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The Nature of Scientific Conceptions: A Discursive Psychological Perspective

Abstract

Over the past three decades, the literature in science education has accumulated a tremendous amount of research on students' conceptions—one bibliography currently lists 7,000 entries concerning students' and teachers' conceptions and science education. Yet despite all of this research and all the advances in the associated conceptual change theory, there is evidence that students' conceptual talk remains virtually unchanged by instruction even under the best conditions. In this article, I describe and exemplify discursive psychology as a theoretical alternative, which ultimately allows me to understand the solid nature of student talk about scientific phenomena and why science instruction faces such challenges in bringing about conceptual change. To exemplify the presentation of the theory, I draw on videotaped interviews that covered ground similar to the one featured in *A Private Universe*. This theoretical alternative questions some of the fundamental presuppositions and assumptions made in the constructivist and conceptual change literature—including the locus of the misconceptions, the relation of individual and collective, and the situated and constitutive nature of the talk eliciting (mis-, alternative, pre-, naïve) conceptions. I conclude with some sobering suggestions and recommendations for the praxis of science teaching and the possibility to bring about scientists' science for and in *all* students any time in the near future.

Keywords: Conceptions, conceptual change, discursive psychology, discourse analysis, situated talk, conversation analysis

> Discourse psychology is a term designed partly to indicate that there is more than a methodological shift at work; there is some fairly radical theoretical rethinking. (Edwards & Potter, 1992, p. 11)

1. Introduction

There is a considerable science education literature on students' ways of seeing and explaining the world. This literature shows that students come to school with ways of talking about natural phenomena that differ from the ways scientists talk. These different ways of talking are evident in the following brief excerpt from an interview with a seven-year old child, an interview intended to solicit explanations of the origins of day and night, the phases of the moon, and the seasons.[1]

Fragment 1

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01  I:  so the question is very simple. (0.24) .hhh could you explain
        me:? 'why:: (0.55) 'why: we have day and why we have night;
02      (1.28)
03  A:  kay (2.06) ((licks lips with smack)) be (0.16) cause .hhhh
        (0.84) we need 'day to pla:y: anweneed night to sleep. (0.69)
        .hhh and then if we dont have 'day we dont have (lunch?) light
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[1] The transcription conventions are those typical in the conversation analytic literature according to the GAT system (Selting et al., 1998): (0.24) – time in tenth of a second; (.) – pause of less than a tenth of a second;.hhh, hh – in-breath, out-breath, respectively, each "h" corresponding to one-tenth of a second; <<dim>something> – (diminuendo) progressively less speech volume; <<p>we need> – (piano) less than normal speech volume; <<pp>uh> – (pianissimo) very low speech volume; = – "latching," that is, not separation between speakers or syllables of the same speaker; pla:y: – each colon corresponds to a one-tenth-of-a-second lengthening of a phoneme; ;.,? – punctuation marks indicates direction of pitch at the end of an utterance unit, slightly and strongly decreasing, slightly and strongly increasing; '`^why – diacritical marks indicate direction of pitch in the word that follows, up, down, up-down, and down-up, respectively; ((smacks lips)) – transcriber's comments are enclosed in double parentheses; ↑day – arrow indicates sudden upward jump of pitch; be – stressed phoneme, achieved by slightly louder speech, higher pitch, or lengthening of phoneme or a combination of these; Hh – capital letters for louder than normal speech; [uh um] – square brackets in consecutive lines indicate overlapping speech.

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and we can bump to <<dim>something or something> (0.47)
.hh=yea (1.04) we can bump to something
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In this situation, the child explains the existence of day and night in terms of human needs generally and those of a child in particular—playing, sleeping, and not getting hurt. This explanation likely is different from that astronomers would provide in a professional context (unless, of course, they are joking over a glass of beer), according to which the earth rotates thereby changing the parts that are exposed to the sun; the parts lit by the sun experience day, the others night, and those in between are in transition (Vosniadou & Brewer, 1994). Science educators, educational psychologists, and learning scientists have come to infer—as part of a "first wave of a cognitive approach"—what have variously been called (mis-, alternative, pre-, preinstructional, prior, naïve) conceptions from such talk; these conceptions generally are ascribed to students, who are said to hold, construct, or appropriate them (e.g., Gilbert & Watts, 1983). Thus, conceptions researchers would (a) interpret the *stretch of talk* to be the result of mis- or naïve conceptions, (b) attribute these conceptions to the child and perhaps her lack of appropriate school training, or (c) characterize the talk as "quite uninformed and uncommitted discussion of phenomena" (as suggested by a reviewer of this paper).

