The complementarity of a representational and an epistemological function of signs in scientific activity

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Abstract

Signs do not only ‘represent’ something for somebody, as Peirce’s definition goes, but also ‘mediate’ relations between us and our world, including ourselves, as has been elaborated by Vygotsky. We call the first the representational function of a sign and the second the epistemological function since in using signs we make distinctions, specify objects and relations, structure our observations, and organize societal and cognitive activity. The goal of this paper is, on the one hand, to develop a model in which both these functions appear as complementary and, on the other, to show that this complementarity is essential for the dynamics of scientific activity, causing a dialectical process of generating new epistemological and representational means. This will be demonstrated with an example of how two scientists with different background knowledge analyze educational data collaboratively.

Keywords: epistemology; activity theory; collateral knowledge; dialectic; Peirce; Vygotsky.

1. Introduction

The distinction between two different functions of signs — a representational one and an epistemological, knowledge constituting one — has been introduced in a theoretical context to describe the epistemological dimension that is characteristic of the semiotics developed by Charles S. Peirce (Hoffmann 2005: 34ff.) — in contrast, for example, to de Saussure’s linguistically oriented ‘semiology.’ Elsewhere, the authors of this article have applied this distinction to better understand how scientists interpret familiar graphs on the one hand, and unfamiliar ones on the other (Hoffmann and Roth 2005). Here, our starting point is the thesis that this distinction is not only basic to understanding how people work with signs...
and representations, but that it is also fundamental for our own work as social scientists when we try to analyze what people are doing in semiotic activity. By using the distinction between a representational and an epistemological function of signs, we reflect here on some most basic problems of our own scientific activity.

In the following, we start with a short recapitulation of some theoretical background to more precisely define our concepts. The goal is to develop a general model by which both the representational and the epistemological function of signs can be described in such a way that their interdependence becomes visible and salient. In the second part, we analyze some examples of our own theory and methodology development on the one hand, and their applications in empirical research on the other. The framework proposed allows us to take a reflexive stance to social scientists’ (educators’) knowledge constructive processes. It is a tool that allows us to realize that whatever ‘reification’ (Bourdieu 1992) we are using to describe what we take as our ‘reality’ has to be open to criticism and refinement. More so, our model becomes an instrument that enables us to break with the instruments with which social scientists rupture the reification of common sense in their work.

2. The representational and the epistemological function of signs

The central goal of educational research is to understand — and to improve based on understanding — processes of learning, teaching, and communicating in classrooms and beyond. ‘Understanding’ means, first of all, to represent what is going on in those processes, that is, to develop theories and both descriptive and explanatory models ‘about’ learning, teaching, and communicating. We need a language to talk about what is in focus; and — as it has become more and more clear through the role semiotic approaches played over the last decades (Cobb et al. 2000; Cunningham 1987, 1992, 1998; Ernest 1997; Hitt 2002; Hoffmann 2000; Hoffmann et al. 2005; Roth 2003; Sáenz-Ludlow and Presmeg 2006) — those ‘languages’ do not only consist of words but of all kinds of signs. From a semiotic point of view, that is from a more general vantage point, the essence of science is to develop ‘semiotic systems’ to understand something.

Using signs and semiotic systems in this way as means of understanding hints at a fundamental complementarity of two functions signs can fulfill. We propose to call them the representational function on the one hand, and the epistemological, or knowledge constituting function on the other (cf. Hoffmann 2005: 34ff.). The representational function is well known
since Augustine and has been described more precisely by Charles S. Peirce as a triadic relation between what he called ‘object,’ ‘sign,’ and ‘interpretant’ (cf. figure 1):

A sign, or representamen, is something which stands to somebody for something in some respect or capacity. It addresses somebody, that is, creates in the mind of that person an equivalent sign, or perhaps a more developed sign. That sign which it creates I call the interpretant of the first sign. The sign stands for something, its object. (CP 2.228)

While Peirce would interpret figure 1 as showing the representational function of signs — a sign represents something for somebody — an epistemological interpretation would put it the other way around, so to speak. A sign is a means to refer to a specific entity in our ‘world’ of objects which again is organized and structured by the semiotic systems our civilization has developed to do just this: to organize, to understand, and to communicate our observations and experiences, that is a means to constitute, or to generate knowledge.

