The Complexity of a Collaborative Interaction

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Abstract

In a collaborative interaction lasting 17 seconds in a middle school classroom, a small group of students learned how to conduct scientific experimentation using a particular software artifact. They made this knowledge visible for the group, repairing confusions and establishing a shared understanding through 16 brief utterances. A micro discourse analysis of this interaction illustrates the complexity of collaborative learning and of its analysis.

To make learning visible as researchers, we deconstruct the references within the discourse. The meaning that the participants constructed is analyzed as constituting an evolving network of semantic references within the group interaction, rather than as static mental representations of individuals. Collaborative learning is viewed as the interactive construction of this network of observable meaning. Shared understanding in this analysis emerges as the negotiated alignment of utterances, evidencing agreement concerning their referents.

Keywords

Collaborative learning, discourse analysis, shared meaning

Methodological Introduction

A fleeting collaborative interaction may be constituted of an astounding complexity of meaning. Several seconds of interaction can require years for researchers to interpret, although the participants understand it on the fly. If we wish to grasp the power, uniqueness and potential of collaborative learning, there is no substitute for the complex task of laying out the meaning relationships that are spontaneously generated in the spark of successful collaboration, where knowledge building on the group level transcends the individual contributions.

We naively assume that to say something is to express a complete thought. However, if we look closely at what passes for normal speech we see that what is said is never the complete thing. The transcript we will analyze is striking in that most of the utterances (or conversational turns) consist of only one to four words. As we will see, these utterances rely for their meaning on references within the context in which they are said. We will refer to this as *indexicality*. In addition, an individual utterance rarely stands on its own; it is part of an on-going history. The current utterance does not repeat references that were already expressed in the past, for that would be unnecessarily redundant and spoken language is highly efficient. We say that the utterance is *elliptical* because it seems to be missing pieces that are, however, given by its past. In addition, what is said is motivated by an orientation toward a desired future state. We say that it is *projective* because it directs the discussion toward some future which it thereby projects for the participants in the discussion.

In analyzing the episode, we make no distinction between "conversation analysis," "discourse analysis" or "micro-ethnography" as distinct research traditions, but adopt what might best be called "human interaction analysis" (Jordan & Henderson, 1995). This methodology builds on a convergence of conversation analysis (Sacks, 1992), ethnomethodology (Garfinkel, 1967), nonverbal communication, and context analysis. The recent availability of videotaping and

digitization permits the required close attention to the role that various micro-behaviors – such as turn-taking, participation structures, gaze, posture, gestures, and manipulation of artifacts – play in the tacit organization of interpersonal interactions. Utterances made in interaction are analyzed as to how they shape and are shaped by the mutually intelligible encounter itself – rather than being taken as expressions of individuals' psychological intentions or of external social rules (Streeck, 1983).

We worked for over a year (2000/2001) without understanding the collaborative interaction that was taped in 1988. We logged the three hours of video, digitized interesting passages, conducted several data sessions with diverse audiences and struggled to understand what the participants were up to.[1] Despite much progress with the rest of the learning session, this one brief moment stubbornly resisted explanation. In the following, we pursue a limited inquiry into the structure of that interaction. We interpret what the individual words and sentence fragments that people spoke meant.

The Complexity of Small Group Collaboration

Conversation analysis has largely focused on dyads of people talking (Sacks, 1992). It has found that people tend to take turns speaking, although they overlap each other in significant ways. Turn-taking is a well-practiced art; it provides the major structure of a conversation. The talk is often best analyzed into conversation pairs, such as question/answer, where one person says the initial part of a pair and the other responds with the standard complement to that kind of speech act. These pairs can be interrupted (recursively) with other genres of speech, including other conversation pairs that play a role within the primary pair (Duranti, 1998).

In much of the three-hour tape from which our collaborative interaction is excerpted, talk takes place between the teacher posing questions and one of the students proposing a response. The teacher indicates satisfaction or dissatisfaction with the response and then proceeds to another conversation pair. This is, of course, a typical classroom pattern (Lemke, 1990). In the collaborative interaction, something very different takes place.

A group of five 11-year-old boys is discussing with a teacher a list describing eight different rockets that can be used in a rocket launch simulation. The list is part of a set of three artifacts they are using: a SimRocket simulation, the description list on the computer screens and a paper data sheet they have been filling in with simulation results. They are trying to come up with a pair of rockets that can be used experimentally to determine whether a rounded or a pointed nose cone will perform better. The following interaction is concerned with the students noticing that rockets 1 and 2 described on the list artifact have the identical engine, fins and body, but different nose cones, while rockets 3 and 4 differ only in number of fins.

