

## A project for an ERP study in the expression of surprise and surprise disapproval

Erika Petrocchi, [erika.petrocchi@unive.it](mailto:erika.petrocchi@unive.it)

Ph.D. student in Language Sciences

Ca' Foscari University, Venice

Tutor: Prof. Alessandra Giorgi

### 1. Introduction

In these pages I present a project for an ERP study aiming to investigate the neural processing underlying the expression of surprise and surprise-disapproval, with special reference to gesture. I plan to visit Max Planck Institute for Psycholinguistics (Nijmegen) where the research group led by Judith Holler addresses these issues.

In the conversational talk, the use of hands with speech is pervasive and appears to be essential (Kendon 2004; McNeill 1992; 2005). Thus, in the study of language comprehension it is important to understand whether the interpretation of gesture is relevant to the interpretation of the associated linguistic string and how the integration between speech and gesture works, coherently with the current scientific debate in the field. Previous ERPs studies focused on semantically-related gestures, such as iconic gestures, whereas my work will consider non-iconic ones.

So far, electrophysiological investigations dealt with the semantic (in)congruence between gesture and speech, the influence of gesture in disambiguation and the effect of the context on the processing of gesture and speech. not much is known on non-iconic gestures, and still less on how the different types of gestures affect linguistic-gesture integration. Studies like the one I am presenting here could be useful in contributing to the detailed neural processing of gestures.

As already noted above, not much attention has been devoted to understanding the neural processing of semantically-unrelated gestures by means of the electrophysiological methodology. Besides iconic gestures, two other types of gestures have been taken into consideration: emblems and self-adaptors (Chui et al. 2018). However, we still have to understand whether the processing of emblems and iconic gestures are different. Finally, the processing of static and dynamic gestures is an under-researched topic as well. In particular, in the case of static and dynamic emblems there are no clear results with regard to the scalp distribution.

Summarizing, my project aims to understand how the brain works when it has to process a special type of gestures namely those gestures that are not aligned with the onset of a target word and do not specifically refer to any word in the sentence. These gestures take their meaning from the (emotional) context they rely on, whereas they do not show a correspondence with the semantics of the linguistic expression associated with them. In fact, these gestures turned out to be regularly aligned with syntax (and not with the onset of a specific target word) in that they usually are realized in correspondence with the nuclear syllable of the verbal form and/or with the negation in case of yes/no counter-expectational questions and with negation and/ or with the wh-phrase in case of wh-questions. The gestures at issue are the artichoke, hands in prayer and the PUOH gesture (Kendon 2004). They cannot be considered as emblems, in that their relationship with the semantics of the clause is not obvious and they do not show a socially agreed-upon standard of well-formedness.

Importantly, they seem to be related to the expression of the speaker's emotion rather than her unuttered evaluation of the whole sentence. Finally, they cannot be seen as iconic gestures in that they do not hold a semantic relationship with any target lexeme in the sentence, such as an unexpressed semantic content conveyed by the hand shape. The use of palm-up open as a co-speech gesture is usually associated with everyday actions such as giving, offering and receiving objects (Kendon, 2004). However, the association is not that obvious in the case of special questions: the speaker is not offering something, she is rather asking for something, namely an explanation. Moreover, this gesture is used both in the case of expression of surprise and in disapproval. The artichoke gesture can be realized either with one hand or both, with all the fingers extended and touching at the fingertips. The presence of this gesture seems to be determined by the disapproval value attributed to the sentence, in that it can appear both in surprise and surprise-disapproval. In the articulation of the prayer hands gesture the palms are one against the other. This gesture seems to be present only in case of surprise-disapproval contexts and show the same distributional properties of the artichoke gesture. Interestingly, all the gestures realized in surprise-disapproval contexts are iterated, moved up and down repeatedly. In other words, the same gestures are static if associated with counter-expectational surprise questions and dynamic (iterated) if associated with surprise-disapproval questions.

By means of ERP experiments on the neural processing of the emotional special questions associated with these gestural patterns, I will be able to compare data on onset times, synchronic alignment of gesture and speech and N400 amplitude effects with the data available in literature on the gestures already studied,

.Self-adaptors do not have a meaning in the clause, the iconic gestures bear speech-related, complementary meaning about usual activities that people do with concrete entities linguistically expressed by target words in the sentence and emblems convey no speech-related meanings. Finally, the syntactic-related gestures I would like to study do not show a direct speech-related meaning .