In the past, a considerable number of studies have been devoted to determining students' alternative conceptions, naive frameworks, or preconceptions; a bibliography compiled by Reinders Duit currently lists 7,000 entries concerning students' and teachers' conceptions and science education (http://www.ipn.uni-kiel.de/aktuell/stcse/stcse.html). Having made it into the common lore of science educators, the most (in-) famous demonstration of everyday talk about scientific phenomena derives from the documentary *A Private Universe Project,* which featured Harvard University graduates who explained, among others, higher summer temperatures

on the northern hemisphere by stating that the earth–sun distance was shorter than in the winter.[2]

To assist students in getting their science right, science educators and learning scientists from other fields frequently recommend challenging students' conceptions, confronting children with experiences, and leading them to be dissatisfied with their conceptions. Despite numerous approaches that employ various forms of discrepant events to undermine entrenched beliefs, most students turn out to resist conceptual change (Duit & Treagust, 1998); and ontological arguments have been provided why some "misconceptions" are likely to resist instruction (Chi, 2005). Presupposed in the recommendations for conceptual change and in theorizing any change observed is, once again, the attribution of (mis-, alternative, pre-, preinstructional, prior, naïve, canonical, non-standard) conceptions not merely to the individual person but to his or her mental structure. This research discussed so far falls into a cognitive approach to conceptual change; another approach with a different ontology and epistemology exists in a sociocultural approach (Mason, 2007). Thus, some researchers draw on the work of Lev S. Vygotsky to suggest that conceptions are not entirely one's own; thus, children first encounter or construct conceptions interpsychologically, that is, in public domain that they share with others, before constructing them intrapsychologically leading them to "reorganize their own understanding" (Varelas, Pappas, & Rife, 2005, p. 140). Others suggest approaches grounded in situativity theory or integrations of the cognitive and situative approaches (e.g., Vosniadou, 2007).

In this paper, I articulate a different theoretical perspective that has not been taken up in (science) education although it had been articulated more than 15 years ago: discursive

[2] Whereas it is accepted scientific knowledge that increasing the distance from a point-form heat source will decrease the amount of energy that impinges on a certain area—and therefore the temperature—the effect of the changing angle between earth axis and sun rays due the earth's revolution around the sun is much larger. A correct answer therefore runs something like this: The lower the angle of sun rays impinging on some area, the fewer rays will strike the area and the smaller the energy received that heats it, and therefore the temperature of the area.

psychology. The discursive psychological approach presented here is "radical," as per introductory quote, not only because it breaks with cognitive approaches of all brands but also because it distinguishes itself from other social and sociocultural approaches to cognition including critical discourse analysis, sociolinguistics, ethnomethodology, and conversation analysis (Potter, 2005). Like an increasing number of researchers in philosophy, social studies of science, social psychology, cognitive science, and education, the discursive psychological perspective theorizes the content and function of *talk* and language itself. Discursive psychology focuses on talk—which is practical, publicly available and therefore accountable, situated, and embodied—rather than theorizing the forever inaccessible contents of the mind, conceptions, or mental constructs (e.g., Clark & Schaefer, 1989) or the situated (e.g., Lave & Wenger, 1991) or embodied aspects of cognition (e.g., Lakoff & Núñez, 2000) offered as alternatives. A number of researchers already suggest that what students bring to school are not conceptions as individual properties, but ways of seeing and speaking about the world that are characteristic of the communities in which people participate (e.g., Edwards, 1993). The forms and contents of these discourses are, like other human practices, functions of the particular contexts in which these are used to expose, describe, and explain relevant phenomena at hand (Watson-Gegeo, 2004); if texts and contexts are treated as meaning-making phenomena, then systematic relations can be established between the social setting and the functional organization of language (Halliday & Hasan, 1985). Thus, even a cosmologist can marvel over the beauty of an autumn sunrise; it would be precisely the talk of a rotating earth that would or might dispel the aesthetic of the moment.