At 1:21:53 in the tape the teacher (T) poses a question. For the past few minutes, T has been dialoging primarily with Chuck (C), who has gone off describing some imaginary rockets he would like to design for the simulation to solve the problem of the nose cone. T's question, accompanied by his emphatic gesture at the computer, succeeds in reorienting the group to the list on the screen. After a significant pause during which C does not respond to this question that interrupted his extended turn, Steven (S) and Jamie (J) utter responses as though talking to themselves and then simultaneously repeat, as if to emphasize that they have taken the floor. But

[1] Logs, digitized clips, transcripts, simulation, etc. are available at http://www.cs.colorado.edu/~gerry/readings. The interaction itself can be viewed at http://www.cs.colorado.edu/~gerry/readings/simrocket/collab_short.mov.

their response was to disagree with the teacher, something not so common in a classroom. So T restates his question, clarifying what it would take to justify an answer. C responds in a confusing way, not directly answering the question, but attempting to apply the criteria T has put forward by repeating T's "same."

1:21:53	Teacher	And (0.1) you don't have anything like that there? ((points to computer))
1:21:54		(2.0)
1:21:56	Steven	I don't think so
1:21:57	Jamie	Not with the same engine
1:21:58	Steven	┌ No
	Jamie	└ Not with the same
1:21:59	Teacher	With the same engine … but with a different (0.1) … nose cone?=
1:22:01	Chuck	┌ =the same=
	Jamie	└ =Yeah,
1:22:02	Chuck	These are both (0.8) the same thing
1:22:03		(1.0)
1:22:04	Teacher	Aw ┌ right
1:22:05	Brent	└ This one's different ((gestures with pen at computer monitor))

T's 1 second pause at 1:22:03, encourages student discussion, and Brent (B) jumps in, cutting T off, lurching forward and pointing at a specific part of the list artifact, while responding to T's quest for something "different." For the next 16 turns, T is silent and the students rapidly interact, interjecting very short, excited utterances in a complex pattern of agreements and disagreements. From the conversational structure, one sees that the standard, highly controlled and teacher-centric dialog has been momentarily broken and a more complex, collaborative interaction has sprung forth. Normally reticent, B has dramatically rocked forward off his chair, pushed through a line of students, filled a void left by the teacher and directed attention pointedly at the list artifact.

Dramatically transforming the stage within which talk takes place, B has signaled an urgent need to resolve some disturbing confusion. We can see the importance of this move in the bodily behavior of Kelly, a student who says nothing during the entire episode. Kelly had been slouched back in his seat, with his head rolling around distractedly up to this point in the transcript. As B leaned forward, K suddenly perked up and leaned forward to pay attention to what was transpiring.

At 1:21:53 T had opened a conversation pair with a question. It was taken as a rhetorical question, that is as one that expected the conversation partner to see that there was something "like that there" and to answer in the affirmative, signaling that he had seen what T was pointing out. We can see that it was taken as a rhetorical question because the negative answers supplied by the students were not accepted. The three students who tried to answer in the negative – first S and J simultaneously, and later C – repeated their answers, as if to re-assert answers that were not called for. Rather than accepting these answers, T rephrased the question and paused for an affirmative answer.

Fig. 1. Teacher, Jamie, Chuck, Brent, Steven and Kelly. Brent has leaned forward to point at the list of rocket descriptions on the computer screen.

B responded to the conflict between the expectation given by the rhetorical question and the attempts by the other students to give a negative answer. The following can be seen as an attempt by the group to

resolve this conflict and provide the sought affirmative answer to T's question, finally completing the interrupted conversational pair.

The Problem

B interrupts T with, "This one's *different*." The word "*different*" goes back to T's last statement. T's full question, elaborated in response to S and J's disagreement was: "And (0.1) you don't have anything *like* that there? . . . With the *same* engine but with a *different* (0.1) nose cone?" In the meantime, S and J had both picked up on T's term "*same*," as had J.

