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(Article begins on next page)

Evolution is an arc along a timeline.

Metaphors embodied in teachers' gesture supports abstract conceptualization and academic lexicon acquisition at primary school

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Abstract

Growing evidence shows the role of teachers gestures not only in L2 learning (Stam & Tellier, 2021) but also in supporting learning in the L1 classroom (Martha W. Alibali et al., 2014; Crowder, 1996; Wilson, Boatright, & Landon-Hays, 2014). The current study aims at contributing to this last perspective. Based on data from a 3rd grade plurilingual classroom in an Italian school, it observes the 'catchments' (McNeill, 2000) in teacher's gesticulation during a cycle of lessons on "The origin of life". The analysis identifies conceptual components based on the TIME IS SPACE metaphor associated with gestures, and observes their alignment with lexical items – either technical or common words (*evolution, ages, ancestors, archaic; change, back, old*) – in speech. The gesture-word association supports both the conceptualization of the notions and the acquisition of the related lexicon: gestures connect recurring concepts to their different verbalisations, ensuring a conceptually coherent representation over the lesson; they establish synonymic relations between technical and common words; and they can also work as memory triggers towards and between concepts and lexical units.

1 Introduction

Conceptualization, that is "the internalization of meanings with functional significance in communicative activity [...] constructed through verbal thinking" (Negueruela-Azarola, García, & Buescher, 2015, p. 233), is a part of both first and second language acquisition. In particular, in the context of language socialization at school, conceptual categories pertaining to specific subject areas have to be acquired together with suitable verbalization in the "academic language": the ability to refer to abstract concepts with low contextual dependence is what defines CALP – Cognitive Academic Language Proficiency (Cummins and Man, 2007).

In the field of cognitive linguistics, since Lakoff & Johnson (1980) seminal work, metaphorical thinking has been seen to be crucial for the development of conceptual categories. Abstract concepts are grounded in embodied physical experience (Reinboth & Farkaš, 2022); and gestures seem to be a crucial carrier of metaphors for the communication of abstract concepts (Cienki & Müller, 2008). Moreover, a growing body of research in neurolinguistics shows the deep-seated interconnection between activities associated with symbolic cognition, such as language processing and conceptualization, and perception or action (Barsalou, 2010; Löhr, 2019; Zwaan, 2014). Research into speech and interaction shows the active role gesture plays in both language comprehension and production (Aussems & Kita, 2019; Fritz, Kita, Littlemore, & Krott, 2021), as well as in language learning (Goldin-Meadow, 2011; Kita, Alibali, & Chu, 2017). Given these insights, it seems likely that gestures can play a key role in the acquisition of abstract concepts in school communicative practices as well. However, despite interesting findings emerging from experimental environments, especially in the field of tutored second language acquisition, little is still known about the role of nonverbal communication in school settings.

Experimental evidence has shown that physical enactment enhances several aspects of cognitive activity (inferential reasoning, memorizing, recalling: Barsalou, 2008), as well as processes of L2 acquisition and use (comprehension, production, memorization: Goldin-Meadow & Alibali, 2013; Stam & Tellier, 2021). In non-experimental contexts however, although the importance of “comprehensible input” has long since been recognized, the role of nonverbal behaviour on the part of the teacher in making input comprehensible has been largely disregarded. Yet nonverbal behaviour can be considered part of “teacher’s talk” (Hudson, 2011), and the accommodation strategies used by teachers in their communicative practices. In L2 students’ perception, teachers’ nonverbal behaviour has different functions: cognitive, emotional and organizational (Sime, 2006); it does not compensate but rather deepens meaning verbally conveyed (Lazaraton, 2004).

Not only in L2, but in the L1 classroom as well, teachers have been observed to adopt unplanned and even unwitting forms of embodied explanation (Alibali et al., 2014; Alibali & Nathan, 2012; Belhiah, 2013; Crowder, 1996; Heath & Luff, 2013; Taylor, 2014), which may give pupils linguistic labels to denominate concepts, provide explicit definitions, add visual representations of their semantic components, or make reference to relevant parts of the ongoing activities. The encouraging results of these studies show that a closer look at teachers’ nonverbal behaviour can help to shed light on a much-debated issue, namely the way ‘academic’ language competence is achieved in school by building on the ‘conversational’ language skills acquired in primary socialization. According to Cummins & Man (2007), cognitive-academic language proficiency (CALP) consists of both cognitive-communicative abilities operating on abstract

concepts and matters (extensive and intensive reading, summarising, presenting, and explaining concepts, etc), and linguistic competence in the specific register of academic communication, with its vocabulary, morphosyntactic and textual structures and usages. Thus, not only in the case of L2 classrooms, but also in an L1 environment, teachers must work as both content and language instructors: they help learners towards the conceptualization of academic concepts and the development of the specific lexicon associated with them. In this perspective, the teachers' task appears circular and therefore almost impossible to achieve: new concepts have to be taught through new words that have not yet been acquired. In view of this, the role of teachers' nonverbal communication as a carrier of meaning and as an aid to conceptualization deserves further investigation, in order to understand how resources of embodied communication are actually exploited in everyday learning environments.