The possibility of generating knowledge by using signs is conceived here within a framework that defines ‘knowledge’ as the ability to do something (Hoffmann and Roth 2005: 129ff.). Thus, ‘knowledge’ is more than ‘justified true belief,’ as the definition established in philosophy says. According to this traditional definition, a condition of ‘knowledge’ is that it can be ascribed to persons in the form of a proposition, as in ‘Mary knows that . . .’ Excluded from propositional knowledge, however, are not only forms of knowledge like practical and strategical knowledge — also called ‘knowing how’ (Ryle 1949), as in ‘knowing how to ride a bike’ — but also further forms of knowledge: for instance iconic knowledge — that is the ability to think of, to identify, and to represent structures and relations — and ‘knowing who we are’ as it is present in self-images, self-consciousness, and understanding one’s role in social relations.
Defining knowledge as the ability to do something — where ‘doing’ encompasses also understanding, perceiving, thinking, and so on — is more general than defining it as ‘justified true belief.’ Such a belief can be part of knowledge defined as ability but not the other way around. Using ‘knowledge’ in a broader sense means that our concept of ‘epistemology’ (the Greek epistêmê translates as ‘knowledge’) does not refer primarily to the problem of justifying knowledge claims but to the problem of how we generate knowledge. From our point of view, the epistemological function of signs is fulfilled in all those situations where a sign is used as a means to do something like structuring our world of objects and relations, or manipulating social events. We make distinctions and specify objects by using symbolic signs (including concepts), we identify relations and structure our observations and experiences by using iconic signs (including pictures, diagrams, etc.), and we organize societal and intersubjective activity by all those signs we are using in communication and interaction (including gestures, modulation of voice, etc.).

As we showed in an empirical study of how scientists work with graphs that were either from their own field of expertise or from other fields, this epistemological function of signs becomes visible when scientists are confronted with familiar graphs (Hoffmann and Roth 2005). Interpreting graphs from their own field, they seem to have immediate access to the reality as described by those graphs. Although being confronted by signs, people speak as if there were no signs at all but directly what those signs represented. Thus, in the case of familiar graphs, ‘when they know a graph very well … scientists conflate them with the phenomenon itself.’ Familiar graphs are ‘transparent’ to us, so to speak, ‘allowing direct access to the phenomena the graph is said to be about’ (Roth and Bowen 2003: 468, 470; cf. Roth 2003). In this situation, signs are means to get access to what they represent according to the scientists’ interpretations.

What we call the representational and the epistemological function of signs can be traced back to two different traditions in the history of semiotics (Seeger 2005). Besides Peirce, an ancestor of the representational approach, Seeger hints at the Russian psychologist Lev S. Vygotsky as somebody who elaborated the basic idea of signs as means that has mediating function. Facing the behaviorist approach predominant in the beginning of the twentieth century, he intended to overcome its limitations by introducing the notion of mediation. Vygotsky’s starting point was his work with handicapped children.

Vygotskij’s approach was characterized by the idea that the relation of stimulus and response has to be re-mediated, that is, new means have to be found for
mediating between the social and physical environment and the activity of the subject. These means are signs. If new signs mediating stimulus and response can be integrated successfully into the structure of behavior, the handicap becomes more or less obsolete — and simultaneously this means that ‘higher functions,’ the specifically human functions, are back in operation again. (Seeger 2005: 68)

Signs work here as ‘self-generated,’ artificial stimuli, as ‘means to develop and to foster higher psychological functions . . . The “power of the sign” for Vygotskij does not so much spring from the sign itself but from using it as a means, from creating new signs arbitrarily to be used as means in novel situations’ (Seeger 2005: 68f). Vygotsky explicitly considers the epistemic function of signs when he discusses how children use a sign when they face a problem that their current knowledge does not allow them to solve. The system of signs employed — for example, in egocentric speech — not only structures perceptual access to the world but also ‘restructures the whole psychological process and enables the child to master her movement. It reconstructs the choice process on a totally new basis’ (Vygotsky 1978: 35, original emphasis). The epistemic role signs play in Vygotsky’s work is explicit when he distinguishes it from other tools:

The tool’s function is to serve as the conductor of human influence on the object of activity; it is externally oriented; it must lead to changes in objects. It is a means by which human external activity is aimed at mastering, and triumphing over, nature. The sign, on the other hand, changes nothing in the object of a psychological operation. It is a means of internal activity aimed at mastering oneself; the sign is internally oriented. (Vygotsky 1978: 55)

In the shift from external to internal functions of the sign, ‘the use of external signs is also radically reconstructed’ (1978: 57). Explicitly referencing G. W. F. Hegel and his project of showing how mind develops by turning upon itself, Vygotsky articulates signs as the required mediating tools (means) that make the development of mind (self-consciousness) by the mind itself possible. The development of ‘higher psychological function’ and ‘higher behavior’ that distinguishes humans from primates lies in the new psychological function possible through the epistemic function of the sign.

Seeger’s essential point therefore can be applied to our distinction: the demand, namely, that a ‘semiotically inspired theory of teaching and learning’ would profit most if what we distinguish in this way or in another would be conceptualized by the notion of ‘complementarity,’ a
concept whose significance for educational research has been highlighted first by Michael Otte (1994, 1997: 360).

