Multimodality and Gestures in the Teacher's Communication

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Abstract. The paper presents a research on the multimodal communication of teachers in the classroom. The "musical score", a procedure for the analysis of multimodal communication, is used to analyse aspects of the signals produced and of the meanings conveyed by teachers while interacting with their pupils, by focusing not only on affective and interactional aspects, but also on the cognitive effects of nonverbal communication. Finally, the paper shows how, based on this procedure, it is possible to analyse chunks of teachers' communication, and to distinguish different multimodal communicative styles among different teachers.

1 Multimodality in the Classroom

Among studies on everyday interaction, an interesting area for the study of multimodal communication is teacher-pupil interaction, a topic generally studied in the domains of education, linguistics, sociolinguistics, pragmatics, and social psychology [1], [2], [3], [4]. [5] applied Ekman and Friesen's analysis [6], mainly stressing the affective and interactional aspects of the teacher's nonverbal communication. But the action of multimodality is not limited to affective issues: it has important effects in at least three domains of educational interaction:

a.   Conversational interaction

The teacher's facial, gestural and bodily communication has an important role in turn-taking management and in providing feed-back to pupils.

b.   Cognitive import

Gestures sometimes convey conceptual, concrete and abstract information [7], [8]; and even gaze signals may convey propositional concrete and abstract contents [9]. Moreover, gesture, gaze and posture may help students to understand the teacher's discourse [10].

c.   Teacher's prejudice

As shown by [4], the "Pygmalion effect", a typical case of a teacher's prejudice that affects a pupil's performance, is caused at a large extent by the feed-back the teacher provides to the pupil, which is mainly conveyed by his/her multimodal communication.

All of these aspects of teacher-pupil interaction point at the necessity of studying the teacher's multimodal communication 1. to enhance teachers' self-consciousness, self-modeling and regulation, 2. to develop Pedagogical Agents, for simulation purposes [11]. Scholars at the crossroads of Psychology, Artificial Intelligence, Autonomous

Agents and Computer Graphics engage in building Embodied Believable Conversational Agents [12], [13], Artificial Agents able to interact with the User through voice, facial expression and gaze, gesture and body posture.

In this view, studying the human teacher's communicative behaviour is a necessary step to discover the rules that govern her or his multimodal communication, not only because it is useful in building Artificial Teachers (would we all like to learn things only from a virtual Mentor?), but also because the approach of simulation, the effort to reconstruct human intelligence and behaviour in machines, is one of the best means to obtain a deeper knowledge of human behaviour. For both these purposes, one has to single out the most typical features of teachers' multimodal communication: what verbal and nonverbal signals they use most frequently, what meanings they convey, and how they combine signals in the different modalities, to communicate the meanings required in their educational interaction.

2   A Human's Meanings

To find out the specific features of the teacher's communication, we start from a theoretical model of communication that makes some hypotheses about all the meanings that human need in general to communicate, and the verbal and nonverbal signals devoted to conveying them, and we predict what meanings a teacher might specifically need to communicate most frequently. Finally, we test these predictions by analysing real data collected in empirical research on teachers' multimodal communication.

We distinguish three classes of meanings Humans generally convey during communication: Information on the **World**, on the **Speaker's Identity**, and on the **Speaker's Mind** [14].

Information on the World. As we talk we provide information about the concrete and abstract events we mention, their actors and objects, and the time and space relations among them. This is provided mainly through the words of sentences and their syntactic structure; but often also by deictic, iconic and symbolic gestures. A deictic gesture indicates something in the surrounding environment: a way to set the reference of our discourse, then a way to explain what, in the external world, we are going to talk about. An iconic gesture instead describes the shape, size or movements of some referent we are mentioning; and this description can be sometimes metaphorically extended to refer to some abstract referent. Finally, some symbolic gestures directly mention some object, feature or action. But not only gesture can indicate or describe; sometimes we point at things or persons by eye, lip or chin direction, and we may refer to features of objects or persons also by gaze, prosody and body movement: we squeeze our eyes to refer to something small or difficult, we open eyes wide to refer to something huge, we utter a longer vowel to say something is long, we speak in a "staccato" way to indicate precision, we refer to a person we know by moving as she does. And also a teacher can add these kinds of information to her verbal discourse by using hands, voice and gaze.