2 The study

If we refer to Halliday's model of communicative meta-functions (Halliday, 2003), gestures can contribute to ideational, interpersonal, and textual functions in discourse. In the current study the focus is on the ideational function of teachers' gestures, i.e on representational gestures (McNeill, 2005)¹. The role of representational gestures in helping language comprehension and learning is well established in experimental studies (Dargue & Sweller, 2018; Drijvers & Ozyurek, 2017). This study aims at exploring the role of teachers' representational gestures in naturalistic data. More precisely, we are interested in how teachers' representational gestures help students in:

- (1) building and shaping the conceptualization of abstract scientific notions;
- (2) matching these concepts with their proper lexical labels.

The data we present were collected from the speech of a female teacher in a 3rd grade plurilingual class in an Italian state school, when the first steps in learning disciplinary content together with its specific academic register take place. Although most students come from immigrant families, they are incipient bilinguals, fluent in Italian and in their heritage languages; in spite of their high-level conversational skills in both languages, many children struggle with the specific registers required at school, as is often the case for second generation immigrant students. The reasons for

¹ For a different focus on the same materials, see Andorno (2022).

this have not been fully understood (Borgonovi and Montt, 2012; OECD, 2012), but a lack of socialization practices in the academic register in any language of their repertoire is often seen as part of the problem (Cummins, 2000). It should be noted, however, that this is not a problem affecting heritage language speakers only: the gap between students' general linguistic competence and that required at school is a long-lasting problem in (Italian) schools at all levels (Berretta, 1991); that is to say, the registers and varieties considered appropriate for schooling are non-native varieties for the majority of students. For this reason, in the context observed in the study, the teacher's concern is to ensure comprehension of the concepts at stake, together with the related scientific terminology. To this end, terms and concepts are revised again and again, and the teacher constantly checks the pupils knowledge of the lexical items encountered in the different materials used (in videos, textbooks and by herself).

In the two lessons observed (each approximately 50 minutes in length), the teacher is dealing with the topic of the origin and evolution of life on Earth. The topic was first introduced in a previous lesson, when a poster depicting the timeline of Earth's history was prepared. The poster, now hanging on a wall and available for deictic reference, exploits the TIME IS SPACE metaphor (Boroditsky, 2000; Boroditsky and Ramscar, 2002; Moore, 2017) in many respects. The timeline has been realised as a long horizontal arrow oriented from left to right, in the direction of the Roman writing system, thus metaphorically referring to temporal relations (MOVING FROM PAST TOWARDS FUTURE IS MOVING FROM LEFT TO RIGHT). The arrow is divided into segments labelled with the geological ages (TIME SPANS ARE SEGMENTS); aligned above each segment, various images show the main events occurring in that age (CO-OCCURRENCE IN TIME IS ALIGNMENT IN SPACE); geological ages have been conceptualized as linearly ordered timespans containing events (TIME SPANS ARE CONTAINERS; EVENTS ARE OBJECTS).

In the first lesson, after reminding students of the work done with the poster, the teacher shows a video cartoon narrating the evolution of the first life forms up to the appearance of dinosaurs; she then discusses the video with the class, in order to link information from different sources (the video, poster images, students' personal knowledge). In the second lesson, the topic of the origin of humankind is tackled via the textbook: the students read a text, suggest relevant points to note on the board and how to link these ideas with the information collected in the previous lesson. In both lessons, according to Crowder (1996), the teacher acts as a describer of scientific models: knowledge is not constructed during the lessons, but rather transmitted to the pupils by the teacher, who then checks their understanding with frequent use of display questions (Long and Sato, 1983) in a multilogue format (Schwab, 2011) typical in Italian schools.


Our analysis is as follows. We first identify (section 3.1) the 'catchments' (McNeill, 2000) characterizing the lessons observed: a series of coverbal referential gestures repeatedly performed

by the teacher. We describe how these gestures – either metaphorically or metonymically, cf Mittelberg & Waugh, 2009) – relate to the key notions discussed in the lessons, thus contributing to their conceptualization (Alibali & Nathan, 2012; Sert, 2015; Smotrova & Lantolf, 2013). We then analyze how the catchments observed associate with speech (section 3.2) and particularly the semantic relation they entertain with their ‘lexical affiliates’ (Schegloff, 1984), the lexical elements temporally aligned with them. Different semantic relations can be identified, suggesting different possible functions for gestures in relation to the comprehension and acquisition of the related lexicon (Belhiah, 2013; Crowder, 1996; Singer, Radinsky, & Goldman, 2008; Taylor, 2014). In section 3.3, the role of the teacher’s gestures in both the conceptualization of scientific notions and the acquisition of lexicon is further discussed in relation to the teacher - students interactional behaviour. Section 4 offers some concluding remarks.

3 Data analysis and discussion

3.1 Catchments and their relation with the lessons’ key concepts

The first series of recurring gestures we identified concern the ideas of segmentation and containment. Segmentation is represented by iconic gestures showing the cutting of one (linear) object in (linearly ordered) pieces, and the measuring and separating out of its pieces². As a whole, these gestures metonymically relate to the segments obtained by and manipulated through the gestures performed (ACTION FOR OBJECT ACTED UPON).

