Handshape is the hardest path in Portuguese Sign Language acquisition
Towards a universal modality constraint

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Sign languages have only been acknowledged as true languages in the second half of the 20th century. Studies on their ontogenesis are recent and include mostly comparative approaches to spoken language and sign language acquisition. Studies on sign language acquisition show that of the manual phonological parameters, handshape is the one which is acquired last. This study reports the findings of a first pilot study on Portuguese Sign Language (\textit{Língua Gestual Portuguesa} — LGP) acquisition, focusing on a Deaf child from 10 months until 24 months of age, and it confirms the pattern previously described for other sign languages. We discuss possible reasons why handshape is harder to acquire, which relate to neuromotor development and perceptual issues, and we suggest that auditory deprivation might delay the acquisition of fine motor skills.

\textbf{Keywords:} sign language acquisition, handshape, neuromotor development, Portuguese Sign Language

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1. Introduction

1.1 Linguistic universals and language acquisition

A common explanation for linguistic universals (such as e.g. the universal distinction between vowels and consonants, the subject–object distinction, the core meaning of concepts such as ‘mother’) derives from Chomsky’s nativist hypothesis (e.g. Chomsky 1986, 1999). According to this position, humans are capable of acquiring language because it is part of their *genetic endowment*. This hypothesis seems to be in accordance with the fact that children — whether hearing (Kuhl 2004) or deaf (Petitto & Marentette 1991) — learn to speak or sign in ‘universal’ (i.e. modality-independent) stages, that is, they reach the same acquisition milestones at more or less the same age. The first of these stages is the babbling stage and the last stage is reached when the child has acquired the grammar of her native language.

On the one hand, the hypothesis which assumes innate knowledge would explain our ability to acquire and use a language as a result of general anatomic features that are very useful for language acquisition. We shall highlight, however, that these anatomic features are independent traits and fulfil additional functions (e.g. all the organs involved in speech production and perception also perform more basic functions than those related to language, and this is also true in the case of manual articulators in the visuo-spatial modality of sign language). On the other hand, language is a result of cognitive pre-adaptations, which make this capacity possible in humans (Hurford 2003).

In these pre-adaptations, or biological steps into the readiness for language, Hurford includes a pre-phonetic capacity to perform speech sounds or manual gestures.

Sign languages have only entered the stage of linguistic research fairly recently, and one of the interesting issues related to this current development is to investigate whether linguistic universals transcend modality (auditive-oral versus visuo-spatial) or whether there are specific universals for each modality. The work of Sandler and Lillo-Martin (2006) contributes to strengthening the idea that linguistic universals are indeed “universal” and surpass the issue of the modality in which is expressed. It is nevertheless important to understand how these universals are revealed, bearing in mind that production and perception happen in a different way in oral and signed languages.
1.2 Phonological development in sign languages and its relation to motor development

We can discriminate and analyse signs by means of their main phonological characteristics, which are usually grouped into three major categories (also referred to as 'parameters') — handshape, location, and movement (Stokoe 1960/2005; Sandler 1989).

The most complex category is handshape (Sandler & Lillo-Martin 2006). Various acquisition studies on several sign languages, namely Spanish Sign Language (LSE; Juncos et al. 1997), Brazilian Sign Language (LIBRAS; Karnopp 1994, 2002), American Sign Language (ASL; Marentette & Mayberry 2000; Cheek, Cormier, Repp & Meier 2001), and British Sign Language (BSL; Morgan, Barrett-Jones & Stoneham 2006), have shown that most errors in sign language acquisition are due to the handshape parameter.

Children seem to be most confident and accurate concerning the acquisition of location, less precise as to trajectory movements, and less precise still concerning handshape. How can we explain the fact that precision in the main phonological categories (handshape, movement, and location) differs from one to the other?