Information on the Speaker's Identity. As we talk, physiognomic traits of our face, eyes, lips, the acoustic features of our voice, and often our posture, provide information on our sex, age, socio-cultural roots, and personality. But besides

providing information on our objective identity, we also inform about the Identity we claim is ours: our image, that is, how we want others to see us. In other words, in any moment of our life and communication we have a goal of Self-presentation: we inform not only about how we are, but about how we want to be seen. This is often done without awareness; but a teacher, at her first class with new pupils, might monitor her appearance and behaviour to project a particular image of herself, to set the basis for future interaction.

Information on the Speaker's Mind. While talking about events of the external world, we also communicate why we want to talk about those events, what we think and feel about them, how we plan to talk about them: we provide information on the **beliefs** we're mentioning, our **goals** concerning how to talk about them, and the **emotions** we feel while talking [15].

a. Among information concerning our own **beliefs**, we inform:

1. on the degree of certainty of the beliefs we are mentioning, by words like *perhaps*, *certainly*, or the conditional or subjunctive verb mode, but also by *frowning*, which means: "I am serious in stating this" [10], or by *open hands palms up*, which means "this is self-evident"[16];

2. on the source of the beliefs we mention, whether they come from memory, inference, or communication [17]: we *look up* when trying to make inferences, *snap fingers* while trying to remember, we make the gesture "*quote*" with index and middle fingers curved twice to mean that we are quoting other people's words for which we are not responsible.

b. While talking we inform about our **goals** concerning our sentence (b.1., b.2.), our discourse (b.3.), and the ongoing conversation (b.4.), then about:

1. the performative of our sentence, that may be conveyed by performative verbs [18], [19] but also through intonation or performative facial expression [20];

2. the topic-comment distinction within a sentence or discourse, which may be conveyed by *batons, eyebrow raising*, *high intensity* or *pitch* of a tonic vowel;

3. the discourse rhetorical relationships: a list may be scanned by words (*first*, *second*, *third...*), but also by *counting on fingers*, or marking all the items in the list with the *same intonational contour*; topic shift may be expressed through *posture shift*;

4. the turn-taking and back-channel structure of conversation: we *raise our hand* to ask for turn; we *nod* to reassure the Interlocutor we are following, understanding, approving of what he's saying.

c. Finally, we inform on the **emotions** we are feeling while talking, not only by affective words, but with gestures, emotional intonation, facial expression, gaze and posture.

3 A Teacher's Meanings

A teacher in classroom interaction may convey all of these meanings; but some are conveyed more frequently, because of the teacher's particular role. Starting from the taxonomy above, then, we can predict the specific communicative profile of a teacher's communication. Of course these predictions stem from our stereotype of the teacher's role, but they can be tested on real data.

3.1 Information on the world.

A great part of the teacher's classroom communication informs about the contents of different disciplines, that include both concrete and abstract information. In some cases, concrete information like the shape of an object or a space, or a sequence of actions is better conveyed by iconic signals, like pictures, paintings, pantomime or iconic gestures. But gestures have proved to be useful also in the explanation of abstract (for example, mathematical) concepts [8].

3.2 Information on the Speaker's Mind.

This is the realm in which teacher's multimodal communication is most informative.

Beliefs. Starting from information on the Speaker's beliefs, namely the degree of certainty of the beliefs she mentions (a.1.), we predict a teacher will not convey uncertainty or doubt so often, given the image of a self-confident person she must generally project in front of her pupils. So, her most frequent expression will be the *small frown* showing that she is serious in what she says, and that she believes it strongly. As to the metacognitive information about the source of her current knowledge (a.2.), during a lecture the teacher will rarely *gaze side-downward*, or *raise eyes up*, because she is usually supposed to remember the things she reports very well, without needing to retrieve them from long-term memory, or to reason long about them.