Metonymic value	Iconic value	Description	Example	Hits
SEGMENT1	Gripping	thumb and index of one hand in shape of a vertically oriented C		14

² We gathered gestures according to their similarity in execution (in the tables, they are verbally described under “description” and shown visually under “example”) and assigned to each of them a code based on the metaphorical/metonymical concept we identified as its more common meaning throughout the lessons observed. Note that the same meaning can be encoded through different gestures based on different metaphors/metonymies.



SEGMENT2	Cutting	hands' palms facing and spaced; joined and horizontally extended fingers, thumbs vertically extended		11
SEGMENT3	Measuring	hands facing each other and spaced, indexes extended		3

Table 1. *SEGMENT* gestures.

Containment is represented by the hands shaped in the form of a bowl, as if they were holding some material or objects: in this case, an object (the container) is metonymically evoked through the action it typically performs (ACTION FOR OBJECT PERFORMING IT).


Metonymic value	Iconic value	Description	Example	Hits
CONTAINER	Holding	hands spaced, facing upwards and slightly oriented towards each other, palms wide open and fingers extended and spaced		21

Table 2. *CONTAINER* gesture.

SEGMENT and CONTAINER gestures occur when the teacher refers to actual segmentation or containment of objects, as in the case of images stuck onto – therefore contained in - the poster³:

- (1) TEA *sul cartellone che abbiamo in classe* # *quali sono le piante* # *quali sono le piante che ritroviamo?*
on the poster we have in the classroom # what plants # what plants do we find?
 SEGMENT2, then CONTAINER

but they more often carry a metaphorical meaning. In the following case, a sentence is both verbally and gesturally conceptualized as a container of information (*in questa frase... ci sono notizie*, ‘in this sentence... there’s a lot of information’):

³ Transcription uses the following conventions: TEA is the teacher; STU is (any) student; an English translation is given on a separate line; gesture codes (in small caps) are aligned with the beginning point of the gesture articulation (cf Kendon, 2004); underlining marks the overall duration of the gesture up to its final holding position.

(2) TEA *quindi. In questa frase, e ancora un'altra cosa, non l'abbiamo detta, ci sono tante notizie.*
so. In this sentence, and one more thing we haven't said yet, there is a lot of information

CONTAINER

SEGMENT and CONTAINER gestures can refer to meronymic (part/whole) relations, as with sections of a video with respect to the video as a whole; the same conceptualization holds both verbally (*la prima parte*, 'the first part') and gesturally:

(3) TEA *ma # la prima parte # che # noi abbiamo visto ## la prima parte di quel video*
but # the first part # that # we saw## the first part of the video
SEGMENT3 SEGMENT1 SEGMENT2

or they can refer to hyponymy / hyperonymy relations. For instance, in the case of biological taxonomy, taxa (here *famiglie*, 'families') are conceptualized as containers of species and animals:

(4) TEA *anche le scimmie appartenevano a una famiglia*
monkeys also belonged to a family
CONTAINER

Note that in (4) a different metaphor is exploited at the verbal level to refer to taxonomic relations: SPECIES ARE FAMILIES. We will come back to the relation between verbal and gestural components of conceptualization in section 3.2.

SEGMENT and CONTAINER gestures in their metaphorical meaning are frequently exploited when the teacher talks about the subdivision of geological time in ages, and about facts and events occurring during the different ages. We have already seen that the TIME IS SPACE metaphor has been thoroughly exploited in an activity in previous lessons devoted to the preparation of the timeline poster. The same metaphor is now exploited in both the teacher's gesture and speech: the timeline is segmented in ages, ages include years, and several ages can be found within a time span; moreover, ages include events. SEGMENT and CONTAINER gestures reinforce this repeated metaphor:

(5) TEA *in questo lunghissimo arco di tempo # ci sono altre tre piccole ere*
in this very long arc of time # there are three other little ages
SEGMENT3

(6) TEA *in questo periodo, questa # tappa ## si sono avuti tanti cambiamenti*

in this period, this stage ## many changes took place

CONTAINER

The second series of gestures we identified concern relations between points along a linearly oriented space. These gestures adopt the teacher's body as a reference point, with respect to which other points are located in the space in front of or behind her. In their metaphorical value, they can refer to different kinds of spatially or temporally ordered relations (TIME IS SPACE): moving backward is moving toward a spatially or temporally preceding point (BEFORE IS BACK); moving forward is moving toward a spatially or temporally subsequent point (AFTER IS AHEAD).




Metaphoric value	Iconic value	Description	Example	Hits
BEFORE1	Moving backwards	hands with fingers joined and bent, wrists rotate towards speaker's shoulders		17
BEFORE2	Pointing backwards	hand in the space in front of the speaker, thumb points backwards		3
AFTER	Moving forwards	hands with fingers joined and bent; wrists rotate forwards, away from speaker		5

Table 3. BEFORE and AFTER gestures.