Is there any difference in the ERPs effects and scalp distribution in processing of these kinds of gestures? Are they automatically integrated with speech (Holle and Gunter 2007)? On the basis of the considerations that the N400 component is a valid index of the semantic processing of both linguistic and not linguistic stimuli and that P300 is an index of syntactic processing of linguistic information, I want to measure the ERP effects in the case of syntactic -related gestures. I want to check if these gestures, like the self-adaptors, produce an effect on the amplitude of N400 (reduction) when compared with the processing of speech-only material and if they produce some effects on the P300 value as well, i.e. enhancement in case of incongruent presence or lack, and reduction in case of regular presence.

## **1. The goals of my research and the results achieved so far**

My work investigates two kinds of special questions in Italian Sign Language (LIS), Vietnamese, Korean and Japanese: counter-expectational and surprise-disapproval questions. <sup>1</sup>

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<sup>1</sup> See Bayer and Obenauer 2011; Obenauer 2004; 2006; Munaro and Obenauer 1999; Munaro and Poletto 2003; Obenauer and Poletto 2000; Hinterhölzl and Munaro 2015; Vicente 2010; Giorgi 2016; 2018.

In Italian (Giorgi and Dal Farra 2018; Giorgi and Dal Farra 2019), German (Giorgi, Dal Farra and Hinterhölzl to appear) and Spanish (Furlan 2019, MA Thesis) both sentence types are characterized by a peculiar syntactic representation, a special intonation, and a typical gesture pattern. In all these languages there is alignment between gesture, prosody and syntax in that the stroke of the hand gesture and/or the head movement is realized in correspondence with the leftmost pitch (usually the pitch on the nuclear syllable of the verbal form).

Holler et al. (2018) show that bodily signals involved in face-to-face interaction facilitate language processing in conversation. Significantly, these bodily signals appear to be dis-aligned (Holler and Levinson 2019). Processing several signals simultaneously is faster than processing speech alone and the multiple layers of visual signals are offset in time rather than neatly aligned in the unfolding face-to-face communication. Special questions with emotional interpretation have the peculiarity to be (almost) fixed multimodal structures. The gestures involved appear to be mandatory, even if, as opposed to prosody, in these cases they do not have a disambiguating role. In most cases, these gestures start before the beginning of the sentence and last until the sentence is completely uttered, and even longer than this. If multimodal signals are integrated effortlessly by the brain even at quite large temporal asynchronies (Holler et al. 2019), why does alignment turn out to be available as well?

In the case of special questions, Italian, German and Spanish show striking similarities. Are the regularities found in bodily signals related to the closeness of the cultures these languages belong to?

In order to address this issue, my research focuses on the interaction of the prosodic, gestural and syntactic component in three culturally and geographically distant languages and in LIS, a language realizing prosody by means of a different modality (non-manual components), paying attention also to the presence of gestures accompanying signs. I found that counter-expectational surprise questions and surprise-disapproval questions are characterized by a special interpretation and prosodic contour in the Eastern languages I investigated, and in LIS as well.

As far as the gesture pattern is concerned, counter-expectational surprise questions are characterized by the presence of widened eyes, head forward movement, nod, shake and raised eyebrows. Surprise-disapproval questions are marked by furrowed eyebrows, shake of the head and squinted eyes. Note that in Italian, German and Spanish special questions are also associated with specific manual gestures. In particular, counter-expectational surprise questions are accompanied by the so-called Palm-Up Open Hand gesture (PUOH, Kendon 2004), whereas surprise-disapproval questions are associated with three different kinds of iterated gestures, i.e. the so-called artichoke gesture, hands in prayer gesture and PUOH gesture in Italian and Spanish<sup>2</sup>. I found artichoke gesture and hands in prayer gesture in LIS as well. The manual components tend to be absent in my corpus of Eastern languages, so they might be culturally determined, even if, when present (few cases), the gestures are the ones found in our Western language samples. The basic non-manual components do not vary across languages: In Japanese, Vietnamese and Korean. In LIS I found the same non-manual components as in counter-expectational and surprise-disapproval questions in oral languages. The difference between LIS and other languages is that the non-manual components are grammaticalized in sign language. In all the cases studied until now, I find an alignment between the