However, it is not easy to see how such a complementarity could be conceptualized with regard to the two functions of signs. We need a more precise understanding of the way in which signs can both represent something for us and be a means for constituting knowledge.

One result of our analysis of how scientists interpret familiar and unfamiliar graphs has been that the triadic relation described in figure 1 is not sufficient to understand the conditions of interpretation. It turns out that in the case of facing an unfamiliar graph, when a graph is not a means for a scientist to get access to what is represented but a problematic object that itself has to be investigated, scientists activate a lot of background knowledge to develop hunches of what is going on (Hoffmann and Roth 2005; Roth 2004). This situation of activating knowledge to find an adequate interpretation of a sign can semiotically be modeled as in figure 2. We use quite different forms of knowledge — including strategic knowledge, symbolic knowledge as realized in certain concepts, and iconic knowledge about structural relationships — to understand a sign.2 To represent this activity we need a further ‘level of mediation,’ so to speak. While a familiar sign on the first level mediates between object and interpretant, a problematic sign is itself an object that is accessible only by a second level of mediation at which given knowledge is used to find an adequate interpretation.

The most interesting result of our study has been that it provided us with evidence that just those knowledge forms that became visible in scientists’ efforts to cope with unfamiliar graphs are implicitly involved when they work with familiar graphs. In our earlier work, we described how a scientist used just those strategies implicitly when confronted with a familiar graph about which he reflected explicitly — in order to solve his interpretation problem — when facing an unfamiliar graph (Hoffmann

Figure 2. Knowledge mediated sign relation
and Roth 2005: 113ff.). This observation supports the hypothesis that the semiotic model described in figure 2 also can be used to represent more precisely what we described by figure 1 above. However, the essential difference is that those knowledge forms that mediate on a second level are not visible usually — both in situations where a sign is an unproblematic means to get access to a world of ‘objects’ and in situations where a sign represents something for us. They are implicitly given.

To also capture this distinction terminologically we distinguished ‘knowledge in focus’ and ‘collateral knowledge,’ a term that was introduced by Peirce. ‘Collateral’ means literally ‘running side by side’ with something else. In our context, collateral knowledge can be defined as those forms of knowledge that remain hidden though being an essential condition for focusing on something. Peirce used the following example to illustrate his concept of collateral knowledge. Suppose somebody says ‘Napoleon was a lethargic creature.’ Readers probably will be surprised to hear that the great conqueror should be ‘lethargic.’ But the point is, to be surprised by this sentence one must already know who Napoleon was and what he accomplished. If we do not know about Napoleon, we can only guess whether it is the name of a lethargic person. We are surprised only when our collateral knowledge about Napoleon contradicts what is said in this sentence. Knowledge in focus, on the other hand, is knowledge that itself is in focus of our attention. The scientist, for example, who reflects on possible strategies to cope with a problem, focuses in this way explicitly on knowledge that usually works collateral. The whole idea of ‘internalization’ in learning theories can be reformulated thus by saying that knowledge-in-focus is transformed into collateral knowledge.

Based on the distinction between knowledge-in-focus and collateral knowledge we can relate now the interpretation of unproblematic, or familiar, signs and that of problematic signs by contrasting figure 2 and 3. While figure 2 describes situations where we have actively to focus on given knowledge forms that might allow interpreting a problematic sign, figure 3 shows that a specific subset of the same network of knowledge forms as mentioned in figure 2 is involved when we interpret an unproblematic sign. However, in this latter situation this knowledge is not in focus, but works collateral, that is as an implicit condition of interpretation.

Collateral knowledge is a condition that has to be fulfilled both with regard to the representational and the epistemological function of signs. As Peirce says, thinking of its representational function, ‘no sign can be understood ... unless the interpreter has “collateral acquaintance” with every object of it’ (EP 2: 496). A sign can only represent something for
somebody if this person knows already how to interpret this sign. It is our prior given collateral knowledge that makes what we call the ‘familiarity’ with a sign. We have to know, for instance, the meaning of the icon picturing a wheelchair on blue ground to interpret this sign correctly when we see it on a parking lot.

The same is true regarding the epistemological function of signs. We have to have collateral knowledge of the meaning of a sign before we can use it to make distinctions, specify objects and relations, and structure our observations and experiences. Figure 3 offers thus a model that can both describe how a sign represents something for us and how we can use it as a means. Both possibilities are conditioned by collateral knowledge. Thus, the same model represents the representational and the epistemological function of signs. With regard to the representational function, this model would be interpreted by reading it from the left to the right side, so to speak — the representation of an object for an interpretant — and regarding the epistemological function the other way around: using a sign as a means to signify an object.