That there is more than the child concerned in the production of conceptions can be gleaned from the following considerations. Taking another look at the brief exchange between interviewer and child (fragment 1), we see that the interviewer is doing more than just posing a question. He is *formulating* what he is going to do rather than just

doing it. That is, by saying "this question is very simple," the interviewer announces that a question is forthcoming and he foreshadows it to be an easy one. He also formulates what he expects the child to provide, an explanation rather than just any response ("could you explain me"). This talk then becomes a resource for the next performance—which indicates the collective production of the situation *as* an interview. (It becomes a resource with and despite all of its ingrammaticisms, which I leave in the transcript because *this* is what people say and what others are dealing with pragmatically rather than with something they are purportedly have wanted to say, and which science educators *routinely* add to transcripts.) Here, the child uses the conjunctive "because," which frames and denotes the subsequent talk as a reason: "We need day to play and we need night to sleep." That is, in both instances, the interviewer and the child have done more than just posed and answered a question: they also have accounted for, formulated, and framed *what* they are doing *while* doing it. That is, they have done so for practical purposes and in embodied and situated ways.

In the process of doing (displaying) practical, accountable, situated, and embodied talk, they have produced an event that viewers of the videotape and readers of the transcript can recognize as a typical interview generally and a conceptual change interview more specifically. They have reproduced a particular societal[3] activity and in the course of it, they have achieved the production of text of the type used in conceptual change interviews to make inferences about conceptual structures attributed to a child's mind. Because the two collude and thereby achieve the interview collaboratively, one has to question whether it is legitimate to extract the child's productions and attribute it to *her* mind; an alternative would be to do choose a unit of analysis that includes interviewer and child, therefore making the (mis-, alternative, pre-, preinstructional, prior, naïve)

[3] English translations of German and Russian (critical) social psychology use the term "social" where the original texts employ the term "societal." I retain the latter, because it embodies all the phenomena of interest to educators and social scientists, including power, social injustice, economic interests, and so forth.

conception a collaborative production made possible by the particularities of the language that they share.

The purpose of this paper is to argue for a "fairly radical theoretical rethinking," as Edwards and Potter propose in their quoted announcement of discursive psychology, of conceptions and conceptual change through a reformulation of talk-in-interaction as process and topic, a rethinking that abandons all ideas of talk as a pipeline between a person's understanding and the world. The language of talk *is the phenomenon of interest* and, I suggest, simultaneously is shared by individual person and culture so that conceptions, ideas, beliefs, or attitudes *always* are general possibilities that inherently belong to the collective other. Furthermore, the language-in-interaction *is the very medium* that produces and reproduces the form of societal activity—it is a form of institutional talk—during which the (mis-, alternative, pre-, preinstructional, prior, naïve) conceptions are elicited; this talk is recipient designed and therefore *for* the researcher or teacher, who inherently is assumed to understand what the talk is about. That is, the ultimate purpose of this paper is to provide a coherent theoretical frame for the relationship between interviews and interview data, on the one hand, and the interpretive reductions that lead researchers to the identification of conceptions and conceptual change.

2. Concepts and Conceptual Change

I begin by outlining just enough of the principles underlying the research on conceptions and conceptual change to be able to highlight how discursive psychology differs from a conceptions and conceptual change approach. I do not provide this description to set up a straw-person but rather to provide an inherently incomplete sketch that allows my readers to understand my choice of a different model. Throughout this paper it is evident that the steps from the interviews themselves to their descriptions and explanations of interviews and their topics require many assumptions and presuppositions

before one can speak of conceptions that individuals are said to hold in their minds. In the subsequent section, I then articulate the main tenets of discursive psychology, as theory and as method, before showing how a discursive psychological approach leads to a different way of understanding and theorizing talk about phenomena that are of interest to scientists and science educators (e.g., models of the universe, earth, sun, day, night).

Interestingly, the sense of the term "(mis-, alternative, pre-, preinstructional, prior, naïve conception" appears to taken as common knowledge, as the search for definitions led me back to the 1980s when this form of research emerged and established itself in what might be termed the "first wave of cognitive research on conceptions." Conceptions are theorized to be cognitive entities, furniture of the conscious mind, but they are unlike signs (Pines, 1985). Conceptions are human inventions that "once labeled become communicable through the use of language" (p. 108); that is, conceptions are different from language, which is but the vehicle that makes them available to others. Conceptions are mental/cognitive regularities that are labeled with words and, by means of these, can be "employed in thought and communication" (p. 108). "A word is like a conceptual handle, enabling one to hold on to the concept and to manipulate it" (p. 108). These definitions are consistent with a recent statement of leading conceptual change theorists and researchers, who describe "conceptions as learners' mental models" and "as the learner's internal representations constructed from external representations of entities constructed by other people such as teachers, textbook authors or software designers" (Treagust & Duit, in press). The essence of the cognitive perspective on conceptual change is, according to Stella Vosniadou (2007), characterized by "knowing as having structures of information and processes that recognize and construct patterns of symbols to understand concepts and exhibit general abilities such as reasoning, solving problems, and using and understanding language" (Greeno, Collins, & Resnick, 1996, p. 18). The mainstream approach to conceptions also is captured by stating that "[c]ognitive approaches provide analyses about the ways in which knowledge *must be structured* and