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<sup>2</sup> Notice that in this specific case the association between PUOH gesture and practical everyday actions is not that simple, i.e. the speaker is not clearly offering nor receiving something (Kendon 1980; see also Giorgi and Dal Farra 2019).

gestural, prosodic and syntactic component. Interestingly, I found an alignment also between the gestural non-manual components (raised brows and head forward movement) and the pitch on the clause-final question particle realizing surprise in Vietnamese. Considering the data gathered so far, it is plausible to hypothesize that the non-manual components involved in the linguistic expression of surprise and disapproval are universal. Moreover, given the fact that these components are always aligned with the syntactic structures I have already mentioned, we could consider them as part of UG (working hypothesis).

As far as special questions are concerned, non-manual linguistic/bodily parameters seem to be regularized (synchronic alignment) and universal (cross-cultural and cross-modal features). In LIS, the non-manual components spread over special questions are the same we found in all the other languages studied plus they turn out to be grammaticalized. Linguistic facial expressions are regular in timing, duration, and activation (Baker-Shenk 1983; Branchini, 2014; Pfau et al., 2012) conveying specific linguistic meaning. As Sandler and Dachkovsky (2009) already noted, if we consider visual prosody in oral languages and non-manual marking in sign languages, we realize that they are made up by the “same raw ingredients”.

## 2. The data

To illustrate the evidence taken into account, consider the following examples.

Scenario I: *Mary calls me on the phone and tells me that she has a new red dress to wear at tonight's party. When I meet her at the party, I see that she has a blue gown. I'm surprised and utter (1):*

- (1) *Ma non era rosso?*  
But wasn't it red? (from Giorgi, 2016b, ex. 1)

Scenario II: *I see Gianni with his best trousers kneeling in the dirt in the garden. I think that he will ruin his trousers. I disapprove of his activity and utter:*

- (2) *Ma cosa fai?!*  
But what are you doing?! (from Giorgi and Dal Farra, to appear, ex.6)

These constructions are introduced by the adversative particle *ma* (but) and showing a peculiar intonation and gestural pattern associated with the counter-expectational and surprise-disapproval values. On the basis of their results, the authors already mentioned proposed that the special emotional interpretation associated with these sentences, realized by means of typical prosodical and gestural patterns, is triggered by a peculiar syntactic representation. In particular, the input to the sensorimotor component for prosody and gesture realization is unique: they are both triggered by the same syntactic property, i.e. the presence of a left-peripheral *Evaluative* head – a prosody/gesture-oriented head in the sense of Giorgi (2014).

## 3. Further developments and theoretical implications

The gestures accompanying special questions expressing surprise and surprise-disapproval are claimed to be triggered by a prosody-gesture oriented evaluative head in syntax, which is responsible for the whole realization of these constructions at the sensorimotor interface (Giorgi

2016; 2018). The main prediction made by this hypothesis (synchronic alignment of prosody, gestures and syntax) has been met by my first cross-cultural and cross-modal observations. I have worked with production tests to date, though, and I did not consider the comprehension task. What can we learn by the work of the parser in this case? We know that certain areas of the brain, in the left inferior frontal cortex, are exclusively recruited when processing input that contains syntactic relations (Friederici, Meyer, and Cramon 2000). Investigations examining event-related potentials (ERP) have discovered components specifically related to processing syntax (Hahne and Jescheniak 2001). The ELAN (the very early left anterior negativity) is the brain response to word category errors, i.e., when the category of a new word does not fit into the current structure being built by the parser<sup>3</sup>. The brain responds slightly differently to morphosyntactic violations: subject-verb agreement violations elicit a LAN (the left anterior negativity), involving around 300-500 ms after the onset of the anomaly (Osterhout and Mobley 1995). Ungrammaticality, like word category errors and morphosyntactic violations, also elicit P600 – an ERP component involving positivity at around 600 ms (Osterhout and Holcomb 1993). The P600 is also a characteristic brain response to garden path sentences, which are grammatical but hard to process for structural reasons. All of these ERP components are different from the N400 component, which is elicited by semantic anomalies. All the studies conducted until now focus on linguistic phenomena mainly, considering prosody and real-world knowledge in some cases, they do not consider the role of co-speech gestures. My idea is that it would be possible to investigate if the non-referential gestures associated with special questions, gestures which are not semantically or pragmatically straightforwardly characterized, are perceived by the speaker as linguistic material. The strong linguistic hypothesis on which my work relies on plus my first results on production tasks suggest that it is possible to hypothesize a formal model able to account for the regular presence of these gestures in case of special questions (linguistic material). In particular, I would like to manipulate the tasks I have already prepared for production tests devising new material for a comprehension task.