In communication, obviously both these functions of a sign are realized. The speaker uses signs as a means to signify something, and for the hearer the same signs represent something. At the same time however, our semiotic model makes clear that communication works only if both partners share the collateral knowledge necessary to use and to understand a sign. Misunderstanding and conflicts result when the collateral knowledge on both sides is different, or not similar enough.

Within this theoretical framework, discrepancies with regard to collateral knowledge are the central problem for teaching, learning, interacting, and whatever depends on communication. But it is also an essential problem for any kind of interpretation and analysis we perform in science. This is what the next section is about.
3. The problem of understanding in scientific activity

In the following example of a study whose results have been published elsewhere (Roth and Middleton 2006), the problem of different collateral knowledge occurs at two levels. At the first level, an undergraduate physics student (Dan) interviews, as part of an internship related to his cooperative education program, a physics professor (Anne) about graphs (cf. figure 4). He conducted this internship in the context of Roth’s laboratory, which previously had conducted research on graphs and graphing among biologists. Dan’s task was to identify physics graphs that were isomorphic with those used in the biology study, and then solicit physicists to provide think-aloud protocols concerning both sets of graphs. In this way, the research would contribute to articulating the role disciplinary knowledge plays in graph interpretation. Dan therefore used graphs from two domains to be able to tease out the discipline-dependent and discipline-independent aspects of graphing expertise.

At a second level, two social scientists have joined forces to analyze the interviews involving Dan and the physicists he had asked to do think-aloud with respect to graphs and graphing. The first is a social psychologist (David Middleton), who has spent much of his life’s work on analyzing interactions, discourse, and workplace communication. The second (Wolff-Michael Roth) is an applied cognitive scientist, with graduate degrees in physics and statistics, but who conducts ethnographic and linguistic studies on knowing and learning science and mathematics.

The analytic sessions of interest are those concerning a particular section of the interview/think-aloud session involving Anne and Dan, which Roth had identified as interesting because the think-aloud session turned into a tutoring sequence. The starting questions for the seventeen-day analysis session were ‘What is going on?’ ‘How does a think-aloud session turn into a tutoring session?’ ‘How do Anne and Dan accomplish the work of the session?’ The two analysts then spent each day doing independent analyses (between two and three hours) then interacting over their work and analyzing segments together (about two hours) and finally spent another two hours to write analyses. Given the different disciplinary backgrounds, it comes perhaps not as a surprise that the two scientists noticed different phenomena and were blind to others. A central focus for both was, however, to understand the kind of knowledge the two interaction participants have to bring to the situation to make it work in the way it did.

On the one hand, Dan and Anne make available to each other the kinds of understanding that are required; they use language as a resource not only to talk about the graph but also to bring about action, such as
asking a question, getting the other to respond to a question, avoiding answering a question. The other aspect pertains to the graphs. ‘What kinds of knowledge do Anne and Dan display?’ and ‘Are these displays available to the analysts?’

On the one hand, there is more generic knowledge that allows Anne and Dan to conduct their interaction. A social knowledge required allowing them to make assessments about the degree to which they are aligned (intersubjectivity) and the knowledge required to bring about alignment if it turned out that they are not.

On the other hand, there is also very specific knowledge about biology and the mathematical aspects. Again, if there are questions about these aspects, the two interaction participants are likely to make them the topic of their talk and therefore available to the analysts.

But there are also forms of knowledge that they take as shared, granted, and therefore as going without saying. These are facts that are taken as self-evident within particular communities of knowing. Talking about the self-evident will be taken as strange, and the listeners may ask themselves why the self-evident has been noted. For example, if two professors at the same university face an open door and one notes, ‘This is an open door,’ this statement will likely raise some questions on the part of the listener. Why would the first professor make such a statement? Why now? What is its function? Perhaps, the second professor might make some attribution about the mental state of her colleague.

Thus we may expect there to be situations in the analyzed video (transcript) where knowledge is required that is not articulated but nevertheless required for understanding what is going on and why the interaction participants are talking in the way they do. That is, not only the content is shaped by this non-articulated knowledge (cf. Barwise 1988) but also the form of the interaction between two or more individuals from the same community of knowledge. This non-articulated knowledge will be available in the same way to other community members but not (or not necessarily) to an outsider. Let us take one segment of Dan’s interview with Anne as a starting point to reflect on two different analyses that were part of the authors’ initial discussions.