One possible explanation is that handshape development, like motor development, (e.g. Piek 2006) follows cephalocaudal (head to tail) and proximodistal (trunk to extremities) patterns, so that motor skills become refined first in the centre and upper body and only later in the extremities and lower body. (For example, swallowing is refined before walking, and arm movements are refined before hand movements.) An infant learns simple skills first and then gradually becomes able to combine them into more and more complex action systems. This would explain the fact that the fine motor control involving more peripheral muscles which is necessary for producing correct handshapes develops later than the motor control required for movement or location. The model of acquisition stages proposed by Boyes Braem (1990), based on a pilot study on stages of acquisition of ASL handshapes, reinforces this idea (see Section 3.1). While the neuromotor system keeps evolving, children continue to develop motor skills that allow them to incorporate differences in handshape. At the same time, the development of their cognitive systems and the interaction with adult signers leads to meaning attribution and reinforces the use of understandable signs.

Several studies on sign language acquisition have identified different stages in standard acquisition of the different phonological parameters. This raises the question of whether we find recurrent patterns in the phonological acquisition of different sign languages.
1.3 The present study

Our study reports the findings of a first pilot study on Portuguese Sign Language (Língua Gestual Portuguesa — LGP) acquisition, focusing on a Deaf child from 10 months until 24 months of age. We will discuss possible reasons why handshape is harder to acquire, which relate to neuromotor development and perceptual issues, and we suggest that auditory deprivation might delay the acquisition of fine motor skills.

Two main questions guided this study: (i) which phonological categories are acquired more easily by children acquiring LGP, and (ii) does phonological acquisition in LGP follow the patterns previously established for other sign languages?

Although there are no norms available concerning LGP development for a child of this age, given that this study is the very first research on native LGP acquisition, the child’s performance turned out to be similar to that reported in other studies on deaf children of the same age learning LIBRAS and ASL (e.g. Boyes Braem 1990; Lillo-Martin & de Quadros 2005) and BSL (Morgan et al. 2006).

2. Method

2.1 Participant

D.C. is a deaf child, the only child of deaf parents. In the first session, D.C. was 10 months (0;10) old and in the last session, he was 24 months (2;0) old. D.C. has two deaf aunts, but the other family members, including grandparents on both sides, are hearing. He was diagnosed as profoundly deaf at four months of age. The parents have communicated with him in LGP since birth. D.C. entered day care at a deaf school when he was 8 months old. At school, teachers and staff communicate with D.C. in LGP.

D.C. does not have any cognitive or social impairments, and he has been subjected to evaluations by developmental pediatricians.

2.2 Data collection and coding

2.2.1 Procedure

Video-recordings were made by a deaf researcher in a natural environment, while the child interacted with his mother, his father, or his teacher, that is, one of the three individuals with whom the child interacts on a daily basis. These interactions took place in varying environments: at home, at day care, or during outdoor activities.
The child’s first sign occurred when he was ten months old, and from this date until he reached 24 months, footage was taken twice a week for 30 minutes each time, for a total of 136 sessions.

We used a Sony DCR-SR290 video camera. During the recording sessions, the child manipulated familiar objects, namely his own toys and picture books. Special toys or books were never used for recording purposes because it was important to us to make the setting as natural as possible.

2.2.2 Analysis
A general methodological issue concerning sign language acquisition research is what should be counted as a sign and what should be seen as a non-linguistic gesture (Meier & Newport 1990). We followed Casey’s (2003) definition of sign according to which manual productions are evaluated on the basis of their form (how close they are to the target), their semantic content (how appropriate their uses are in a given context), their linguistic content (combination with other linguistic devices, e.g. pronouns, negation, etc.), and the child’s age (most native signers have an established vocabulary by 18 months).

All the signs produced by the child were compared with the mother’s, from whom D.C. had received the signed input. This input was considered D.C.’s target.

2.2.3 Data coding
Data coding took place at two different moments: first, the child’s signs were identified after watching the recorded footage several times. For annotation, we used ELAN (http://www.lat-mpi.eu/tools/elan), a free multi-media annotation program widely used in sign language research. ELAN integrates the transcripts of our tokens and the corresponding video clip into a single file, so that each annotation is time-locked with the relevant segment of the video.

Following their identification, signs were described using the three major phonological categories (e.g. Sandler 1989): (i) handshape, (ii) movement, and (iii) location. Any differences between the child’s sign and the adult’s target sign were registered.