### 3.1 Method and materials

In my first experiment, I addressed the issue of counter-expectational and surprise-disapproval questions devoting particular attention to their prosodic and gestural components. I constructed 4 trials, one in Vietnamese, one in Korean, one in Japanese and one in LIS. The critical items were 15, in that each trial consists of 5 counter-expectational surprise questions, 5 surprise-disapproval questions and 5 declarative sentences composed by a main-subordinate configuration which contain surprise overtly expressed (the verb *surprise*). Each of these sentences is connected to the appropriate context. Given the fact that no studies have been made on the topic in issue, in the first session, I run an elicitation task. I read 5 specific contexts meant to introduce counter-expectational values and 5 specific contexts meant to introduce surprise-disapproval value. After each context, the native speaker participants were asked to utter the sentence which they considered the most appropriate and natural as a reaction to that context. No instructions were provided but ‘say it in the most

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<sup>3</sup> See Schacht et al. (2014) for a broader perspective.

natural way'. No references have been made to prosodic or gestural aspects. The participants were videotaped. I used the video material for conducting an ELAN analysis. In addition, the audio files have been extracted from the videos, analyzed and annotated with Praat and ToBI system (except for signers). I obtained 10 sentences spontaneously produced as a reaction to surprise and surprise-disapproval contexts. They showed a significant regularity in their form, so I could start a formal investigation on these sentences, which probably rely on the same type of syntactic structure. I discussed with expert linguists native speakers of the each language under investigation, in order to control the fitness of the context used to elicit any single sentence and the formal regularities they featured. The special questions so detected have been used to device a repetition task. Thus, I run a repetition task, which as been proposed to new informants. In this case, the consultants have been presented with a context read aloud by the experimenter (the contexts were the same used in the first experiment). Then, they were presented with the sentence they had to repeat. The sentence was presented in a written form in order to do not suggest any prosodic cue. The consultants have been videotaped. Then I extracted also the audio files for each videotape, and I analyzed the audio files with Praat and ToBI system whereas the videos have been annotated with ELAN. Through ELAN analysis, I could measure the time of the happening of gestures and non-manual components plus their duration.

### **3.2 An ERP study on processing of syntactic-related gestures**

Given the striking similarities found in the cross-modal and cross-cultural realization of these sentences, my project is to construct new materials from the trials I have already built, manipulating the presence of gestures and non-manual components in 8 conditions: (i) eliminating manual gestures where they usually (coherently) appear in the production of my informants; (ii) inserting manual gestures where they are not present in the productions, thus where they are not expected; (iii) eliminating non-manual components where they are present in the productions I have collected, maintaining the spontaneous occurrence (position) of manual gestures; (iv) inserting unexpected non-manual components maintaining spontaneous manual gestures; (v) sentences which have an incoherent alignment between manual gestures and non-manual components; (vi) sentences that show an incoherent alignment between manual gestures and the prosodic pitch related; (vii) sentences that show a dis-alignment between the non-manual components and the prosodic pitch related. Finally, (viii) the spontaneous productions of my informants, as a control condition.

The videos will be produced with the help of a native speaker collaborator already aware of the experimental procedure. Any video will be presented to the informants preceded by the listening of the audio file relative to the context given in the language under investigation.

As it is known, much of the ERP research concern the neural processing of iconic gestures and are focused on semantic incongruence or violation of meaning (Kelly et al. 2004; Kelly et al. 2010; Wu and Coulson 2005; 2007; 2011; Özyürek et al.2007; Holler and Gunter 2007). Iconic gestures hold a semantic relationship with the utterance. In this case, gesture and speech are complementary in conveying related but non-redundant semantic information. In all these studies, it was seen that the negative-going N400 component is generally observed in cases of mismatched and incongruent conditions with semantic violation. Thus, the N400 component has been widely recognized as an index of semantic processing of linguistic and non-linguistic (including gestures) stimuli, and of gesture-speech integration.