Goals. The teacher's communication (as opposed to the layperson's) is supposedly particularly rich in providing information about her sentence, discourse and conversational goals. As shown by studies on teachers' behaviour [1], the teacher's performatives, i.e. the specific communicative intentions of her sentences, are a great number: question, peremptory order, advice, approval, praise, blame, reproach, question with an indirect meaning of command, praise with an ironic meaning of blame; but they are rarely conveyed by the classical performative verbs (*I order*, *I advice*, *I propose...* [18], [19]); they are generally expressed by intonation, gaze or facial expression. Instead of saying *"I order you to turn off you cellular"*, the teacher will express the propositional content of the speech act (*"Turn off your cellular"*) while conveying its performative by a severe directive intonation, and/or by a serious face, no smile, head up, gaze staring at he pupil. Performative intonation and performative facial expression [20] are sophisticated devices of human communication, devoted to convey even the most subtle nuances that distinguish performatives from one another. This is why the teacher's voice and face behaviour are important in educational interaction.
One more frequent and important information the teacher conveys, but mostly not by verbal language, is about the relative importance of the different parts of a sentence of discourse: the topic-comment distinction. More than in everyday communication, the teacher needs to distinguish, within her sentence or discourse, the beliefs that pupils have to retrieve from their long-term memory (topic) from the new beliefs to connect with them that are the object of the teacher's present communication (comment).

Often, to explain new concepts that to be understood require reference to previous contents, the teacher has to recall a lecture or an activity performed even months before. This distinction between what is to be retrieved from memory and what is coming as new is generally expressed by facial and intonational devices [10].

Again, gesture and intonation are of help when the teacher makes explicit the rhetorical relationships among different parts of the discourse she is delivering. An aid to understand and memorise a discourse is to know the Author's outline. This is why a teacher often says: "I'll now speak of X… now I come to topic Y…". But this can also be done in nonverbal ways: a posture shift, for instance, signals we are moving to another topic or starting a digression [21]. Another way to stress transition to another sub-topic is counting paragraphs, not only verbally (*"first… second…. third…"*) but also gesturally, by *counting on fingers*. Intonation has an important role too: a recurrent intonational contour signals we are listing different items of the same class, while we can mark a parenthetic clause through lower pitch and intensity [22].

The signals to regulate turn-taking and to provide back-channel are particularly important in classroom interaction, both for teacher and pupils; and the teacher must be particularly aware of these signals, whether delivered from herself or the pupils. A trivial example is when a pupil *raises a hand* to ask for a speaking turn. But while this holds in a classroom with a quite asymmetrical structure and rigid interactional norms, it could not hold in a democratic group or while working in a small team. In this case, a teacher that wants all members to talk must be aware of more subtle ways of asking for a speaking turn: *leaning forward*, *opening mouth* as in starting to speak, *opening eyes wider*.

Finally, a back-channel signal is any communicative verbal or nonverbal act performed by an Interlocutor to provide a feed-back to the present Speaker about whether the Interlocutor is *a.* understanding, *b.* believing, *c.* approving, and *d.* finding interesting what the Speaker is saying. I can say *"I see"* or simply *nod* to tell you I understand what you are saying; if I don't understand I'll say *"I can't follow you"* or *frown*; if I understand but I don't believe it, I can say *"I don't believe it"*, *shake my head* or show a *facial expression of doubt or perplexity*; I can *nod* also for approving, and *shake head, shake index finger*, or *frown* for disapproving; if what you say is very interesting I'll say *"You don't say!"*, or *"Oh!"* emphatically, or *raise eyebrows* to show surprise; but if I am not very much concerned or definitely bored, I can cyclically repeat *"oh"*, with a very flat intonation, or even *yawn*.

Now, some back-channel signals may be emotionally loaded, since they imply an evaluation and then may touch or hurt the Speaker's image or self-image: letting the speaker know that I don't believe what she says, or that her talk is boring, may be offensive. So we can predict 1. what back-channel signals are more frequently provided by teachers and pupils, respectively, and 2. what back-channel signals are more relevant for, respectively, teachers' and pupils' behaviour. A very young pupil will not perform many back-channel signals of incredulity, not only because it is implausible for him to have a knowledge base sufficiently larger than the teacher's enabling him to know things contrasting with what she says; but also because, even if the pupil really does not believe the teacher, he might be afraid to offend her by showing it. Again, a pupil will be particularly sensitive to back-channel signals of approval and disapproval. Conversely, if a teacher thinks motivation is an important basis for learning, she will pay attention to signals of interest or boredom.