about the *structures* of knowledge *in learners' minds* that will be available to support task performance and to transfer to new situations" (Anderson, Greeno, Reder, & Simon, 2000, p. 12, emphasis added).

Conceptions are organized into networks of relations, which often are represented in node-link diagrams (Champagne, Gunstone, & Klopfer, 1985) or ontological category trees (Chi, 1992); conceptions themselves can be thought of as theoretical nodes where a multitude of meaningful relations cross. Researchers have come to denote *misconception* the use of conceptual relations in inappropriate contexts (Ueno & Arimoto, 1993). Concept map, semantic network, or node-link diagram are some of the diagrammatic forms that illustrate concepts and the conceptual relations in which they are involved. These relations are expressed in propositions that may be communicated in the form of sentences. Thus, for example, node-link diagrams (concept maps) have been used to show the differences between radical and non-radical (simple, slight) conceptual change, corresponding to conceptual change across and within ontological categories (Chi, 1992). Depending on the study, conceptual change may refer to the process of change or outcome of the change process; recent conceptual change theories integrate affective components that are said to mediate the change such that there may be no change, superficial change/assimilation, or true conceptual change/accommodation (Gregoire, 2003). In any event, the process is of psychologically (cognitively) real nature (Keil, 1989), though tools, artifacts, and social configurations may mediate the change process (e.g., Roschelle, 1992; Vosniadou & Kollias, 2003).

Conceptual frameworks (conceptions, mis-, alternative, naïve conceptions) generally are inferred from interviews (e.g., Posner, Strike, Hewson, & Gertzog, 1982), clinical interviews (Pines, 1985), or tasks in which persons are asked to demonstrate/predict, observe, and explain some physical phenomenon (Champagne, Klopfer, & Gunstone, 1982). There is an (implicit) assumption that the (interview, task) situation itself does not mediate the conceptual organization but that the situation simply allows reading out—

like a computer printout that shows the results of a calculation or the contents of computer memory—an at least temporarily stable mental organization (Ueno, 1993). Strong arguments have been made on sociocultural grounds contesting the "reading off" of conceptions from interview texts (Halldén, Haglund, & Strömdahl, 2007). However, the fact that conceptions are very resistant even to intensive instruction (e.g., Chi, 2005; Duit & Treagust, 2003) gives legitimacy to the reasonable nature of the assumption that conceptions and mental models are independent of the environment in which they are elicited. The resources in the setting have been treated as transparent (e.g., Schoultz, Säljö, & Wyndham, 2001). Thus, the method of identifying a conception is to excerpt statements interviewees make irrespective of anything else in the setting or the nature of the setting itself. This can be seen in the following excerpt from the seminal article on the nature of conceptual change:

> (I) . . . it seems these are strange results. What attitude do you take of these results?
> (CP) I say they don't really mean all that much; it just depends on what your frame is. It's sort of like potential energy depends on the way you define zero to be?
> [. . .]
> CP's reference to potential energy is significant in pinpointing a conception which enables her to regard the values given to a variable as arbitrary, being dependent solely on the observer's point of view. She attempts to resolve some counterintuitive results of Einstein's view of time by drawing an analogy between time and potential energy. No matter that the analogy might break down with further analysis—it serves her belief in absolute time. (Posner et al., 1982, p. 219)

In this quote, the authors derive from the quoted interview excerpt that the subject CP has a conception that "enables her to regard the given to a variable as arbitrary, being dependent on the observer's point of view." There is no reference to the fact that CP has

responded to a query on the part of the interviewer (I) and for the purpose of answering this query rather than primarily developing relativity theory—which is done as a matter of course *in* and *through* the interview. The authors attribute an intention to resolve "counterintuitive results," when in fact the event shows us that the interviewer denoted the results as "strange." Asked what she makes of these "*strange* results [emphasis added]," CP then makes statements that complete the interviewer's utterance as a question, which means, she has to address the strangeness. There is no indication or evidence that she would have noted or talked about anything strange: it is the interviewer who occasions the response. As a result, the cognitive approach often focuses on what people (students) do *not* do, how they misconstrue, misconceive, or alternatively conceive of some phenomenon; thus, "the constructivist approach to cognition has emphasized forgetting—the distortions, confabulations and general unreliability which results when memories are schematically assembled in some kind of cognitive processor" (Edwards & Potter, 1992, p. 36). I show below that interview participants talk about scientific phenomena even when they have never talked or thought about them before, in which case, what they say cannot be driven by or be the result of a conception.