In the lessons observed, these gestures are always used with a metaphorical meaning. They are used for instance to talk about subsequent steps in a line of reasoning (REASONMENT IS A PATH):

(7) TEA *facciamo un attimo un passo indietro*

let's take a step back for a moment

BEFORE1

or to describe the linear ordering of the information in a text:

(8) TEA *ci sono informazioni che vengono # prima # delle altre*

there are some pieces of information coming # before # others

BEFORE1 AFTER

On the basis of the TIME IS SPACE metaphor, and the reciprocal ordering of time spans, BEFORE and AFTER gestures are largely exploited to refer to the main topic of the lessons: the unfolding of events along the timeline of geological ages, and their relation with respect to the current time. The following example shows one of many occurrences of a BEFORE gesture with reference to the past:

(9) TEA *i primi ominidi nacquero cinque milioni di anni fa*

early hominids appeared five million years ago

BEFORE1

The final series of gestures we analysed refer to change and transformation. These concepts are encoded through highly conspicuous gestures involving hand and forearm in circular and arced movements, sometimes oriented along a (time)line. According to the metaphors TIME IS SPACE, STATES ARE LOCATIONS, changes of state are conceptualized as changes of location, therefore movements.



Metaphoric value	Iconic value	Description	Example	Hits
<i>CHANGE1</i>	Cycle	hand+forearm rotate repeatedly and move forward slightly		17
<i>CHANGE2</i>	Arc(s)	hand+forearm draw an arc /a series of small arcs moving from speaker forward/right to left/left to right		37

Table 4. CHANGE gestures.

In the following excerpt, a cycle gesture is used in its iconic value to refer to a difference in the ordering of information in the text, when compared to the actual ordering of events along the timeline:

(10) TEA *possiamo invertire informazioni. possono essere anche, ribaltate*

we can switch around information. it can also be switched

CHANGE1

CHANGE1 CHANGE1

In the lessons observed, these gestures are mostly used with a metaphorical value, and play a crucial role when talking about the evolution of organisms across geological ages. In the following excerpt, iconic and metaphorical values co-occur (organisms evolved, acquired breathing abilities, and moved onto land):

- (11) TEA *gli organismi man mano hanno imparato a re-spi* + ...
 organisms little by little learned to b + ...
 STU + rare
 + *reathe*
- TEA *e # dall'acqua si sono spostati sulla* + ...
 and from water they moved onto + ...
 CHANGE2
- STU + *terra*
 + Earth

In most cases, CHANGE gestures only carry a metaphorical meaning. This is the case with the concept of evolution, which is gesturally conceptualized as a movement along the timeline (EVOLUTION IS A PATH):

- (12) TEA *per i primi esseri viventi, piano piano, # c'è stata un'evoluzione,*
 for the first living beings, little by little, # there was an evolution,
 CHANGE2 CHANGE2
- TEA *anche per # gli uomini c'è stata una lenta, lenta, evoluzione*
 for human beings too there was a slow, slow, evolution
 CHANGE2

Many further aspects of the evolution phenomenon are encoded in arc and cycle gestures: evolution is depicted as a unidirectional movement from the speaker forwards, therefore (according to the metaphors PAST IS BACK, FUTURE IS AHEAD) moving from the past towards the future; as a cycle, evolution is not depicted as a single, sudden and completed event, but as a process slowly and repeatedly taking place over generations; as an arc, it has a peak indicating the highest point of development of organisms and flourishing of species, and possibly a subsequent decline leading to extinction (GOOD IS UP, BAD IS DOWN)⁴. Interestingly, both

⁴ Although this last property would be criticized in an orthodox interpretation of the theory, it is quite a common trait associated with evolution theory in popular opinion and educational materials (Werth, 2012). The same metaphor of an arc of progressive improvement is for instance often observed in images representing “the path of humankind”, such as the following one available on the Internet (the added irony about the recent decline of humankind rests precisely on the same visual metaphor):

metaphors – TIME IS AN (arrow drawing an) ARC, TIME IS A CYCLE – occur as alternative conceptualizations of time in scientific work by geologists in different centuries (Gould, 1987).

3.2 Semantic relations between the catchments and their lexical affiliates

In this part of the analysis, we will describe the lexical affiliates appearing in speech when the observed catchments are performed. As recognised in the relevant literature, gestures do not always align temporally with their coreferential verbal expression (Goldin-Meadow & Alibali, 2013; Kita & Ozyurek, 2003; Wagner, 2014). Speech-aligned and non-aligned gestures can occur as part of different cognitive processes (Crowder, 1996). Gestures precede coreferent speech as part of the process of conceptualization, therefore carrying a more speaker-oriented function; conversely, gestures more often align with coreferent speech when they act as a carrier of communication, in order to help the hearer’s comprehension. In the lessons considered, as expected given the characteristics of the teacher’s speech previously described, temporal alignment of co-significant speech and gestures does indeed occur more frequently.

The following tables show the lexical elements co-occurring with gestures and sharing a semantic relation with them⁵.