Emotions. As to information about emotions, a teacher may feel various kinds of emotions during class work: joy, stress, anxiety, enthusiasm; tenderness, compassion, love, hatred, worry, anger, interest, curiosity, boredom. Of course, the very fact that a teacher expresses her emotions may be subject to sanction; so some teachers may claim they do not express their emotions to pupils, but yet their emotions can leak out from nonverbal behavior: anxiety or anger may be not expressed by a specific signal, but by some aspects of how one performs verbal or nonverbal signals: some sub-parameters of gestural or bodily behaviour like rhythm or muscular tension may vary producing a particular muscular tension in making gestures, a higher pitch of voice in speaking, a higher speed in moving around in the classroom.

3.3 Information on the Speaker's Identity

The teacher's multimodal communication provides information about her identity: the image she wants to project of herself as an easy, serious, rigorous teacher may be conveyed by her exterior look (clothing, hairdo) but also, once more, by the way she produces verbal and nonverbal signals: smooth movements may provide an image of a relaxed and easy-going person, jerky movements tell of a hectic behaviour.

4 The musical score of the teacher's communication

Testing our predictions about the teacher's multimodal communication requires us to assess the quantity and quality of multimodal communication in different teachers and to single out the communicative and teaching style of different teachers. To this goal, a tool is needed that is capable of showing how many and what meanings the teacher conveys, but also how these different meanings are related to each other.

In a previous work, [14] proposed the "musical score", a procedure for the transcription, analysis and classification of signals and their interaction in multimodal communication. This procedure (Poggi, Pelachaud & Magno, this volume), has been applied to the study of the teacher's multimodal communication.

5 A research study on the teacher's multimodal communication.

We conducted a research study on the teacher's gestural communication in four classes of a Primary School in a village of the province of Rome, Italy.

5.1 Method

The behaviour of 4 female teachers in 3 different classes was videorecorded. For each teacher, 40 minutes per class were collected and 10 minutes out of these were thoroughly analysed with the "musical score". The classes are three 2nd grades (7 year old pupils) of around 25 pupils each.

The aims of our research were: 1. to state how many and what types of meanings are conveyed by the teachers' gestures, and 2. to single out different communicative styles of the teachers. Using the "musical score", all gestures of each teacher were analysed and classified as to three features:

1. type of gesture: following [23] we distinguished deictics, symbolic, iconics (pantomimics, pictographics, spatiographics), batons and self-manipulations;
2. type of meaning conveyed: according to the typology above, the teacher's gestures were classified as providing Information on the World (IW), Information on the Speaker's Mind (ISM), and Information on the Speaker's Identity (ISI);
3. gesture function, that is, the relationship between the meaning of the gesture and that of the concomitant word or sentence: repetitive, if it provides the same information as the other item; additive if it provides additional but congruent information; substitutive if it tells something that is not told in the other modality; contradictory, if the information it expresses is incompatible with that of the other item; or indifferent, as it makes part of a different communicative plan [14].

5.2 Data Analysis: the Teacher's "Musical Score"

Let us see a fragment of the teacher's communication analysed through the "score" (Fig.1).

In the prosodic modality, the teacher stresses the words *I*, *tree*, *my*, *paper*, as if pointing at the key words she wants the pupils to pay attention to (an Information on her goal of emphasising these words, then an Information on the Speaker's Mind, ISM). But at the indirect level, she invites the class to compare these objects, and this aims at showing how different in size they are (an Information on the World, IW). Both direct and indirect meaning have an additive function, because this concept of the difference in size (quite important for the teacher's goal of explaining the concept of symbolic representation) is not conveyed verbally. This is a typical example of how prosodic communication may tell much more than the verbal signal.