3. Discursive Psychology

Discursive psychology, according to a recent comment of one of its founders, is an "emergent discipline" with an approach to cognition that differs from other discursive approaches including sociolinguistics (Potter, 2005). It is an approach in which the theoretical and analytic focus is moved away from the individual mind to processes of social interaction (Hepburn & Wiggins, 2005), making it akin to the language socialization paradigm in second language acquisition (Watson-Gegeo, 2004). Cognitivism and its problems constitutes one area in which discursive psychology engages with social critique, which is oriented toward traditional psychological topics, such as cognition, thought, and, here, conceptions and conceptual change; and it re-

specifies these topics in terms of the methodical, situated *discursive* production of mental entities (Potter & Edwards, 2003). Some scholars take discursive psychology to constitute but a method for analyzing everyday talk. However, its inventors claim that it is more than a method; it is a particular framework for theorizing phenomena that are explained in very different ways by cognitive and social psychologists (Edwards & Potter, 1992). But it also is more than a simple paradigm: It is "an approach embedded in a web of theoretical and metatheoretical assumptions" (Potter, 2003, pp. 784–785). In this section, I articulate both the theoretical and methodological aspects of discursive psychology. In this, I articulate a theoretical framework distinctly different from the one that oriented a generation of conceptual change research (Posner et al., 1982) and also distinctly different from sociocultural approaches that maintain the distinction between interpsychological (mental) and intrapsychological mental processes (e.g., Säljö, 1999; Wertsch, 1991).[4] But my intentions are similar in that I provide a paradigm that may fruitfully orient a new generation of research.

3.1. Theory

The main focus of discursive psychology is the orientation toward the ways in which speaking and writing are employed as forms of social and societal action. It thereby comes to treat psychology as "first and foremost something practical," and, insofar as psychology "is an object, in DP it is *practical, accountable, situated, embodied and displayed*" (Potter, 2005, p. 740). Thus, discursive psychologists are interested in theorizing the interactional work being done *in* and *through* talk. Here the preposition

[4] According to the cultural-historical activity theoretic approach that Vygotsky's students have developed, the distinction between intramental and intermental is not very useful, as all human activity simultaneously irremediably and irreducibly involves the inner and outer (Mikhailov, 1980). Recent phenomenological studies, too, show that the Self (intramental) and the Other (intermental) are irremediably and irreducibly intertwined (Franck, 2001). Most recently, even formerly staunch advocates of the cognitive approach to conceptual change propose softening the boundaries between inside and outside the head but "consistent with the conceptual change approach" (Vosniadou, 2007, p. 55).

"in" means that talk is the context in which the work is being done and the preposition "through" indicates that talk is the main tool by means of which this work is accomplished. The fundamental theoretical position of discursive psychology is that talk is both terrain/context and tool of human activity. Talk therefore not only establishes and maintains the topic, but also establishes and maintains the activity in which participants talk about a particular topic.

This theoretical position leads discursive psychologists to a double refusal concerning the relationship between everyday talk (e.g., in interviews) and purported contents of the mind. In the traditional forms of conception and conceptual change research, researchers employ at least two processes of abstraction to get from the details of everyday situations to (mis-, alternative, naïve) conceptions that discursive psychologists refuse as legitimate: *gross categorization* and *restriction* (see Edwards & Potter, 1992, p. 5). The first process is at work when analysts attribute a stretch of talk (utterance) to an individual, by abstracting what is being said from the conversation as a whole. In contrast, discursive psychologists consider stretches of talk as the contingent continuation of earlier talk and as a resource contingently used/referred-to in subsequent talk. Each utterance no longer is treated as if it were standing on its own. The second aspect of this first process is another form of gross categorization when the talk is theorized as the public *expression* of an underlying conception. In contrast, discursive psychologists do not attribute stretches of talk to *one* underlying conception; talk is no longer taken to be a neutral means for reading out and making public what is in the speaker's head.[5] Talk is variegated and even the most stringent interview protocols lead to variations in questions and interactions (Suchman & Jordan, 1990). Coherence and reproducibility are achievements and require, because of the inherently variegated and heterogeneous nature of language, some form of gross categorization in everyday lay as well as professional discursive praxis. Discursive

[5] A suitable analogy would be the printout from a computer, which makes available to the user whatever the central processor does or what the memory has stored.

psychologists take the question whether two different expressions mean the same as inherently open, even if participants, for the purposes at hand, presuppose or construct them as the same.