Despite the pervasiveness of semantically-unrelated gestures, only a small of attention has been paid to understanding neural processing of this kind of gestures through the use of electrophysiological methodology (Chiu et al. 2018). Would these gestures be processed similarly to meaningful gesture? Did the semantically-unrelated gestures produce a reduced or an enhanced N400? To what extent the various types of incongruent gestures differ from each other in processing? Is there any gradient in the continuum of semantic distinctions between different kind of gestures?

The gesture I would like to study, such as hands in prayer gesture, for example, are not properly iconic in that they are not directly associated with the semantic content of any target word in the sentence. They are not self-adaptor gestures either. Taken as a whole, artichoke gesture, hands in prayer gesture and PUOH gesture cannot be considered straightforwardly emblems (Goldin-Meadow 1999; Kendon 1995; 2004; McNeil 1992; 2005). The emblems express the speaker's unuttered evaluation of the content of the entire utterance. Moreover, emblems have socially agreed-upon standards of well-formedness. These gestures are in fact connected with the emotion expressed by speaker and interestingly they are not in association with the semantical content of any target words in the sentence. In addition, the temporal synchrony between the two modalities is not found at the onset of a word, as in case of meaningful gestures, rather the stroke of the gesture coincides with the nuclear syllable of the verb and or with the instantiation of the negation, in case of yes/no questions and with the instantiation of the wh-phrase in case of wh-questions. Probably, these emotional gestures are directly related to the syntactic component, although they are anyway considered by the semantic processing due to the fact that the integration between gesture and speech has been recognized to be automatic, also in case of self-adaptors gestures, which elicit the N400 effects, as well. Given the fact that past researches show that the amplitude of N400 vary between speech-only and speech-gesture condition (the gestures facilitate the semantic processing and the integration of speech-gesture if they are semantically congruent and affect integration if they are incongruent). Our brain automatically processed gestures as voluntarily produced by the speaker as intrinsically communicative. Chui et al (2018) use the so-called intentional stance notion (Dennet 1987) to explain this fact. My idea is that probably there is also a syntactic-effect: language is multimodal in its nature and the syntactic component is not blind to gesture. In this perspective, is fundamental to investigate gestures which are not straightforwardly semantically-related to the sentence and which seem to be triggered in syntax though. They situate in the middle between iconic meaningful gestures and self-adaptors and not meaningful gestures. In these cases, in congruent conditions I expect a reduced N400 effect in that these gestures rely on the context, i.e. for processing would require the availability of pragmatic and world knowledge. However, we expect a difference in amplitude compared to iconic gestures. They are not properly semantic-related. Coherently, in case of incongruent conditions we expected an enhanced N400. In these cases, in addition, we expect also a P600 effects, in that these are computed as syntactic violations as well. P600 effects have not been studied in correlation with meaningful gestures, though. Probably, it would help us to understand the role of syntax in speech-gesture integration as well. It could help us investigate the dynamic interaction among interfaces from the neural processing perspective. Moreover, as it is well-known there is still divergence regarding the detailed neural processing of gestures.

## **4. Further developments.**

### **4.1 At the sensorimotor interface: gestures and non-manual components**

As I have showed in the previous section, using the measurements relative to the gesture patterns I have already observed, it would be possible to investigate the role of the alignment found in these constructions in its interaction with gestures. Secondly, we would have the opportunity to study positive evidence focusing on those cases in which the gesture pattern is evident and forcing the informant to compute sentences with gestures. Indeed, gestures are almost always present, however, they can also be absent. One important thing to understand is why they are almost always present, given the fact that they are not semantically relevant, nor they are useful to disambiguate, as opposed to prosody. Recall that pronouncing the same sentences without gestures is perceived unnatural in spontaneous conversation.

If the gestures present in these constructions are triggered by syntax (the language is intrinsically multimodal; see Giorgi 2016; 2018), one hypothesis could be that they are missing in Western languages can be perceived as a syntactic violation, resembling at least those cases in which a reanalysis is needed, like in the so-called garden paths (ERP negativity value of P600, as in the case of structure that is grammatical but hard to process for structural reasons).