From the 277 tokens produced, those tokens that were phonologically identical repetitions of tokens previously produced by the child were removed from the corpus analysis. We kept only 172 tokens that, although repeated, showed some phonological differences in an effort to reproduce the target handshape, movement, or location. In terms of types, D.C. produced 145 types.
3. Results

3.1 Handshape development

Handshape is the most complex phonological category in sign languages in that its description requires the highest number of distinctive features (Sandler 1989; Sandler & Lillo-Martin 2006). The four fingers and the thumb can be selected — alone or in combination — which, in Sandler’s model, is captured by the features [all, one, ulnar, radial]. Selected fingers can have different positions, that is, they can be fully extended or bend at any joint, or at more than one joint at once, and the thumb can be adducted or abducted, it can contact fingertips, or close over the fingers; these various positions are described by the features [open, close]. Moreover, the whole hand may be oriented in various directions and the selected fingers may be characterized by the orientation features [palm, wrist, front, fingertips, ulnar, radial] (Sandler & Lillo-Martin 2006). Sign languages exploit the degree of freedom of the individual fingers although there are also certain constraints (e.g. all selected fingers must be specified for the same position).

Boyes Braem (1990) was the first researcher to propose a model of handshape acquisition; her model includes four stages of acquisition. Here we follow Boyes Braem’s (1990: 110–115) description and model of predicted stages of acquisition of handshapes (note that the features she uses are not identical to those suggested by Sandler). The handshapes mastered at stage I involve the manipulation of the hand as a whole and of the radial group of fingers (e.g. handshapes [1] and [12] in Table 1). After the first stage, the child can no longer rely on adapting handshapes she uses in daily life to the function of linguistic communication. Stage II corresponds to the hearing child’s age of initial language acquisition. At this point, the handshapes acquired during the first stage are fully mastered. The new handshapes acquired at stage II involve the acquisition of the following features applied to specific digits (see Table 1 for illustrations of the handshapes; in the text, we refer to handshapes by means of the numbers specified in Table 1).

+ Close (e.g. handshape [3]);
+ Extension of the ulnar fingers (fingers 2+3+4) as a group, as in handshape [14];
+ Contact of the opposed thumb with all the fingers, as in handshape [5].

In stage III, there is a differentiation between the individual fingers and what is required for the early and highly functional pincer grasp handshape. This means

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2. The feature + Close, as used by Boyes Braem, refers to contact between the fingers, not to closing of the hand (that is, the feature indicates the opposite of spread, not the opposite of open/extended). In Sandler’s model this would be captured by the feature [joined].
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Stage I: manipulation of the hand as a whole and of the radial group of fingers (e.g. handshapes [1] and [2])

Stage II: acquisition of features applied to specific digits (e.g. handshapes [3], [5], and [14])

Stage III: differentiation between the individual fingers (e.g. handshape [6])

Stage IV: activation and inhibition independent and out of serial order of fingers 2 and 3 of the ulnar group (e.g. handshapes [7] and [8])

In our data, handshape was the phonological category in which most deviations were registered in relation to the target production (46.15%; see Figure 1).

By age two, D.C. had acquired 32 of the 76 handshapes recently recognized as being part of LGP (Carmo 2010). Table 1 contains a subset of these 32 handshapes,

Table 1. A subset of the handshapes acquired by D.C. (with their numbers, as used in the text)

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that groups of fingers are activated as well as inhibited. In stage IV, the child learns to activate and inhibit independently and out of serial order the weakest fingers of the ulnar group, i.e. fingers 2 and 3. For instance, the difficulty of handshapes [7] and [8] results from the fact that the thumb contacts the middle finger. Such handshapes thus require an idea of “finger order”.

In (1), we provide an overview of the four stages as well as example handshapes which were acquired by D.C. at the individual stages.

(1) Stage I: manipulation of the hand as a whole and of the radial group of fingers (e.g. handshapes [1] and [2])

Stage II: acquisition of features applied to specific digits (e.g. handshapes [3], [5], and [14])

Stage III: differentiation between the individual fingers (e.g. handshape [6])

Stage IV: activation and inhibition independent and out of serial order of fingers 2 and 3 of the ulnar group (e.g. handshapes [7] and [8])

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which we will use for illustration. The first handshape used by the subject seems to be the easiest one: a handshape that is simply a lax, open hand (handshape [1]). In Boyes Braem’s (1990) model, this handshape is included in stage I.