In the gestural modality, the first gesture is a deictic, more specifically a case of abstract deixis [8]: it points out the window, where a tree might be, but in fact is not. Its indirect meaning is that, even if a tree is not there, trees do exist: an Information on the World. The following gesture, lowering arms with palms inward, as if limiting the borders of the paper, is a pictographic gesture, representing the shape of the paper; at an indirect level it means that the big tree outside can be reproduced in a place within reach and with a small size. Both meanings provide an additive Information on the World.

5.3 Results

The "score" analysis of all fragments allowed us to distinguish the different communicative styles of the four teachers. First we computed the amount of occurrences for each different type of gesture (see Table 1).

Fig. 1

Teacher C explains that even very large objects can be represented in small graphic representations; to do this one can use iconic signals equivalent but not equal to their referents, by maintaining some similarities, while abandoning others.

v. SD	*Se io volessi riportare un albero sul mio foglio* Suppose **I** want to reproduce a **tree** on **my paper**
p. SD	*Increasing intensity* *word stress on **io**, **albero mio foglio***

MD I You should pay attention to these words
　II I want you to realise how different in size these things are

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MT I ISM
　II IW

F　I Additive
　II Additive

g. SD	g.1: raises r.arm up (toward the window), holding a pen with cupped palm and ind..and mid..finger	g. 2: lowers arms in neutral space, palms inward

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ST I g. 1: deictic,　　　　　　　　　　　g. 2 pictographic
　II

MD　I g.1: I refer to a hypothetical tree out there; g.2: I represent it on my paper
　　II g.1: the tree I refer to really exists;　g.2: I represent it in something small and within reach

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MT I　g.1: IW　　　　　　　　　　　　　g.2: IW
　II g.1: IW　　　　　　　　　　　　　g.2: IW

F　I Additive
　II Additive

Legenda:
v.= verbal modality; p-i.= prosodic-intonational modality; g= gestural m.; f.= facial m.; b.= bodily m.
SD= Signal Description; ST= Signal Type (not considered for prosodic modality); MD= Meaning Description; MT= Meaning Type; F= Function
IW= Information on the World; ISM= Information on the Speaker's Mind; ISI=Information on the Speaker's Identity

Table 1

	A		C		M		R		Tot.	
	n.	%	n.	%	n.	%	n.	%	n.	%
deictics	13	28,3	6	14,6	8	27,6	16	34,8	43	26,5
symbolics	14	30,4	11	26,8	5	17,2	18	39,1	48	29,6
pantomimics	7	15,2	6	14,6	3	10,3	4	8,7	20	12,3
pictographics			4	9,7	1	3,4			5	3,1
spatiographics	1	2,2	2	4,9			1	2,2	4	2,5
iconics	8	17,4	12	29,2	4	13,8	5	10,9	29	17,9
batons	6	13	5	12,2	5	17,2	6	13	22	13,6
self-manipulations	5	10,9	7	17	7	24,1	1	2,2	20	12,3
Tot.	46		41		29		46		162	100

Teacher M uses gestures much less than the other teachers do. She produces more batons (17,2%) and self-manipulations (24,1%) than all other teachers, while among her own gestures, the most frequent are deictics (27,6%). A and R produce more gestures than the other two, both with the highest percent for symbolics (R=39,1%, A 30,4%), followed by deictics (R=34,8%, A=28,3%). Teacher C differs from the others since her iconic gestures exceed even symbolics in percent (29,2 vs. 26,8%). As to the distribution of gesture types, symbolics and deictics are far the most frequent (29,6 and 26,5%).
Let us see the distribution of gestures with respect to their Meaning Type (Table 2).

Table 2

	A		C		M		R		Tot.	
	n.	%	n.	%	n.	%	n.	%	n.	%
IW	34	42,5	36	50	24	50	33	41,2	127	45,3
ISM	38	47,5	35	48,6	24	50	43	53,7	140	50
ISI	8	10	1	1,4	0		4	5	13	4,6
Tot.	80		72		48		80		280	100