Gesture	Co-occurring words	Relevant semantics	Hits
SEGMENT	parte, suddividere	Part	3+2
	tipo	Kind	2
	cartellone, paese	Material objects	1+1
	video		2
	parola, paragrafo, termine		1+1+1
	a un certo punto, all’inizio	Time spans	1+1
	era, tempo, periodo		9+3+1



⁵ According to Kendon (2004), we considered a word co-occurring with a gesture when it is (almost) aligned with the gesture stroke; we considered it as a gesture lexical affiliate when it holds some semantic congruence with the concept evoked by the gesture; in cases where more than one word has this property, all of these are included in the table; gesture occurrences for which no lexical affiliates can be identified among co-occurring words are signalled as ---. Thus, the total number of “co-occurring words” does not correspond to the total number of gestures.

	---		2
CONTAINER	racchiudere, occupare, insieme	Union	1+1+1
	far parte, appartenere	Inclusion	1+1
	cartellone, parete	Material objects	2+1
	era, periodo	Time spans	10+1
	---		1

Table 5. Words aligned with SEGMENT and CONTAINER gestures.

Gesture	Co-occurring words	Relevant semantics	Hits
BEFORE	prima/o, già, antico, arcaico	(Moving) back (in time)	5+1+1+1
	progenitore		1
	indietro, precedere, risalire		2+2+4
	lontano	Distance	1
	---		1
AFTER	fine	Time spans	1
	anni, tempo, passare		1+1+1

Table 6. Words aligned with BEFORE and AFTER gestures.

Gesture	Co-occurring words	Relevant semantics	Hits
CHANGE	cambiare, cambiamento, diventare	Change	2+2+2
	evolvere, evoluzione		10+7
	apparire, comparire	Appearance	1+2
	avvicinarsi, passare, risalire, spostarsi	Movement	1+2+1+1
	cominciare	Start	1
	imparare, respirare	Processes	1+1
	a un certo punto, alla fine, all'inizio	Time spans	1+1+1
	anni		1
	prima		1
	lento, man mano, pian piano	Graduality	4, 1, 4

Table 7. Words aligned with CHANGE gestures.

Gestures can co-occur with abstract words precisely referring to the same metaphorical concepts they evoke: this is the case when SEGMENT gestures are used with words such as *parte*, 'part', *tipo* 'kind' or *suddividere*, 'to split'; CONTAIN gestures with words such as *racchiudere* 'to include'; BEFORE gestures with words as *prima* 'before', *indietro* 'back'; CHANGE gestures with words *cambiamento* 'change' and *cambiare* 'to change'.

However, gestures do not always associate with words in such a trans-modal synonymic relation; more frequently, they co-operate in conceptualization through a bimodal encoding of different semantic components. A simple example comes in the domain of temporal relations. According to the TIME IS SPACE metaphor, the teacher frequently refers to time flow and time spans as segments along a timeline; two semantic components can then concur to define time reference: the location of the time span on the timeline with respect to a specific reference point (before/after), and the relative distance between them. In the following excerpt, reference to the relative distance is offered by the adjective *lontano* ('far away'), while the location in the past is made explicit by the BEFORE gesture; the resulting meaning is therefore "far away in the past":

(13) TEA *è un'era proprio lontana lontana*

it was an age far far away

BEFORE1

Moreover, note that the conventionalized verbal metaphors encoding time relations refer to two slightly different versions of the TIME IS SPACE metaphor (Boroditsky, 2000). In the gestural metaphors observed so far, the speaker moves across the timeline, from past toward future; past time spans are therefore behind the speaker's back, as in *facciamo un passo indietro*, 'let's take a step back' (ex. (7)). In a different implementation of the metaphor, time can be conceptualized as moving with respect to the speaker, from behind her back toward the space in front of her; past time spans therefore precede the speaker, and more ancient time spans precede more recent time spans:

(14) TEA *se vogliamo rappresentare tutti gli anni che # hanno preceduto noi*

if we want to represent all the years which # preceded us

BEFORE1

Furthermore, temporal movements from past towards future can be verbalised as a descent, possibly through the metaphor of the flowing of a river from its source in the mountains down to its mouth (TIME IS A RIVER). In the following example, researchers evaluating events occurring in past time spans are described as climbing back to them (*sono risaliti*, lit. "they re-climbed"):

TEA (*i paleontologi*) sono risaliti all'età di questi reperti

(palaeontologists) went back (lit. re-climbed) to the age of these finds

BEFORE1

While the verbal metaphors change, the gestural representation is kept consistent: the speaker constitutes the fixed *origo*, the space in front of the speaker represents the future, the space at the speaker's back represents the past. In helping pupils decode the movement along the timeline, gestural cues are therefore more reliable than verbal cues.

In a different distribution of the work of conceptualization, gestures evoke general concepts which speech further specifies. In the following excerpt, before its actual verbalization (*si è evoluta*), the concept of evolution is evoked as a unidirectional movement by an arc gesture; the gesture, performed twice, co-occurs with words referring to a gradual process over the years (*man mano, col passare degli anni*, 'little by little, over the years'):

(15)TEA *perché poi man mano # col passare degli anni ## nell'era neozoica la scimmia si è evoluta*
because then little by little # as times went by ## in the Neozoic age the ape evolved

CHANGE2

In other cases, the same gesture refers to punctual or sudden change, such as those evoked by the co-occurring words *ribaltare* 'overturn' and *invertire* 'switch' in Example (10). Further, when used together with *cominciare* 'to start', *apparire* 'to emerge', the same gesture is used to refer to a specific phase, namely the starting point, of a change process:

(16)TEA *cominciano ad apparire, compa / nascere # delle strane forme di animali*
they start to show up, to ap/ grow # some peculiar forms of animals

CHANGE1

In all these cases, gestures encode a general, vaguer concept further specified by speech.

