of the human groups at the time may favour the spread of genetic mutations (such as those involved in unusually high rates of deafness in a population), several reasons argue against this idea: (i) the statistical rarity of such special communities across present-day populations, including isolated ones, suggests that we may assume this to be a feature of Upper Palaeolithic populations too. This must be combined with the scarcity of the archaeological remnants that have made it to our times. The combined low probability of both events makes it highly doubtful that the hand stencils correspond to a 'village' or 'rural' sign language in the mentioned sense. (ii) Shared sign languages are dependent on a very unstable ecology, that can be modified by small changes in the gene/mutation ratios. The Martha's Vineyard Sign Language spoken between the seventeenth and the early twentieth century disappeared for exactly that reason. In the Western European context, we are talking about an archaeological feature that is temporally bounded, but potentially spans across millennia within the cultural period called the Gravettian.

A more important reason to discard the rural or village language hypothesis comes from the fact that there is a more apt candidate for a plausible scenario in which a sign language could have developed in that period. Within the rich typology of sign language types attested across the world, together with the sign languages associated with the presence of a deaf population, we must also count non-primary sign languages that do not imply the presence of an uncommonly high deaf population. As a matter of fact, bimodal bilingualism (oral and signed language bilingualism) is a relatively common feature among hunter–gatherer societies, and does not depend on the presence of a deaf population. This is the environment in which the sign languages that have been called 'alternate' have developed [65]. One of the first descriptions of an alternate sign language is due to Walter E. Roth at the end of the nineteenth century [103]. He carefully analysed many of the signs used in the sign language of the Queensland First Nations. The Queensland communities that he described were bimodal bilinguals. His informants were speakers of several languages of the Boulia region in northwest Queensland (e.g. Pitta-Pitta), and signers of a regional language. Walsh [68] explicitly compared those signs with the hand stencils in the Queensland rock art, and pointed out their striking parallelism (figure 3).[9] Alternate sign languages arise quite naturally in contexts in which there is a cultural niche that favours the use of sign language: Divale & Zipin [108] suggest that all traditional cultures involving alternate sign languages have a primary dependence on hunting for subsistence. The advantages of a signed language for hunting are evident, but the relevant cultural niche may also include other features, such as mourning rituals that forbid spoken language for long periods [65], or the need for a neutral language for communication across a highly diversified oral language landscape. Similar cases of bimodal bilingualism have been studied in North America (Plains Indians [66][10]; Nunavut (Inuit) [111]), Mesoamerica (Guatemala, [112]), Europe (Armenia, [113]) and Africa (Khoisan [114]).

Alternate sign languages seem to display a number of specific typological features in relation to primary sign languages that look particularly helpful for meeting the challenge involved in mapping a sign language by means of hand stencils. First of all, Kendon [65] notes for the North Central Desert sign languages of Australia that the use of the face as part of the sign is rare, so the absence of face representations associated with the stencils is perhaps less problematic here. He also notes that the large majority of signs are one-handed signs (about 80%), unlike in primary sign languages, in which most signs are two-handed. Bauer [115] observes that in Yolŋu Sign Language, 66% of the signs of her data corpus are one-handed. Fehn & Mohr [116] claim that about 78% of the signs in the Ts'ixa hunting language are one-handed. Likewise, similar observations are made for PISL [117]. The stencilling technique that involves spraying paint over an immobile hand (typically the left hand) placed against the wall is specially apt for the representation of one-handed signs. Kendon [65] also notes that about two-thirds of the signs in North Central Desert Sign Languages are articulated in neutral space, a default space in front of the signer. This takes away some of the potential ambiguity of the stencilled sign in relation to its location parameter. The degree to which all those features characterize the set of alternate languages varies,[11] but there seems to be a tendency to reduction in some key aspects of the phonology of sign languages. The possibly more restricted system that characterizes the phonology of alternate sign languages may have favoured the development of a graphic representation through stencilling.[12] We think that this is the right scenario in which to address the Gravettian incomplete hand stencils of the Franco-Spanish area.

This paper presents the hypothesis that the so-called incomplete or 'mutilated' hand stencils found in cave art of the Upper Palaeolithic Gravettian period is the result of purposeful replications of handshapes that may be part of repertoires of signing. We used an algorithm applied to sign language to determine the articulability of handshapes based on biomechanical criteria, and we evaluated the relative difficulty of the hand stencils *qua* signs described by Leroi-Gourhan in the cave of Gargas with regard to those criteria. We concluded that they are within the normal range of articulable signs in sign language. They do not require the support of a solid surface. We made a further connection between those signs and the widespread bimodalism (signing and speech bilingualism) that can be observed in hunter–gatherer populations, which is at the origin of the category of 'alternate sign languages' described as part of the typology of signing languages. If this hypothesis is right, the Gravettian hand stencils may be the oldest attested instantiation of writing.

Data accessibility. This article has no additional data.

Authors' contributions. Authors are listed in alphabetical order. Both authors participated in all stages of research and share full authorship.