1:22:05	Brent	└ This one's different ((gestures with pen at computer monitor))

T had used the terms, "same" and "different" to clarify what he meant by "like." In rhetorically asking, "Don't you have anything *like* that there?" T was suggesting that the list of rockets ("there" where he was directing their attention) included a rocket whose description was "like" the rocket they needed, namely one that had the same engine but a different nose cone from the one that they would compare it with.

T's original statement at 1:21:53 was *elliptical* in its use of the term "like". It assumed that the audience could infer from the context of the discussion in what ways something ("anything" "there") would have to be like the thing under discussion ("that"). After two students responded that they could not see anything like that there, T tried to explicate what "like" meant here. He did this by picking up on J's "Not with the same engine" and defining "like" to mean "with the same engine, but with a different nose cone." Scientific talk tries to avoid the elliptical ways of normal conversation. Throughout the session, T models for the students this explicit way of talking, often taking what a student has stated elliptically and repeating it in a more fully stated way. Now T is doing just that. Sometimes one of the students will pick up on this and start to talk more explicitly. Here B's utterance picks up on the term "different" as a key criterion for determining likeness, implicitly referring back to T's utterance and interpreting it by applying it.

Of course, the problem for us as researchers is that B's exclamation, "This one's different," is itself elliptical. In what way is "this one" different? Fortunately for us, we can solve our interpretive problems because the student utterances make their references explicit in order to solve the students' interpretive problems – and we can take advantage of this.

The Confusion

There is also the interpretive problem of reference or *indexicality*. B is pointing at the list of rocket descriptions, but it is impossible to tell from the video data which description he is pointing to. Even if we knew which one B was pointing to, his utterance does not make clear – for us or for the other students – which other rocket he is comparing with the one to which he is pointing. We have to deduce the answers to both these questions from the ensuing discussion, to see how the participants themselves took the references. For this is how the group-level meaning of the discourse establishes itself.

J's immediate follow-on utterance begins with "Yeah, but" indicating a response that is partially supportive. Since we know that J is responding to B, we know that J's use of "it" refers to B's "this one." C in turn builds on J, reclaiming the floor by interrupting and completing J's incomplete utterance of the term "nose cone." So C's subsequent utterance – which he ties to the preceding with "but" also uses "it" to refer to B's "this one."

1:22:06	Jamie	Yeah, but it has same no…
1:22:07		(1.0)
1:22:08	Chuck	Pointy nose cone=
1:22:09	Steven	=Oh, yeah=
1:22:10	Chuck	=But it's not the same engine

Here we see the conflict begin to be stated. C's "but" suggests a disagreement with B and possibly with J also. In the next second both J and B come back with "yes it is," showing that they took C's comment to be a clear disagreement with what they were saying.

K's non-verbal behavior again indicates that something unusual is going on. Now he rocks forward onto his elbows where he can follow events more closely. He stays in this position for the rest of the interaction.

At this point in our interpretation, we have several shifting factions of opinion. At first, all the student utterances seemed to be disagreeing with T's. Following B's bold gesture, some of the student utterances seem to be disagreeing with others. We have not yet worked out the basis of this disagreement because of the fragmented nature of the utterances that form our data.

We have actually overcome the problem of the elliptical – but not the indexical – character of the utterances by looking closely at how the individual utterances build off of each other, repeating the use of the same words or using conjunctions like "but" or "yeah" to signal continuity of topic. However, it is harder to know, for instance, which rockets are indexed by pronouns like "it." It seems likely that J and C are, in fact, indexing different rocket descriptions with their use of the pronoun "it." This would certainly cause confusion in the discussion because the repeated use of the same word should signify commonality of reference. To determine which rockets they are each indexing in their utterances, we will have to see how the students clarify these references.

The Repair

In the next couple of seconds, J and B state virtually the same thing simultaneously. This indicates that the state of the group discourse – from the perspective in which J and B are viewing it – must be very clear. That is to say, the network of indexical references as interpreted in J's and B's utterances is univocal. Within this set of references, C's claim that "it's not the same engine" is clearly wrong. J and B insist that "it" is the same engine.

1:22:11	Jamie	Yeah, it is, =
1:22:12	Brent	=Yes it is,
1:22:13	Jamie	┌ Compare two n one
	Brent	└ Number two

Here J and B support their counter-claim precisely by clarifying the references: they are talking about similarities and differences between rocket number 2 and rocket 1 on the list artifact.