3.1. Interpretation 1: A social psychologist’s collateral knowledge

David Middleton had this to say about the transcript:

We have already seen that the assessment formulations are interactionally accountable. The formulation of an assessment provides an explanation slot within the interaction. We can see this also in this episode. ‘A’ reformulates her interpre-
tation of the graph — so presumably that means that the population is increasing — as a plausible consequence of her line of interpretation. In terms of her gestures (pointing) she displays a clear orientation to the graphical material. She has shifted the interactive attention to the graphical material. ‘D’ is made accountable to this reformulation of the material. Is that right? His hesitant reply is the dispreferred mode (Pomerantz 1984). He does not confirm or deny ‘A’s reformulation. ‘A’s’ latched qualification provides a further explanation slot which is taken up by ‘D.’ However he too reformulates in a way that offers another version of how to proceed and in turn provides a further assessment formulation — ‘right.’ This in turn is further reformulated by ‘A’ — ‘I’m looking at the slopes of the curves.’ Out of these contingently reformulated assessments we see the start of a form of distributed responsibility for graphs and rubric. This first statement of task orientation directly aligns ‘A’ with the graphical work. She is now positioned as accountable for examining them in a particular manner. ‘D’ defers to that position without any committal or linkage to his immediately prior formulation of the graphical problem.

In this statement, David focuses on the interactional properties of the tape and transcript. The interpretive text is filled with discipline specific discourse, including the terms ‘formulation of an assessment,’ ‘expansion slot,’ ‘reformulates,’ ‘dispreferred mode.’ The grounding in the disciplinary discourse (knowledge) is further highlighted by the, for an analysis perhaps early, reference to the literature (‘Pomerantz 1984’). In addition, the interpreter highlights the particular interaction and discourse as displaying an orientation toward the graph, which is here and elsewhere in the materials contrasted with an orientation toward the text. Anne and Dan are shown to be responsible for these different parts of the task, the former for explicating the graphical materials, the latter for the way in which the task is described in the text.
The collateral knowledge exhibited in this interpretation clearly is that of a discipline concerned with interactional behavior, and who does what and who is taking responsibility for what in and as part of some conversation. This collateral knowledge is used by David as a means to make sense of what happens in the interview. The ‘signs’ that are visible in the interview’s transcript and in the video fulfill a representational function for him, but what they represent for him becomes visible only in the epistemologically used signs he formulates in his interpretation. David’s interpretation therefore constitutes and construes first of all that knowledge about the realization of social interaction and social relations that he finds in the interaction between Anne and Dan.

David did not attend to the mathematical details Anne and Dan articulated. In some instances, he felt at a loss altogether — for example, when the issue Anne and Dan talked about were second and partial derivatives. And he did not reflect on the two sets of institutional roles that the two participants have: (a) professor and student and (b) expert and interviewer.

3.2. Interpretation 2: The collateral knowledge of a cognitive scientist and physicist

Michael Roth had this to say about the transcript:

The participant framework is one in which Dan takes the role of the interviewer (division of labor) and Anne the role of the respondent. The two co-produce the interview. At the end of the turn, Anne asked Dan, ‘Is that right then?’ Here, rather than responding to the request for producing a think-aloud, she actually asked a question of the co-participant in the interviewer/researcher position. This is a request for change in the participant framework that they had agreed upon at the outset.

Dan was hedging. Anne then reframed, in fact, narrowed the frame of the request by making the query ‘I am right then?’ specific to one part of the graph. Dan did not respond directly, in absolute terms, but attempted to turn the responsibility for the answer back to Anne, ‘if you take . . .’ Anne countered, ‘I am looking at the slope of the curves.’ Whereas Dan described taking the difference or sum (second part of sentence) of the birthrate and death rate, Anne now articulated her previous actions as involving a focus on the slopes. Dan (apologetically) responded, ‘Oh, okay.’ In her response, Anne not only suggested that she was looking at something other than the relation of birthrate and death rate graphs, but also made a statement about the appropriateness or rather inappropriateness of Dan’s answer to her first request.

There was a long pause. Anne’s utterance ‘Okay’ and the movement of her pencil to the graph were actions that indicated to the coparticipant that she was
actually doing something, focusing on the task, and more particularly on the
graph — rather than the text (which will be the domain of Dan).

In this situation, the two are not aligned. Anne was making salient the slopes
saying, ‘birthrate is increasing faster’ while moving the tip of her pencil along the
curve. In Dan’s response to the query if she was right, he talked about the values
of the rates that needed to be subtracted, or rather, added.

Dan in physics/expertise display mode: In describing the total rate as an addi-
tion of birthrate and death rate, Dan displayed the disciplinary disposition of a
physicist rather than that of an ecologist or an everyday person not versed in
mathematical physics. In physics, birthrate and death rate are the derivatives of
the population with respect to time. Because death rate decreases the population,
the derivative would automatically be a negative value, which Dan articulated as
‘the death [rate], which is negative.’ The two rates have to be added rather than
subtracted as this is suggested by the graph, in which both rates are plotted on
the positive axis. Anne knows this and responds appropriately that she is not
looking at the difference in the functions but at the differences in the slopes of
the two functions.