The subject used this handshape repeatedly up until the third month of video recording. This handshape is also the one that appeared with the highest frequency throughout the entire observation period (46.05% of all produced handshapes).

In the second month, a new handshape appeared. This handshape (handshape [9]) also involves the manipulation of the hand as a whole. Similarly to handshape [1], all fingers are selected but now they are closed instead of fully extended.

In the third month, two other new handshapes appeared (handshapes [4] and [10]), in which only two fingers move. D.C. thus made the transition from selecting all fingers to using fingers independently, in this case, the middle finger and the thumb. As predicted for stage III (Boyes Braem 1990), the child can differentiate the individual fingers from the pincer grasp handshape and inhibit and activate the group of fingers.

In the fourth month, he used the whole hand or just the middle finger with the thumb (e.g. handshapes [8], [11], and [13]). In the fifth and sixth month, he started to use the index finger together with the thumb, resulting in the two handshapes [2] and [7]. Interestingly, and unexpectedly, only at this point, he also began to use the index finger in isolation from the others, resulting in handshape [12], which actually corresponds to stage I of Boyes Braem’s (1990) acquisition model. This was the second most frequent handshape (37%) produced by the child, as it is not only part of certain lexical signs but is also used by D.C. to point at what he sees and what he wants.

Following these developments, as months went by, new handshapes kept appearing, including two, which are not part of the handshape inventory of LGP. As mentioned previously, by the age of 2, D.C. had acquired 32 different handshapes. When the participant was 17 months old, that is, after 7 months of observation, a sudden increase in the number of handshapes occurred. At this time, he started to produce many signs he had never used before.

As for handshape accuracy, we observed that of all the identified handshapes, 39.36% corresponded to the handshape of the target sign while 60.64% of the handshapes produced were not target-like. In a sense, this result is not unexpected. Other acquisition studies, e.g. the one carried out for ASL by Conlin et al. (2000), also found that, in contrast to place of articulation, handshape errors occur quite frequently.

76 handshapes in Portuguese Sign Language, based on Carmo’s description (2010), and valid for now.
3.2 Movement development

In sign languages, *movement* comes in two types: path movement and hand-internal movement. The shape of path movements can be *straight*, *arc*, 7 (in ASL), and *circling* (Sandler 1989).

Hand-internal movements are the result of a change in handshape or orientation during the articulation of a sign. They can be of different kinds, such as *hooking*, *flattening*, *releasing*, *squeezing*, *rubbing*, *twisting*, *nodding*, and *circling*. Hand-internal movements may be single or repeated.

D.C. altered target movements by (a) using a different path movement (e.g. straight instead of arc movement, as observed in *GOODBYE*, or straight instead of wave-like movement, as observed in *DOLPHIN*), or (b) changing the sign hand’s internal movement.

3.2.1 Path movement

Most of the movements we observed in the recordings were produced correctly. As for straight movement, we did not find any deviations in relation to the target movement. Arc movement had a score of 89.66% correct and 10.34% deviant in relation to the target movement. Wave-like movement obtained a score of 75% correct and 25% deviant in relation to the target. As for circular movement, there were no deviations, as the child performed this movement type flawlessly.

We observed the following deviations in path movement in relation to the target sign:

i. Arc movement was always replaced by straight movement (e.g. *GOODBYE*).
ii. Wave-like movement was replaced by straight movement or else performed by approximation (e.g. *DOLPHIN*).

Morgan et al. (2006) found comparable changes in the acquisition of path movement in BSL. In contrast to D.C., however, the child in their case study, Gemma, regularly changed the circular path movement to a straight path movement. In their opinion, and at this stage of acquisition (19 to 24 months), the child recognizes that movement is obligatory in a sign’s phonological representation but tends to fill this slot in the template with a movement that is easier to articulate (e.g. straight movement instead of circular, arc, or wave-like movement).

3.2.2 Hand-internal movement

With respect to hand-internal movements such as flattening, hooking, and twisting, we did not find any deviations in relation to the hand-internal movement of the target sign. The signs *RABBIT* and *OCTOPUS* (which require the flattening
movement) and fan (which requires the twisting movement), for instance, were produced correctly.