J's imperative, "compare two and one," is first of all an instruction to C to look at the descriptions of rockets 2 and 1 on the list. At the same time, it is a reminder that the purpose of the whole discourse is to conduct a comparison of rockets in order to determine the best nose cone shape. J's utterance serves both to propose an explicit set of indexical references for the problematic discussion and to re-orient the discussion to the larger goal of solving a specific scientific task. His utterance thus serves to state both the indexical and the *projective* basis of the discourse. He is saying that the group should be indexing rockets 2 and 1 in the list comparison so that they can then conduct a comparison of 2 and 1 in the datasheet artifact as their projected future task.

J and B have now solved our task of interpreting the indexical references for us. Of course, we might still want to try to reconstruct the networks of references that different participants had at different points in the discourse. We would thereby be retrospectively reconstructing the process

of construction that the discourse originally went through to reach this point. We would be "deconstructing" the discourse.

If we go back to the minute of discussion between T and C that preceded our transcript, we indeed find the source of the confusing references. C had switched the discussion from nose cones to fins and had in fact solved the problem of how to determine the best rocket fin configuration. He said to compare rockets 3 and 4, which are identical except that rocket 3 has 3 fins and rocket 4 has 4 fins. Then C wanted to return to the problem of nose cones. He proposed making the simulation software modifiable by users so that he could either change the nose cone of rocket 3 or 4, or else change the engine of rocket 2 to match the engine of 3 and 4 so he would have a pair with the same engine as his baseline rocket (3 or 4) but different nose cones. So C was actually following the right theoretical principle already. However, his description of the changes he would make got quite confusing – plus it made unrealistic assumptions about the software.

So T's opening remark, directing C and the others back to the list on the screen can now be seen as a *projective* attempt to have C recognize that rockets 1 and 2 could be compared as is without changing one of them to be comparable to 3 or 4. In other words, the list had this built-in structure – that C was not seeing and taking advantage of – that the semantics of the artifact had been organized to solve the problem of rocket comparisons. Unfortunately, because the discussion had been focused on rockets 3 and 4 as the basis for comparison, none of the students could see at first that 1 and 2 met the criteria. As J said, there was no rocket with a pointed nose cone, "not with the same engine," where we can see that "same" referred here to same as the engine in 3 and 4.

When B points to what must be rocket 2 and says, "This one's different," his utterance refers to the fact that rocket 2 has a pointy nose cone, which is different from all the other rockets. At this point, B's and J's utterances must be taken as comparing rocket 2 to rocket 1. Because when C keeps insisting that "it's not the same engine" (meaning 2's engine is not the same as 3 and 4's), B and J retort "yes it is" and explicitly refer then to 1 and 2. As they repeat that they are looking at descriptions of rocket 2 and another rocket with the "same" engine, even C gradually aligns with the reference to rockets 1 and 2. With this look back at the situation prior to our moment, we can reconstruct how our interaction developed out of its past and we can determine a consistent and meaningful interpretation of the references of the utterances, as understood from the perspectives of the different participants' utterances.

The Resolution

In the final segment of our transcript, C responds to J's clarification. When J says "compare two and one," C actually turns to the computer screen and studies it. With gradually increasing alignment to what J is saying, C says tentatively, "I know." This is the first time during this episode that his utterances are agreements. J goes on to instruct on how to make the comparison of rockets one and two: note how they "are the same." C's "Oh" response indicates a change in interpretation of things. B makes even more explicit how J's "are the same" is to be taken, namely that both rockets have the same kind of engine.

1:22:14	Chuck	(0.2) I know.
1:22:15	Jamie	(0.2) Are the same=
1:22:16	Chuck	=Oh
1:22:17	Brent	It's the same engine.
1:22:18	Jamie	So if you ┌ compare two n one,
1:22:19	Chuck	└ Oh yeah, I see, I see, I see
1:22:21	Jamie	(0.8) Yeah. Compare two n one. So that the rounded n- (0.1) no the rounded one is better. Number one.