Salient in the first paragraph is the fact that the interpreter highlights
the change in participant framework. This, of course, requires at least fam-
iliarity with the associated discourse, and also with the concrete situ-
ation of the interview setting that he analyzes. He knew that Dan was
the researcher intending to elicit Anne’s expertise about graphs. In such
a situation, one expects Anne to think aloud and Dan to listen or, if any
question–answer sequences were to be expected at all, it would be to Dan
to ask the questions and Anne to respond.

To do this kind of analysis, the interpreter uses his collateral knowledge
about the type of social situation and the actual distribution of roles that
the participants Anne and Dan take. The scientific discourse about par-
ticipant framework is his epistemological means to generate knowledge
about the interview. Interpreting Dan’s utterance as a form of ‘hedging,’
avoiding a straight answer, again appears to presuppose familiarity with
the corresponding concept in the conversation analytic literature.

Central to Michael Roth’s analysis is that he displays mathematical
knowledge typical for physicists. Based on this collateral knowledge, he
emphasizes in his interpretation that Dan reframes the mathematical rela-
tions actually displayed in the graph. In this graph, reflecting a biological
community, both birthrate and death rate are signed positively (are posi-
tive quantities); to find the net rate, one has to subtract the death rate
from the birthrate. In physics, however, the death rate, because it is a
rate that decreases the size of a population would be a signed negatively
(i.e., would be a negative quantity) so that the net rate would be ex-
pressed as birthrate plus death rate. The analysis brings out that Anne
not only does understand this reframing but also points out that she is in fact looking at something else altogether. She is looking at the slopes of the rate functions displayed, not at the values of the rates.

The analysis then brings out that Anne’s statement thereby also becomes a statement about the appropriateness of Dan’s intervention. That is, the analyst not only points out that Anne makes a statement about what she is looking at but also articulates that Dan’s utterance, at a second level, did not respond to her question. Omitted in this analytic text is the fact that Anne emphasized the reflexive pronoun and action ‘I’m looking . . .’, which David had emphasized in his analysis. Knowledge of this emphasis nevertheless appears to be important to this interpretation, for it contrasts that she is doing or asking something differently than what Dan articulated.

An interesting aspect here is the different level of reflexivity. Anne and Dan display knowledge for one another typical of physicists, but do not reflect upon that fact. Talking about the birthrate and death rate as being signed positively and negatively rather than both positively in the graph is to them like water is to the proverbial fish. Dan does not say, ‘in biology it is like this (both positive) but in physics we take the two rates as signed opposite.’ The collateral knowledge embodied in this statement, however, comes out in the interpretation of the social scientist with the physics background — who already has conducted research on graphs and graphing in the biology community. But it has to be noted nevertheless, for the social scientist with the physics background (Michael) could take Dan’s statement about the relation between birthrate and death rate in the same way as Dan and Anne. In such an instance, therefore, he would be subject to the same preconstructed knowledge as the participants and to the same situation analyzed — a possible danger of being or having gone native that threatens all of social analysis. It requires the social scientist ‘to break with his or her ordinary common sense, or with scholarly common sense in its ordinary form’ (Bourdieu 1992: 251). Noting such things is similar to the travelers, who note that some thing or other is different between the different countries they have visited already.

3.3. A comparing, meta-theoretical analysis

When we look at the two interpretations, therefore, the second one brings out the specifically mathematical knowledge that usually is collateral for a physicist. This was even further salient in other parts of the transcript and analysis, where the mathematical aspects were more exotic, such as second and partial derivatives. That is, different interpretations result from different collateral knowledge.
What David could see were the repeated efforts at reframing. These were significant for him — based on his collateral knowledge — from the structure of the utterances displayed. Yet the significance of Anne’s comment with respect to her looking (and talking) about the slopes of the rate functions rather than about the rate functions themselves can only become salient if the analyst has collateral knowledge in mathematics available. It is interesting that, in this case, availability of mathematical knowledge leads to a further difference in the analyses. Seeing the mathematical dimension of Anne’s statement allows Michael to interpret her emphasizing the personal pronoun (‘I’m looking . . .’) as a reproach that Dan has not answered the question she really has asked him to answer. That Dan understands this can be seen from his subsequent acknowledgment ‘Oh okay,’ which Michael interpreted to constitute an ‘apology.’ That is, without understanding the mathematical aspects negotiated here, David can see in Dan’s comment an acknowledgment, but Michael can see in it an ‘apologetic acknowledgment.’ That is, Michael’s interpretation brings out a particular social action that David’s interpretation does not bring out and, in fact, cannot bring out because of the lack of the mathematical and discipline-specific knowledge required. In this particular case, it is not just mathematical knowledge displayed, but in the way this knowledge is displayed it also has a social function; and, despite his background and experience in the social function of language and discourse, David cannot detect this aspect of social function.