Discursive psychologist reject a second reductive process, *restriction*, which is at work when researchers use questionnaires and structured interviews containing forced choice items or an interview protocol from which they do not deviate for the purpose of comparability across interviews. In forced-choice items, students typically are presented with a few alternatives, one of which corresponds to the ways in which scientists talk about the phenomenon, the other four correspond to typical ways in which those individuals express themselves that are said to have mis-, alternative, naïve, prior, pre-, or pre-instructional conceptions. Discursive psychologists actively take participants' natural talk-in-interaction into consideration and reject approaches that take highly circumscribed responses to be data while disregarding natural talk. Conceptual change researchers generally are confronted with the difficulty to describe the transitions—if they occur—between two conceptions (e.g., Duit, Roth, Komorek, & Wilbers, 2001).

From a discursive psychological perspective, highly heterogeneous talk especially during learning phases is taken to be the norm (Roth, 2005b). Each particular conception requires specific forms of talk to conduct the reduction; but in the transition, we expect forms of talk that cannot be attributed to one or the other conception—the talk has the appearance of conceptual *muddle*, which is just the way discourse approaches in philosophy (Rorty, 1989) and learning sciences (Roth, 2005a) formulate in a *positive* way the discursive patterns between two forms of more stable but nevertheless heterogeneous talk. This form of talk, therefore, is not like "exploratory talk," which relates to the talk people (students) are capable of producing as a written draft relates to the writing they produce (Cazden, 1987); rather, it is the very language people in transition are capable of during a period that only later is recognized as one of transition. Sabir, the language mixtures spoken by Mediterranean merchants—which consisted, depending on the

particular situation, of varying amounts of Arabic, Greek, French, Italian, Portuguese, Spanish, and other languages—constitutes a useful analogy for languages spoken at the interface of two and more cultures, including those of the mundane everyday world and science (Roth, in press). Muddle and Sabir, therefore, are not deficits but are the *necessary forms of talk* during the transition between pre-instructional and post-instructional forms of talk about certain phenomena. Muddle and Sabir are observed when one form of talk changes into another, where propositions are tested and discarded *without* an underlying conceptual framework driving the different forms.

For discursive psychologists, both forms of reduction are unsatisfactory because these adumbrate what they take to be the real phenomena to be analyzed and theorized. Talk in everyday settings, including the talk by means of which interviews about conceptions and conceptual changes are conducted, draws on the resources available in the setting. This talk is full of mumbles, stumbles, malapropisms, pauses, stupidities, and solecisms; and yet, conversation participants pragmatically employ these resources to make interaction work despite, and in fact drawing on, the production of what from the perspective of written language are errors. More so, as I show in this paper, this talk is designed both for the interview generally and for this interviewer specifically—whether any stretch of talk can be theorized independently of the situation and other interaction participants ought to be an empirical rather than accepted and presupposed matter. Although the fine detail of talk may appear to be messy at times, it is precisely this messiness that provides participants with the resources for making interviews and talk about concepts possible. "[T]he finest levels of conversational detail, every speech error, pause, overlap and lexical correction, might be there as a 'designed' or consequential feature of social action" (Edwards & Potter, 1992, p. 6). Discursive psychologists believe that deleting such conversational detail may come at the price of understanding not only how the interview comes about but also what it is about. Thus, one recent study showed that participants in interview/think-aloud protocols at times treat pauses as indicating

resistance to respond or as evaluations that they have done/said something wrong (Roth & Middleton, 2006). Even if we assume that a speaker thought about and planned what she wanted to say and only then said it—which hardly, if ever, is the case in real-time conversation—her private intentions are not available to the recipient, who presupposes that everything made available to him in talk is designed and intended or expresses something *directly available in some stretch of talk itself*. Discursive psychologists theorize how people make use of talk as a resource, including all its shortcomings and in the way this use is made available, in turn, to other participants and recipients. As a principle derived from conversation analysis and ethnomethodology, the fine detail is crucially important for the sense of the activity performed and the topics talk covered in the process; this fine detail constitutes the very resource that interaction participants pragmatically deploy and use for constituting and exposing the sense of a situation.