J now repeats his double-edged imperative, "compare two and one." But he precedes it with "so if you." Now he is not only telling C to look at these two descriptions and to compare them, but also saying that if you do this then you can go on and do something in the future, namely compare the data that the students had collected in the previous hour for these two rockets and determine the best nose cone design. While C is conceding that the descriptions of these two rockets meet the criteria that T spelled out at the start of the interaction, J has started to look over the data sheet that he had been holding ready at hand during the whole conversation and had brought up to his line of sight at 1:22:13. (S had also gone to retrieve his data sheet at 1:22:15, after hearing J's first "compare two and one" and then checking the list on the screen for a moment.) Now J announces the findings from the data. In the final utterance at 1:22:21, J compares 2 and 1 – but now their data, not their descriptions. He announces that the rounded nose cone is better based on its performance data. He stops himself in the middle of this announcement with a glance between the list and the datasheet artifacts to check his analysis, which requires combining information from them. Finally, he links the conclusion about the rounded nose cone to the rocket description ("number one"). This not only resolves any possible conflict about the references of the discussion, but shows how they worked to solve the larger task that had been projected for the discourse.

At the end of our collaborative interaction, a quiet consensus has been reached. J and S have moved on to the data sheets and everyone else is looking intently at the list, having acknowledged T's rhetorical question, "And you don't have anything like that (rocket 1 and 2 descriptions, with the same engine and different nose cones) there (in the list)?" Now all the references are aligned with those of T's original question, bringing an end to the breakdown of references and allowing the group to affirm the question and move on to solve their task using the newly comprehended list artifact.

Making Learning Visible

By making explicit the references that grant meaning to the discourse, the students made visible to each other the understanding that was being expressed in the interactions. In particular, they made visible the elliptical, indexical and projective references that had become confused. As researchers, we can take advantage of what the participants made visible to each other to also see what was meant and learned as long as we stand within a shared interpretive horizon with them (Gadamer, 1960/1988). Methodologically, our access to these displays is ensured to the extent that we share membership in the culture of understanding that the participants themselves share. For instance, we are native speakers of English, have experienced middle school classroom culture in America, have a lay understanding of rockets, but may not be privy to the latest teen pop culture or the local lore of the particular classroom so we can legitimately interpret much but perhaps not all of what goes on. The equivalent of inter-rater reliability is established by our developing interpretations of the data in group data sessions and presenting those interpretations in seminars and conferences of peers, where our interpretations must be accepted as plausible.

In our preceding analysis, we have seen that the factors that have in cases of individual learning been taken to be hidden in occult mental representations can in cases of collaborative learning be taken to be visible in the discourse. The meaning of utterances – even in elliptical, indexical and projective utterances – can be rigorously interpreted on the basis of interaction data such as digital video or discussion forum logs. Learning – now viewed at the group unit of analysis – can be taken to be a characteristic of the discourse itself. In addition to the group's shared understanding, however, one can also determine the interpretive perspectives of the individual participants,

particularly in cases where there are breakdowns of the shared understanding and the participants must make things explicit.

The Constitution of a Group Perspective

The preceding analysis gives us a new insight into the nature of the *group perspective*. It is true that only individuals can interpret meaning.[2] But this does not imply that the group meaning is just some kind of statistical average of individual mental meanings. A group meaning is constructed by the individual members as they interact. We have now seen an example of how this works. The discourse is elliptical, indexical and projective; that means that it implies and requires a (perhaps open-ended) set of references to complete its meaning. These are supplied from the individuals' interpretive perspectives. The on-going assumption is that everyone supplies roughly the same references. From time to time there is a breakdown and it becomes clear to the members of the group that different people are supplying different references. In the case we have observed, the group members repair their problem by clarifying what the references should be. This continues until – for all practical purposes – it seems that the utterances of all the members imply a common interpretation of the references. Now the conversation can go on, which means that the group has decided that the group understanding is repaired.

This does not mean that we must assume that everyone in a group always has the same understanding. In our analysis we saw that different interpretive perspectives can and do arise. C and T had different and at times incompatible perspectives on the discourse. The other students intervened to repair this breakdown in group understanding. They did this by using the simulation screen as a shared artifact and tying the discourse to it. The problem revealed itself to be a matter of C and T interpreting the references of the elliptical, indexical and projective utterances that took place in the group discourse as referring to different items. Note that in our analysis it is not a matter of C and T advocating for different thoughts hidden in their heads but of their utterances implying different interpretations of the references in the publicly available group discourse.

The approach illustrated in this paper suggests a rigorous method for laying out the complex interactions that occur in similar instances of collaborative learning, The method focuses on deconstructing the network of semantic references that are interactively constructed in the group discourse, eschewing any inferences concerning participants' mental representations.

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[2] The methodological recognition of interpretive perspectives avoids the reduction to behaviorism in bracketing out inferred mental states and focusing on observable interaction.