Competing interests. We declare we have no competing interests.

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Endnotes

[1]Furthermore, occasionally, as is the case in Gargas, an adult's wrist can be observed sustaining an infant's hand against the wall. Likewise, forensic analyses of finger flutings in these caves also attest the joint authorship of the hands of several individuals in the creation of finger flutting panels [24].

[2]In Gargas for instance, the most common stencil is the one in configuration 'O', i.e. one where all the fingers except the thumb are absent (see figure 2). Notwithstanding, the cave displays large amounts of Rugolean and Mirian finger flutings on ceilings, on walls and within crevasses in the Lower Chamber, which require the joint action of several fingers (cf. [8,54]).

[3]This hypothesis includes the possibility that some of the hand stencils may represent numbers in a counting system. As a matter of fact, beyond deaf populations, many speaking communities also employ manual counting systems (cf. Brookes & Nyst [62] and references therein). The counting hypothesis for Palæolithic stencils has been independently suggested by Rouillon [60], who studies the possibility that hand stencils in Cosquer may represent counting series. Overmann [61], who studies stencils in Gargas and Cosquer as expressions of a counting system, suggests that at least some of the handshapes (those that present non-sequential extended fingers, such as K, F, B, C and G) may require a non-numerical interpretation.

[4]Alternatively, middle and ring fingers can be fully extended due to the juncturae tendinum (e.g. in configurations with an immediately adjacent 'independent extensor finger'. Under this circumstance, 'the middle and ring behave as if they have an independent extensor' [63, p. 156]). As a consequence, in a configuration such as F in figure 2, the IEC value will be 0. See Table 1.

[5]An anonymous reviewer comments that handshape C is not highly frequent in the world's sign languages, but that here it appears in a high proportion of stencils. This high frequency could support a hypothesis whereby these are emblematic handshapes, given that

in current deaf sign languages where this handshape does occur, it tends to be treated as a bit special or it is associated with certain clusters of lexical morphology. We leave this issue open for further research.

[6]Plus maybe their orientation and pigment choice.

[7]Note that, likewise, writing in, for example, Latin script does not represent all the grammatical aspects of a spoken language either; all the suprasegmental information, syllabification, prosodic phrasing, accent and intonation are typically absent (as in this text, where only a subset of the segmental information is represented).

[8]More recent work by Rozelle [95] on the dependency between the handshape and the location parameters in four unrelated languages (Finnish Sign Language, New Zealand SL, American SL and Korean SL) yields non-uniform results, with Finnish and New Zealand SLs showing a significant dependency between location and type of handshape, and American and Korean SL showing virtually none.

[9]Walsh was impressed by the similarity of the incomplete hand stencils that he found in central Queensland and some of the hand sign language recorded by WE Roth 600 km west of where those stencils were found, so the connection between the two things relies on an assumption of cultural continuity, as pointed out by a reviewer. Kendon [65] describes the geographical extension of sign language among the aboriginal people in the following way: it is common in central and north-eastern Australia, including Arnhem Land and western Cape York; it is either absent or much attenuated in the northern parts of the region further to the west. It appears to have been widely used in the Western Desert, but evidence for sign language in the extreme west and the south is scant. As far as we can tell, hand stencilling in rock art is properly included in the regions where sign language has been in use (see [104]). Chronological information about hand stencils in Queensland is rare. A study by Goodall *et al.* [105] of the hand stencils at Fern Cave (Chillagoe Region in north Queensland) suggests they were produced in between 4000 and 1000 years BP. Studies of rock art in western Arnhem Land provide earlier chronologies (see [106,107]).

[10]Remarkably, the PISL has been employed in a wide geographic area (extending from British Columbia and Saskatchewan, to south of Rio Grande) by speakers of at least 40 distinct spoken languages (of different families: Algonquian, Athabaskan, Caddoan, Eskimo-Aleut, Iroquoian, Kiowan, Salishan, Siouan, Uto-Aztecan, Zuni, etc.) but it has been restricted to nomadic populations: 'It seems never to have extended west of the (Rocky) mountains, except among the Nez Percés and other tribes accustomed to make periodic hunting excursions into the plains, nor to have attained any high development among the sedentary tribes in the eastern timber region' [109, p. 567]; 'Those who do the most travelling and meet the greatest number of people of a different tongue, have the greatest necessity for its use, and when this need dies away for any cause, the sign language falls at once into decay and is soon forgotten, surviving only in tradition and inherited gesture'. [110, p. 211].

[11]Bauer [115], for instance, observes that in YSL, facial movement is frequent as part of the sign, and that the signing space includes areas unlike those available in primary languages, and larger than neutral space (the whole body perimeter).

[12]The supposedly reduced status of the phonology of alternate sign languages is an open issue. See the recent work by Jorgensen [118], that applies Brentari's [96] model to the phonological structure of an Australian alternate sign language, the Western Desert Balgo sign language. See also [115,119–121] for partial descriptions of sign actions—typically focused on handshapes—in signing communities in other parts of the Western Desert and in Arnhem Land.

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