3.3 Location

Like handshape, the location category is made up of different subcategories. The model we follow divides the location category into two features classes: (i) place, which is the major body area, and (ii) setting. The place category includes the unary features [head] [trunk], [non-dominant hand], and [arm]. Place can be further specified by the setting features [hi], [lo], [ipsi], [contra], [proximal], [distal], and [contact], such that, for instance, the right side of the forehead would (for a right-handed signer) be characterized by the place feature [head] and the setting features [hi, ipsi] (Sandler & Lillo-Martin 2006).

The acquisition of location seems not to pose many problems for D.C. although some errors are registered. Signs with the place feature [head], for instance, i.e. signs that cannot be seen by the signer during articulation (e.g. bird, cow), tend to be articulated at a more distant point so that he can visually control their production and have visual feedback of his own signing.

In contrast to research on handshape, there are only few studies on the acquisition of location by signing children. Bonvillian and Siedlecki (2000) found that location was the most accurately produced parameter, when compared to handshape and movement. Conlin et al. (2000) also found high accuracy for the production of location as compared to handshape or movement.

In our study, too, location was the phonological category that presented the fewest deviations in relation to the target location, scoring only 11.49% deviations and 88.51% target-like locations. As for the deviant productions, 45% of the errors occurred in the signing space with no body contact, 35% involved a wrong location on the face, 5% involved a wrong location on the body, and 15% occurred on the non-dominant hand. Taken together, our data suggest that place features are acquired before setting features and that [distal] is acquired before [proximal].

These findings thus confirm previous studies on sign language acquisition, namely Morgan et al. (2006) for BSL, and Bonvillian and Siedlecki (1996) and Conlin et al. for ASL. Although the latter study found that location was the most accurate part of the children’s sign productions, reporting 25% errors in 255 signs, the authors did not provide any explanation for these findings. The study conducted by Marentette and Mayberry (2000) about emerging phonological system in sign language, specifically in ASL, yielded similar results.
3.4 Summary

Signs emerged throughout the 15 months while we observed the LGP acquisition of our subject. The total number of sign tokens was 172 and we identified 145 sign types. 72 of the sign types (i.e. almost 50%) suffered from alterations.

Most changes (46.15%) affected the handshape parameter, followed by changes in movement (23.08%), and in location (11.54%), as illustrated in Figure 1.

![Figure 1. Distribution of errors and correct productions across the three major phonological parameters](image)

4. General discussion

This study was based on a corpus of 172 tokens recognized as being signs of LGP, which were collected from a set of video recordings made by a deaf researcher. A Deaf boy was filmed repeatedly while interacting with various communication partners in the acquisition period between 10 and 24 months of age.

The questions which guided this study were divided into two subjects:

i. Which phonological categories are acquired more easily by children acquiring LGP?

ii. Does phonological acquisition in LGP follow the patterns previously established for other sign languages?

In the following two subsections, we will discuss these issues.
4.1 Acquisition of phonology

The present study clearly shows that in the process of acquiring LGP phonology, \textit{handshape} is the hardest parameter to acquire. At the end of the observation period, i.e. at two years of age, D.C. has acquired 32 handshapes, but the process that leads him to master the target categories is long and deviations from the target handshapes are frequent (46.15%).

The first handshape D.C. acquires is an open handshape with all the fingers extended or relaxed, and the second handshape is the one where all fingers are closed. As Marentette and Mayberry (2000) highlight based on their research data, handshape [1] (all fingers extended and spread; see Table 1) is likely to occur in early signs. Our results confirm this prediction. These handshapes are progressively replaced by more complex ones as D.C. slowly acquires more complex features and feature combination of his first language's phonology.

It is interesting to point out that the first handshapes which D.C. acquires involve the use of all fingers (as in \textit{goodbye} or \textit{to-call-someone}), while the handshapes that require finer coordination of fingers are only produced in a more consistent manner after he is 18 months old (as in \textit{cat}, \textit{three}, or \textit{egg}). Besides the motor aspect, for which we can refer to general developmental rules, we also have to take into account the role of perception. As the signs become more complex, different handshapes emerge, differing only in less evident aspects, which may account for some confusion in the child.