The second aspect deals with the possible manipulation of non-manual components. It would be interesting to compare speakers and signers' reactions given that in LIS these same non-manual components are linguistic components.

### **4.2 Synchronic alignment and dis-alignment**

I expect that, at least in case of emotional constructions, some syntactic violation is perceived at the onset place in which the non-manual gestures are expected (alignment locus, mainly).

Why synchronic alignment is at disposal along with dis-alignment of bodily signal accompanying speech? The idea is that the alignment of bodily signals is related to the degree of their 'conventionalization', so to say. They are not regularly aligned in case of non-specific and unpredictable constructions produced in face-to-face conversation, they are regularized in case of special (syntactically predictable) emotional constructions; they are grammaticalized in sign languages.

The second aspect deals with the possible manipulation of non-manual components. These sentences are perceived as unnatural, technically speaking infelicitous, if uttered with a blanked face, or with hands in pocket. As we have already seen, non-manual components are cross-culturally e cross-modally present. It would be also interesting to study the comparison between speakers and signers' reactions. Finally, it could be possible to present the informants with videos by speakers of a completely different mother tongue, asking to express which is the message the speaker is trying to convey. Finally, recall that in LIS these same non-manual components are also linguistic components. Is there any difference between the participants' ERP values in terms of P600 effects?

I expect that, at least in case of emotional constructions, some syntactic violation is perceived at the onset place in which the non-manual gestures are expected (alignment place, mainly). If it is the case, gestures would be to be considered part of grammar. Why synchronic alignment is at disposal along with dis-alignment of bodily signal accompanying speech? The idea is that the alignment of



bodily signals is related to the degree of their ‘conventionalization’, so to say. They are not regularly aligned in case of non-specific and unpredictable constructions produced in face-to-face conversation, they are regularized in case of special (syntactically predictable) emotional constructions; they are grammaticalized in sign languages.

### **5.3 Artichoke gesture and Q<sub>ARTICHOKE</sub> wh-sign in Italian Sign Language (LIS)**

The artichoke gesture in surprise-disapproval contexts has been found in Italian, Spanish and LIS. In the literature on Italian Sign Language, there is no agreement on the analysis of this gesture. It is found in case of the so-called ‘improper duplication’, always after a proper wh-sign, and in case of simple wh-questions, as the unique wh-sign present (Branchini et al. 2013). When it appears in simple wh-questions, it is used as a lexical variant for all wh-signs. In this case, it can also be accompanied by special mouthing which suggests the first phoneme of the Italian word for the correspondent wh-word. No reliable trigger for these special interrogative constructions has been found to date. Moreover, in my (pilot) experiments, the artichoke gesture turned out to be present also in the case of yes/no counter-expectational questions with a disapproval interpretation. Given its fixed clause final position in wh-questions of and its role of generic wh-element, this element has been interpreted as a sign. In particular, it has been hypothesized that it could be an interrogative particle, in the sense of Aboh and Pfau (2010). Concerning my experiments on special questions, this turned out to be present in both sentence types counter-expectational surprise questions and surprise-disapproval interrogatives, which are not real (informative) questions plus I never found case of ‘improper duplication’. In my data, the articulation of this element is preceded by a break in intonation (pause) and by a change in gaze direction, namely the gaze of the signer is no longer directed to the (fictive) addressee. Finally, I never found instances of mouthing. My hypothesis is that LIS has at disposal both the (homophonous) components: the artichoke gesture in case of the expression of surprise and surprise-disapproval and the Q<sub>ARTICHOKE</sub> sign in case of real questions. Studying the neural processing occurring in the computation of the (apparently) same element in both the different condition through a proper ERP investigation could reveal some differences in potential in case of syntactic violation when it involves codified linguistic elements vs non strictly codified elements (non-manual component in LIS, artichoke as a sign vs artichoke as a gesture). As the kind of differences has already be found in N400 amplitude in case of speech gesture trials with respect to speech-only trials computation. The idea is that we could find gestures along with signs (Goldwin-Meadow and Brentari 2017), and the wh-artichoke gesture can cover both the roles. The ERP measurements could help us to disambiguate these different uses.

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