All in all, the four teachers convey more Information on the Speaker's Mind (50%) than Information on the World (45%), and the amount of Information on the Speaker's Identity is quite low; but with individual differences. C conveys more IW than ISM, while A differs from the other teachers for her relatively high percentage of Information on the Speaker's Identity (10%): a striking difference if compared to 5% ISI for R and 1,4% for C, but, especially, to the total absence of these kinds of signals in M. Teachers A and M represent two completely opposite patterns. A is very expressive and extroverted: as we have seen in Table 2, she makes a lot of symbolic and iconic gestures, and she has a highly dramatic behaviour. She also performs many

gestures of self-manipulation, but a great part of them belongs to the class of Information on the Speaker's Identity, because they indirectly aim at self-presentation, namely at a good presentation of her physical appearance: she often smoothes her hair, she arranges her suit by touching her buttons. She seems in fact like a highly narcissistic teacher. M's self-manipulations, on the contrary, even if they are her relatively most frequent gestures (24,1%), never aim at self-presentation, as shown in Table 3, where she never provides Information on the Speaker's Identity.

Let us now see what functions are fulfilled by gestures with respect to verbal communication in the four teachers (Table 3).

Table 3

	A		C		M		R		Tot.	
	n.	%	n.	%	n.	%	n.	%	n.	%
repetitive	27	58,7	20	48,8	15	51,7	24	52,2	86	53,1
additive	12	26,1	10	24,4	14	48,3	18	39,1	54	33,3
substitutive	1	2,2	8	19,5			4	8,7	13	8
contradictory	6	13	3	7,3					9	5,6
Tot.	46		41		29		46		162	100

From Table 3 it results a clear-cut prevalence of gestures with a repetitive function (53,1%), but also gestures providing additional information are quite frequent: a third of all gestures. The most striking difference among teachers is the high amount of substitutive gestures in C: 19,5% of her total gestures, as opposed to 8,7% for R, 2,2% for A, and none for M. This substitutive use of gestures by C is very peculiar: quite often she uses gestures instead of words not because she cannot or does not want to use the corresponding words (as it has been shown to happen with Aphasic patients, [24]): she makes the gesture before saying the word as a pedagogical ploy, to give the pupils the time to utter the word themselves, before she does. She invites the children to actively participate in her lecture by completing her explanations and reaching solutions thanks entirely to these nonverbal helps she offers them.

One more interesting result is the presence of a fair amount of contradictory gestures (13%) in A's behaviour: a quite high percent if compared to C who contradicts herself quite less (7,3%) and to M and R whose gestures never contradict speech.

From the quantitative but also qualitative analysis of the fragments collected, semantically enriched by the use of the "score", the profiles of the four teachers stand out clearly. Teacher A is quite focused on her own image, but she has a considerable charisma over pupils; yet at times, as we have seen, she happens to convey contradictory commands that may puzzle children. Teacher C tends to focus specifically on her work of teaching, not so much on her pupils; nonetheless, she looks quite passionate and expressive during classes. Teacher M looks quite shy, almost depressed, in her classroom behaviour, and she is not expansive even with pupils. Teacher R, finally, tends to establish exclusive relations with single children, for example as she sits down close to a handicapped girl, and talks to her in a low voice, thus establishing intimacy and complicity; or as she reprimands a disobedient child.

Do these different styles affect the classroom social climate? In fact, A's classroom is very lively and noisy, while B's class is very quiet and silent. Might this depend from the teacher's style? Further investigation is needed to answer this question.

6 Conclusion

Teaching is a typical human behaviour; a complex behaviour, because in teaching you must take into account not only what you want to teach, but also those whom you teach, as well as the context of learning. And while teaching you have to communicate knowledge, but you also have to elicit and sustain passion, motivation, and positive emotions in those whom you teach; finally, to manage their relationship with you. Communication in all modalities is the medium of this complex transaction of beliefs, feelings, and relations. Clearly, then, there is good reason to study teachers' multimodal communication, in order to train better teachers in both the Artificial and the Human domain. But to study all the subtleties of the teacher's communication requires sophisticated tools that allow the researcher to capture all the signals produced by a teacher, all their meanings, and all the complexities of their combination. We have reported a research on teachers' communication where thanks to the "score", a tool for the analysis of multimodality, we analysed some of the complexities of this behaviour, and outlined the different styles of different teachers. An interesting issue to investigate in future research is how these different styles affect important aspects of classroom interaction, such as the pupils' emotions, motivation, and cognitive development.

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