This example of different interpretations of one video sequence supports our central thesis that our own scientific work is always determined by collateral knowledge we are using, on the one hand, to make sense of signs and representations and, on the other, to generate knowledge. The representational and the epistemological functions of signs seem to be always combined. However, more interesting might be the consideration that there would not be any development of scientific knowledge if there were no confrontations between different collateral knowledge in different people. If both our analysts had not talked to each other, they could not have learned as much as becomes visible in their joint publication (Roth and Middleton 2006). There is not much development if you can see only what your already given collateral knowledge allows you to see.

We therefore can conclude that what seemed to be a central problem of communication — i.e., understanding presupposes shared collateral knowledge — is at the same time the very condition of learning. Only if we do not share all what we know collaterally, we are challenged by the problem of understanding perspectives and approaches that are going beyond our own horizon.
The interesting question one may ask is how new knowledge can be created in the collaboration of two scientists with different backgrounds. Even if this is a question too big to be answered in the space available for this article, there is one point that could give us at least a clue. We already saw that what we distinguished as the representational and the epistemological function of signs sometimes seemed to be nearly indiscernible. Since the structure both of representation and of knowledge constitution can be modeled in the same way (cf. figure 3), it is only — with regard to this model — the ‘direction’ in which we read this model that makes the difference. In our cognitive practice, however, both are going hand in hand since the collateral knowledge that determines which signs we are using as a means to structure our world of objects is exactly the same we are using to interpret these same signs when used by others.

Based on the theoretical framework sketched here, the decisive step of learning seems to take place when we realize — as in the case of unfamiliar graphs mentioned above — that our collateral knowledge is insufficient to interpret a sign immediately and without problems. Struggling with a sign and looking for an answer how to interpret it forces us to reflect on our collateral knowledge, putting it into the focus of our attention. This seems to be a precondition to enlarge our collateral knowledge, in whatever way that might be possible.

One way to explain this possibility might be that an unfamiliar sign challenges us to generate an explanatory hypothesis, that is to perform what Peirce has called an ‘abduction’ (cf. Hoffmann 1999). Once we have a hypothesis, we can think about implications of this hypothesis, and finally test its implications empirically. Even if it is a hard question to answer how the abductive generation of a hypothesis itself could be explained, it should be clear from what we developed so far that only collateral knowledge of a further level can be taken into account for that.

While abductive hypotheses formulation is essential for interpreting signs within the representational framework, there is another creative process that can best be described from an epistemological point of view. Using signs as a means to constitute knowledge by structuring our world of ‘objects’ implies that inventing new signs means to develop new possibilities of knowledge. This can be shown by what happened between formulating the different interpretations mentioned above and the final publication. The ultimately agreed upon and published interpretation goes beyond a simple addition of the two contributions. The interaction of the two social scientists allowed them to arrive at a new level of understanding. For example, when the two discussed David’s analyses, it became salient that pitch and pitch contours may play a role in the phenomenon David had described. Michael had already developed previously
knowledge about the phenomenon of pitch and pitch contours as semiotic resource to analyze interactions, and he gained experience with software tools that can be used here. This led to the following statement that augmented David’s analysis of the interview sequence quoted above:

A’s contrasting response is evident from the way pitch was displayed. Whereas during the think-aloud portion her pitch was between 180 and 200 Hz, her framing of her own activity ‘I’m looking’ was associated with a significantly higher pitch around 280 Hz with a maximum at 291 Hz. That is, her pitch range was hearably higher, contrasting not only her earlier ways of speaking, but also the pitch range currently produced by the interviewer (110–140 Hz). The very same structure is exhibited in Episodes 9 and 10. (Roth and Middleton 2006)

In this excerpt, we see at the very end an additional feature not previously discussed — an analysis of prosody is used to substantiate an analysis that we find basically outlined in David’s initial analysis. In the joint article, the analysis of prosody is an integral part, substantiating in important ways — sometimes by means of graphs — the analytic claims. Thus, the analysis of prosody, the literature on this method, and knowledge about the software that can be used to do the analysis became important epistemological means. They allowed substantiating the claims David made on the basis of interpretation grounded in different knowledge.

While David, at the beginning, did not know much about the analysis of prosody, Michael was unfamiliar with the phenomenon of ‘hedging’; he acquired this knowledge as part of the analysis sessions. For example, in those instances identified as ‘hedging,’ Dan’s pitch levels remained within his normal range. But when Dan clearly attempted to oblige Anne in her requests for further information or assessment, Dan’s pitch moved into Anne’s range, which means his pitch had to nearly double. Important to the collective analysis was not only the knowledge that pitch plays a role in interaction and knowledge how to do the pitch analysis (procedural), but also attention to a particular social phenomenon that David brought to the particular situation. What turned out to be new knowledge was the way in which Anne and Dan displayed pitch as an interactional resource — at the unconscious level.