A still different relation between word and gesture can be described when gestures focus or reveal the relevant conceptualization of specific words in the given context: in this case gestures do not so much add semantic specifications to the words but rather draw attention on the specific sense in which a word is used in the discourse context. This is clearly observable with SEGMENT and CONTAIN gestures occurring with words such as *paese* 'country', *parola* 'word', *paragrafo* 'paragraph', which are contextually conceptualized as 'parts' of a larger entity (the world, a text), or 'containers' of other entities (animals, meaning); the same happens for words such as *famiglia* 'family', *periodo* 'period', intended as groups (of living organisms, of years), as shown in ex. (2). and (4).

Finally, in some cases (marked with '---' in Table 5, Table 6 and Table 7), speech-gesture semantic alignment does not concern lexical items, but rather morphologically and grammatically

encoded verbal features. This is the case in the following excerpts, where reference to past time is encoded by the use of past tenses and the adverb *già*, ‘already’, ‘yet’, and it is made visually explicit by a BEFORE gesture (in ex. (17), the intended time span is a previous lesson; in ex. (18), the evolutionary age the teacher is talking about):

(17) TEA *che cosa abbiamo detto quando abbiamo parlato delle ere?*
what did we say when we talked about ages?
BEFORE2

(18) TEA *ma esistevano già le lumache in quest'era?*
but did snails already exist in this age?
BEFORE2

3.3 Catchments in the interaction between teacher and students

The joint work of lexically encoded meaning and visual metaphors evoked by gestures appears particularly striking in the teacher’s use of two key words clearly conceived as the focus and goal of the observed lessons: the notions of *era* ‘age’ and *evoluzione/evolvere* ‘evolution’/‘evolve’.

As we have already seen, ages are conceptualized as segments on the timeline containing years and events. This conceptualization is first prepared through the poster construction and later repeatedly reinforced by both verbal and gestural conceptualization. Speech and gesture cooperate intensively: in the two lessons observed, 37 out of the 91 occurrences of the word *era* (i.e. more than 1/3) are aligned temporally with one of the observed gestures; more specifically, 25 of them are SEGMENT or CONTAINER gestures. Conversely, 10 out of 21 occurrences of the CONTAINER gestures are aligned with the word *era*. This association is emphasized particularly in highly significant discourse points, such as when the definition of *era* is recalled. In the following example, a clearly perceivable CONTAINER gesture is performed at the height of the speaker’s shoulders, and is held all through the enunciation of the definition:

(19) TEA *queste ere # erano proprio / racchiudevano tanti tantissimi anni*
these ages # were indeed / include many many years
CONTAINER

TEA *vi ricordate che vi ho detto che un'era è un insieme lu/ di anni # un grande insieme di anni*
do you remember I told you an ‘age’ is a set lo/ of years # a huge set of years

Evolution is conceptualized as a unidirectional change occurring gradually along the timeline and across ages. This conceptualization was worked out through the poster activity, where images of different living organisms are linearly ordered along the time arrow, and is repeatedly referred to with the recurrent association of words and gestures. The words *evoluzione / evolvere* are used 30 times in the lessons observed, and in 13 cases (again, more than 1/3) they are aligned with CHANGE gestures. Conversely, 17 out of 54 CHANGE gestures co-occur with the words *evoluzione / evolvere*. Once again, an emphatic, highly perceivable and repeated realization of a CHANGE gesture is performed when the definition of *evolution* is recalled:

(20) TEA *l'evoluzione che ci è / che c'è stata. cosa vuol dire 'evoluzione'?*
the evolution that is / that took place. What does 'evolution' mean?

CHANGE1

STU *eh: # è quel lento cambiamento, che c'è...*

eh # that slow change that is...

TEA *il lento cambiamento che c'è stato dalle scimm / fino ad arrivare...*

the slow change that took place from mon / coming up to...

CHANGE1 (3 times)

allSTU

all'uomo!

to man!

Thus, a stable association of key words and catchment gestures does indeed constitute a leitmotiv of the lesson and offers clear paths for their conceptualization.

In a similar, although less focussed and emphasized manner, other words possibly not part of the students' lexicon are verbalized together with a gesture that offers a cue to semantic traits relevant for the current discourse. The verb *risalire* (lit. 'to re-climb') occurs 7 times, always with the metaphorical value of 'going back in time', 'dating back to', 'tracing back to', and in 4 cases it aligns with a BEFORE gesture. In this case, a silent definition of a potentially unknown word or a metaphorical sense of a word is given through gestures.