Despite handshape being the hardest phonological parameter to acquire, the progress the child makes concerning its acquisition during the observation period is remarkable. For example, the sign \textit{mickey} is initially articulated with a very simple handshape (i.e. handshape [12] in Table 1), but only one month later, D.C. already articulates it correctly with target handshape (i.e. handshape [10]). It is important to point out that it may also have an impact on the acquisition process whether a certain concept is important to the child. By using the sign more frequently, he not only improves his motor development, but also increases the probability of adults giving him feedback, thereby raising the chance of imitating the correct model and sharing a common meaning.

Concerning movement, our subject started by performing movements generally less accurately. In the sign \textit{car}, for instance, the correct movement is articulated mostly with the lower arms. Instead, D.C. involves more proximal joints, resulting in a more extended movement, and also moves his entire trunk. Similarly, in the sign \textit{dolphin}, the target wave-like movement of the hand and arm was substituted by a linear movement in combination with a movement of the trunk. Only when he is 20 months old, his realization of movement becomes more precise and thus more target-like.
4.2 Universal patterns of acquisition

Returning now to the results of the previously mentioned studies on the acquisition of sign language phonology (in the acquisition of sign language as a first language), the data we collected in the present study allows us to verify the existence of a recurrent pattern. The child in our study showed a regular pattern concerning the acquisition of phonological categories. These results thus confirm the biological steps into readiness for language, which, in this case, includes a pre-phonetic capacity to perform manual gestures (Hurford 2003).

Movement and location were easier for D.C. to acquire, without major deviations, while handshape was the hardest category to acquire — a pattern that replicates findings reported for the acquisition of LSE, LIBRAS, BSL, and ASL.

Marentette and Mayberry (2000) provide an explanation for the accuracy of young children in producing location and their difficulty in producing handshape. Location is easier because children have a cognitive representation of their body to anchor this acquisition parameter. In contrast, the handshape acquisition has no mental representation to provide an easy entry to the phonological system. We propose that the reasons which lead to this difficulty in acquiring handshape lie in neuromotor maturation. However, the difficulty cannot be explained by this phenomenon alone.

On the one hand, as stated previously, motor skill development follows the two principles already mentioned — cephalocaudal and proximodistal developmental patterns — which relate to the correct acquisition of the finest (i.e. most complex) handshapes in signs. On the other hand, we have to take into account possible perceptual confusions between very similar handshapes. Given that development is always a dynamic and complex process, motor development itself amplifies the physical and social world of the child, placing new challenges in front of him, which in turn will motivate new developments.

Interestingly, in addition to this discussion, some research findings (Horn, Pisoni & Miyamoto 2006) suggest that there is a developmental difference between gross and fine motor skills in prelingual deaf children. For gross motor skills, a positive relationship between age and motor development was observed. The opposite trend was found for fine motor skills. It is likely that there are close links between language and motor systems as a result of shared neural processing resources in the premotor cortex (Wilson et al. 2004).

This would explain the delay in the development of fine motor skills in this population, and would also be a reasonable explanation for there being a general tendency of every studied sign language to follow a similar developmental path, which in turn seems to hint at the existence of a universal pattern for languages in the signed modality.
Further research is needed to confirm our findings and to reach a better understanding of the modality-independent and modality-specific factors that play a role in phonological acquisition. If auditory deprivation delays the acquisition of fine motor skills that would suffice to explain why deaf children seem, in a “universal” way, to require more effort in the handshape parameter, while acquiring the other parameters effortlessly.

5. Conclusion

Our study confirms the phonological acquisition patterns previously described for other sign languages. It thus further supports the idea of certain universal linguistic patterns for the acquisition of languages belonging to the visuo-spatial modality.

In the future, we believe it is important to develop studies which can strengthen this hypothesis, and such research ought to be based on systematic neurological studies. Knowing that language and motor skills share neural resources in the premotor cortex, we would be able to understand whether the “delay” or the attested difficulty in handshape acquisition is related to auditory deprivation.

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References


University of Portugal (DVD publication in Portuguese Sign Language, Collection: Masters in LGP, PT Foundation Felis Project, 2010-0-0092).


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