When we develop new methods, or apply methods to new research areas, or when we develop new theories and concepts, we develop and apply new means to structure our world of objects, to identify things we did not distinguish before, and to organize our own communication. That is, the development of new semiotic systems is an essential part of developing knowledge. Creating new signs means to develop at the same time the collateral knowledge necessary to use and to interpret these signs.
Both the processes of abductive hypotheses generation and the creation of new signs and sign systems are combined within the practice of science. Since developing new semiotic means implies developing new collateral knowledge of how to use these means, we expect that other people can interpret these new signs by developing for themselves adequate hypotheses that again form new collateral knowledge for them, eventually. Just this mutual dependence of inventing new means and interpreting them is what we suggest to call the \textit{complementarity} of the representational and the epistemological function of signs. Without such a complementarity of \textit{using} signs and \textit{interpreting} them, learning and the development of knowledge would be impossible.

The process of learning itself can be described as a ‘dialectic’ process — based on our observation that we need the ‘challenge’ of interpreting unfamiliar signs to develop new collateral knowledge. We are using the often-problematic concept of ‘dialectic’ (cf. Hoffmann in press) here according to a non-Hegelian definition of a ‘dialectic system’ we developed elsewhere (Hoffmann and Roth 2004). Essential for our understanding of a ‘dialectical’ process is that such a process starts from a certain tension between elements of a given belief system, or from a ‘breakdown’ of well-established collateral knowledge in problematic situations, and that it needs a ‘level of mediation,’ a ‘space’ to develop new means of understanding. From our point of view, we need the tensions between different collateral knowledge — either given as differences between different people as in our example or as differences between a starting network of collaterally given knowledge forms and a developed one — to initiate processes of learning; learning that can be described as a dialectical process based on the complementarity of the epistemological and the representational function of signs.

4. Conclusion

This article combines a more theoretical focus on the one hand with a more practical orientation on the other. With regard to theory development within the field of semiotics, the main results are the following: (a) we clarified the distinction between two functions signs can fulfill — the representational and the epistemological, knowledge generating function; (b) we developed a model (figure 3) that can describe \textit{how} both these functions can be fulfilled, a model which emphasizes that ‘collateral knowledge’ is necessary both to interpret signs and to use signs to generate knowledge, that is to distinguish objects, to structure our experiences, to organize interaction, and so on; (c) we showed that communication
presupposes a complementarity of both sign functions since the possibility of understanding depends on shared collateral knowledge between sign producer (‘sender’) and interpreter (‘receiver’); and finally, (d) it turned out that learning and the collaborative development of knowledge can be described by assuming a ‘dialectical’ relation between using a sign epistemologically and interpreting it representationally — a relation that is dialectical because learning and development are motivated by a tension between different sets of collateral knowledge, or by a breakdown of a given system of collateral knowledge when we are facing an unfamiliar situation.

The practical results, on the other hand, concern the work of social scientists analyzing what happens in interaction. With regard to that, the article contributes to understanding how collateral knowledge forms brought by the social scientist to the analysis of interactions makes salient particular kinds of knowledge forms that are at operation in the interactions analyzed. In this way, our framework provides a tool for breaking with the all-too-quick reification of common sense notions on the part of social scientists (e.g., Bourdieu 1992; Holzkamp 1983). The concepts developed in this article are epistemological means for themselves that allow us to analyze essential constraints and conditions of our own work. Networks of collateral knowledge cannot only be found as a condition of understanding — and as a condition of learning — between Anne and Dan on the ‘object’ level of analysis, and between David and Michael on that level of analysis that provides different signs and semiotic systems to describe what happens on the object level, those networks of collateral knowledge can also be found on the meta-level of this article, and on the level of potential readers, and so on. That is what makes our work so dynamic, so open-ended, but also so risky and tentative. We are all and every time captured in systems of implicit, collateral knowledge, and it is only communication — and the difficulties and tensions in communication — that allows learning and the development of collateral constraints of understanding.

Notes

* The preparation of this paper was in part supported by grants from the Social Sciences and Humanities Research Council of Canada.
1. Cf. Aronson, Harré, and Way 1995 for the complementary role of both these kinds of models for the development of science.
2. The main goal in Hoffmann and Roth 2005 was to distinguish those knowledge forms more precisely.
5. CP 8.178; MS 318.
6. Elsewhere, this has been called the Peircean ‘three step process of abduction, deduction, and induction’; cf. Hoffmann 2005.

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