Furthermore, the repetition of gestures not only with "difficult" and technical words, but with more common and familiar words as well, allows for synonymic relations to be established and supported between known and possibly unknown, new words. This is the case for the pairs *evolvere* 'to evolve' – *cambiare* 'to change' and *evoluzione* 'evolution' – *cambiamento* 'change', which the teacher establishes as synonyms through explicit definitions (see ex.(20)) and alignment with the same gestures: 6 out of the 24 occurrences of the word *cambiamento* are aligned with a CHANGE gesture, the same gesture which is systematically associated with the word *evoluzione*. The joint work of verbal definitions through synonym pairs (*l'evoluzione è un*

cambiamento, ‘evolution is a change’) and the associated use of gestures evoking the same concept allows learners to conceptualize the notion and to give it a lexical label; moreover, it establishes connections between possible unknown words and concepts of the academic language and more familiar words and concepts.

One last function we identified for referential gestures in the classroom interaction is for the teacher to give hints to students and actively engage them in the lesson. As seen in ex. (20), the meaning of words is often elicited by the teacher in form of display questions. In these questions, gestures can anticipate the meaning and function as a hint for the audience. In the following example, the teacher asks for the meaning of the word *arcaico*, ‘archaic’, which is at the same time projected by the aligned BEFORE gesture:

- (21) TEA *vi ricordate come / che cosa vuol dire # arcaica?*
do you remember how / what does # archaic mean?
BEFORE1
STU *prima!*
before!

In the following examples, the expected answer about the fate of amphibious animals is partly suggested by the CHANGE gesture⁶:

- (22) TEA *gli anfibi poi a un certo punto cosa fanno, gli anfibi?*
amphibians at a certain point what do they do, amphibians?
CHANGE1 (4 times)
STU *diventa/ si trasformarono nei rettili*
they beco/ they turned into reptiles

In other cases, the same hint to clarify verbal expressions is given both by speech and gesture. This is the case for the semantic component of ‘past’, concerning the words *antichi* ‘ancient’ and *progenitori* ‘ancestors’ (ex. (23)), ‘change’ in the expression *dalle... alle...* ‘from... to...’ (ex. 0), ‘container’ in the word *famiglia* ‘family’ in its technical, taxonomical sense (ex. 0):

- (23) TEA *cosa abbiamo detto, che ‘progenitori’ cosa vuol dire? i più antichi?*
what did we say, that ‘ancestors’ means...? the most ancient?
BEFORE1

⁶ Note that, in these cases, gestures do not align with their verbal counterpart, which are rather projected in the subsequent turn: this phenomenon is partly responsible for the lack of precise lexical affiliates of gestures in Table 5-Table 7.

(24) TEA *dalle, alle, indica proprio? ## l'evoluzione che ci è / che c'è stata
from, to, it indicates exactly? ## the evolution that/ that took place*
CHANGE1

(25) TEA *come tutti gli animali, anche le scimmie, fanno parte di una? fa...?*
like all animals, monkeys as well, are part of a fa...?
CONTAINER

It can be noted that students seem to use teachers' gestural hints, as they answer the teacher's questions (ex. (21), (22)). Moreover, in at least one case, we observe a student catching the teacher's gestural hint to provide the expected answer after many ineffective attempts at elicitation:

(26) STU *l'estinzione, l'estinzione come de:/ degli ominidi*
extinction, the extinction of hominids

TEA *l'estinzione? cioè non ci sono più, muoiono tutti?*
extinction? you mean they're not there anymore, they all die?

STU *sì*
yes

TEA *sei sicuro?*
are you sure?

STU *sì*
yes

TEA *mh. e non lo so! l'estinzione degli ominidi?*
mh. I don't know! the extinction of hominids?

STU *sì*
yes

TEA *sei sicuro?*
are you sure?

STU *sì*
yes

TEA *mh: non è che si estinguono, è che...?*
mh: it is not that they become extinct, it is that...?

CHANGE2

STU *si cambiano*
they change

TEA *cambiano!*

they change

4 Concluding remarks

With this study, we aimed to investigate how, in a real, natural environment of a primary school setting, the teacher's gestures are used and possibly help students in (1) building up and organising knowledge about abstract scientific concepts (conceptualization) and (2) matching such concepts with their corresponding lexical labels (lexical development within the academic language).

In the domain of conceptualization, the data observed confirmed the importance of metaphors as a carrier of abstract concepts emerging from material everyday experience. As Smotrova & Lantolf point out, "abstract reasoning is based on experiences of acting upon physical objects in the environment" (Smotrova and Lantolf, 2013, p.411). In the lessons observed, the TIME IS SPACE metaphor is widely exploited: time spans are conceptualized as linear segments, and temporal relations are conceived in terms of linear order and inclusion; evolutionary phenomena and changes over time are conceived as movements along the timeline. Such metaphors are evoked through various practices and multiple communicative modalities: iconographic materials based on these metaphors are actively prepared by pupils and repeatedly referred to by the teacher; words and definitions used by the teacher rest on the same metaphors; and teacher's gesticulation repeatedly encodes the same metaphors.

The gestures we identified with the meaning of SEGMENT, CONTAINER, BEFORE, AFTER, CHANGE, work as catchments (McNeill, 2000) throughout the lesson, constantly referring to the key issues (evolution across geological ages) and helping not only in the conceptualization of single notions but also in linking them together into a coherent picture. Thus, in conjunction with speech and iconographic support, gestures help in anchoring new, abstract and decontextualised concepts such as 'geological age' and 'evolution' to known notions and processes such as cutting long objects in smaller units and putting them in linear order, including objects inside containers, moving objects along linear, circular, and spiral paths.

In this, gestures work in combination with speech. However, the role of gestures cannot be simply considered as secondary with respect to speech, as a sort of trans-modal synonymic component enhancing concepts at play. Speech and gesticulation are two different and complementary forms of thinking, which cannot be processed in isolation (Kelly, Özyürek, & Maris, 2010; McNeill, 2005). Firstly, gesticulation is global and synthetic, whereas speech is segmented and analytic. Therefore, through speech-gesture bimodal encoding, the grasping of new concepts can benefit not only from two different carriers, but of two separate ways to

conceptualize. As an example, whereas in speech different semantic traits of the concept of 'evolution' (e.g. change through generations, graduality, monodirectionality) are separately mentioned at different points in the teacher's explanation, each CHANGE gesture depicts them as a whole through its different subcomponents (direction, shape, speed). The relevant semantic traits are focussed on at different moments in speech and held together in a coherent conceptualization through gestures. Secondly, gestures are (at least partly) non-conventionalized: their metaphorical/metonymical value has to be interpreted through their iconic value. They can therefore offer a tool to decode the conventionalized – and possibly unknown – meaning of co-occurring words: an ARC movement can be recognized as referring to an arc-shaped spatial movement (iconic value), or to a change occurring in time (metaphorical value: TIME IS SPACE; STATES ARE LOCATIONS); and the meaning of its lexical affiliate *evolution* can be interpreted from this. Thus, "verbal contributions and gesticulations not only happen synchronously, but they also concomitantly shape speaking and thinking" (Negueruela-Azarola, García and Buescher, 2015, p. 236)

When the possible role of teacher's gestures in the development of lexical competence is considered, multiple functions can be recognized. As already said, gestures provide their possibly unknown lexical affiliates with concepts to be anchored to. Moreover, in evoking concepts relevant for the current speech, gestures help in contextualisation of word meaning, that is they help in explicating, enriching and enhancing the specific senses of words relevant for the current discourse, out of their general or usual meaning. Taking into consideration gestures-speech association, gestures can therefore reinforce, disambiguate, or enrich the semantics associated with verbal speech, providing information which is otherwise implicit, inferable or only available in different points of the discourse. Moreover, the repeated association of the *same* gesture with *different* words supports the building of synonymic relations between known and unknown words. As a whole, the gestural component of teacher's speech *creates* word-meaning association and word-word synonymic relations; *enhances* key concepts underlying the words used; *contextualises* word meaning; and *assures speech-internal cohesion* among recurring concepts associated with different verbal cues.

From an acquisitional and developmental perspective, it is important to note that in actual classroom settings, these functions are not always clearly distinguished and are possibly unevenly distributed among pupils. When learners are struggling with the language variety at hand, as is often the case with academic varieties used in schooling, and even more so for pupils having the same language as an L2, the teacher's speech can be perceived as ambiguous and obscure. Given this, the same gesture may at the same time, but not in the same way for different hearers, support and enrich the conceptualization of already known words, disclose unknown synonymic relations,

strengthen the knowledge of newly encountered words, disambiguate words of multiple or uncertain meaning, or offer a first clue to the comprehension of unknown words.

Our interest in the analysis centred on the use of gestures in teacher discourse; we therefore adopted a teacher-oriented perspective. In order to shed light on how and whether gestures are significant for pupils, their reactions to the teacher's gestures, and their behaviour in oral production activities, both in gesticulation and speech will need to be investigated. We will hopefully develop this point in further studies, but for the moment, we can perceive that, in the way pupils react to teacher's display questions, they seem to show they are using the teacher's gestures as a hint for the encoded concepts. Even more significantly, we observed at least one instance in which a pupil, struggling to find the answer expected by the teacher, is finally able to find it after looking at the teacher's gestural suggestion. These initial observations suggest that the catchments observed also work as memory triggers towards and between concepts and lexical units.

These results once again show that, although mature academic communicative competence includes a full range of decontextualized communication practices concerning abstract notions, the use of multimodal, contextualized communication at school plays a significant and still underestimated and under-investigated role in the process of acquiring these competences. As Andrä et al. observe, "learning in natural environment is multisensory" (Andrä, Mathias, Schwager, Macedonia, & von Kriegstein 2020, p. 816) and, in Lazaraton terms, "classrooms are the locus of embodied practice" (Lazaraton, 2004, p. 111). Multimodality in teaching is nowadays increasingly encouraged and can take many forms (van Leeuwen, 2015). Within teaching practices, this recommendation is often conceived as concerning the use of technologies (Herodotou, 2018; Parmigiani, 2004; Rivoltella, 2014), thus equating multimodal and multimedia communication (Lauer, 2009). Results from the analysis of everyday communication practices in low technology school settings suggest that teacher training programs should equally – and possibly mostly – raise the teachers' awareness of the multimodal resources naturally embodied in human communication.

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