Both forms of reductionism—to individual or social—are unsatisfactory, because they do not account for the continuously unfolding nature of any culture generally and of language and forms of talk specifically. They do not account for the fact that ways of talking (understanding) change even when people do not explicitly focus on changing their ways of talking (understanding), even in the absence of dissatisfaction and search for more parsimonious theories. The fact is that new understandings generally spring up unpredictably; they *emerge from* rather than *are determined by* the contextual particulars of societal forms of activity and specific social situations. In resisting gross categorization and restriction, discursive psychologists actively work against two forms of reductionism: social and cognitive. On the one hand—i.e., on the social side—this means that all phenomena of thought and reasoning, mind and memory, are reduced to social explanations as socioculturally and cultural-historically formed and then, in a process described as internalization, moved from an interpersonal plane to an

intrapersonal plane.[6] The learners thereby come to be cultural dopes, merely doing what culture prescribes them to do. This form of reductionism is familiar and includes social constructivists and constructionists (Edwards & Potter, 1992). On the other hand, cognitive approaches tend to reduce all phenomena of thought and reasoning, mind and memory, and to events happening in the brain. These events are frequently modeled in terms of how computers work, that is, in rational information processing models. What people do and say in everyday situations, therefore, is thought to be a causal consequence of their mental models, cognitive frameworks, personal theories, and so forth (e.g., Anderson, 1985). Language here mostly is treated as the neutral medium between someone's mind and another person (e.g., the researcher). The general practice in conceptual change research is to look for patterns in students' talk and to derive from it conceptual structures in their minds. In this approach, individuals are treated as if their mental models or conceptions *determined* their (discursive, practical) actions. In contrast, the discursive psychological approach takes the question about what counts as adequate knowledge, memory, concept, or theory to be a matter that participants themselves resolve in a pragmatic manner for the situation at hand (e.g., Roth & Middleton, 2006). The criteria for these resolutions themselves may constitute a discursive terrain that is to be established on (and with) the resources provided in/by the same terrain.

3.2. Method

Discursive psychologists forbid themselves to get into the head of participants—e.g., by attempting to produce cognitive models that explain what goes on inside a person's head—but concern themselves with discourse that is publicly available to all participants in a conversation; they theorize just what is available for everyone to see and hear,

[6] There are a number of works that show how remembering and forgetting, for example, are a collective rather than individual process (e.g., Middleton & Brown, 2005). More so, although Vygotsky [1986] takes a dialectical perspective, he generally gets the credit for this non-dialectical framing of learning processes that he never intended (Roth & Lee, 2007; Zinchenko, 2001).

because it is the only thing culture has for reproducing itself and that newcomers have for becoming part of the collective. That is, discursive psychologists are concerned with the ("vulgar," "everyday") competencies of people who participate in talk in and through which they simultaneously constitute the social (societal) activity (the work required to produce and reproduce the event *as* interview) and the topic of the interview.

Discursive psychologists treat discourse as *social* practice, which they study as an irreducible phenomenon rather than as a theoretical abstraction. Returning to the opening interview situation, the two turns are taken as an irreducible unit—although involving individual bodily and embodied performances. Thus, what the interviewer has been doing with his utterance becomes a question only in and through the following utterance. In the present case, we can easily see the situation as the reproduction of a question–response or query–answer pair. This would not have been the case if the situation had unfolded in the following (hypothetic) way:

Fragment 2

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01  I:  so the question is very simple. (0.24) .hhh could you explain
         me:? 'why:: (0.55) 'why: we have day and why we have night;
02       (1.28)
03  A:  i dont have time right now.
```

In Fragment 2, the child responds as if she had been asked to give some of her time to engage with the interviewer to talk about whatever he wanted to talk about. That is, whereas from an individualistic perspective, the interviewer might have had the intention to ask a question about day and night, the utterance comes to be a request for time from the perspective of the turn sequence as unit of analysis. That is, from the perspective of the conversation as an irreducible event, the initiation has been acted upon as a request for time rather than as a request for explaining the reasons of day and night. Discourse analysts now would focus on the fact that the child has performed what conversation analysts call a *dispreferred* response (Pomerantz, 1984), that is, she has rejected an invitation to answer a question, and the problem this poses for the unfolding conversation

is how the participants, here interviewer and child, are going to manage the rejection. One way to mediate the rejection might be for the child to provide an explanation, for example, by saying "My mother told me to be home at five" and the time is almost five o'clock. Or the interviewer might try to get agreement by saying, "Oh, it will only take three minutes of your time." In any case, discursive psychologists are interested in understanding how talk is used in each case to manage social situations, both their form and their content. These two aspects go on all of the time and simultaneously so that we cannot abstract the content of talk from its function without doing harm to our understanding of the phenomenon; and we cannot abstract the content of one person's utterance ("'Kay, because, we need day to play and we need night to sleep" or "I don't have time right now") from what other people have uttered in the same setting.

Procedurally, therefore, discursive psychologists take a turn pair as *one* unit, following the proposal of speech act theorists (e.g., Austin, 1962), who postulated that a speech act consist of a performance (locution), an intent (illocution), and an effect on the recipient (perlocution). A speech act therefore is completed in and through the performance of the next person, which provides evidence for the perlocutionary dimension of the speech act. Readers easily will find many examples in their own everyday lives that show that illocution and perlocution may run apart, for example, when a listener responds to an utterance by saying "this is an insult" and the original speaker comes back saying "it was meant as a joke." Here the recipient and the original speaker articulate for one another the differences between perlocutionary and illocutionary dimension of a previous speech act. (The overlap of speaker and addressee and irreducibility of the speech act to individuals goes even further, as the latter already commits him- or herself in listening *while* the former produces a locution [Roth, 2007].) In discourse analysis—the method discursive psychologists preferentially employ—articulating what one has said, done, or heard is denoted by the term of *formulation*. That is, in the last examples, the recipient *formulates* to have been insulted—rather than, as

this sometimes happens in certain milieus, punching the other in the face—and the initial speaker formulates to have intended a joke. Thus, in the opening example, the interviewer formulates that he is going to ask a question and that it will be very simple one at that; he announces and circumscribes the performance and intent of the speech act that follows.

3.3. Principles of Discursive Psychology

To summarize, then, discursive psychology is an approach oriented to the functional analysis of language-in-use, written or spoken. The questions discursive psychology poses pertain to the way in which language pragmatically is employed and deployed for managing interactive situations (the terrain, context) as well as their content (intent). Language is thought of as the primary but not sole reality-constituting resource in and for practice; gestures, spatial configuration, bodily orientation, prosody, setting, and other features constitute integral parts of everyday communication that speakers and listeners orient to in an active manner (Roth & Pozzer-Ardenghi, 2006). As a form of summary, here are five major tenets in which discursive psychology distinguishes itself from other approaches (Edwards & Potter, 1992, pp. 28–29).

1. Discursive psychology is a theory and method for investigating naturally occurring talk, such as, central to our concerns, interviews and classroom talk involving scientific concepts;
2. it is concerned with the content of talk and its social rather than linguistic organization;
3. it takes (discursive) actions, constructions, and variability as its analytic objects; variations in the way people account for some phenomenon yield insights to the role situational particulars play in forms of discourse;
4. it has an interest in understanding the rhetorical functions of talk and it intends to understand the social functions that variations in talk serve; and

5. it has a particular interest in how cognitive issues of knowledge and belief, fact and error, truth and explanation are constituted in and through talk

In the following sections, I work out what this schematic articulation of a discursive psychological approach means for a theory of scientific concepts and conceptions.

4. Talk about Scientific Phenomena: A View from Discursive Psychology

In the past, most researchers deemed conceptions to belong to the minds of individuals; they are considered to be stable structures in the mental organization about scientific and nonscientific phenomena. The content and structure of these conceptions are thought to be available through a person's talk during interviews or their answers to questionnaires. My analyses exhibit the fundamental nature of conceptions-producing language-in-interaction as practical, accountable, situated, and embodied. Given that talk generally is quite variegated, researchers have to "distil" or "abstract" conceptions from widely ranging and varied participants' responses and simultaneously assume (presuppose) that the variations in talk constitute (error) variance of otherwise different but equivalent forms of talk. In the following sections, I articulate how an adult and a seven year-old girl explain scientific phenomena—in interviews conducted by longtime teachers and doctoral students who are part of my research team—and explicate the talk within a noncognitive framework. (Communication involves more than words, but for space-saving purposes, I limit myself mostly to talk leaving unaccounted for other crucial communicative dimensions including gestures, orientations, perceptual gestalts, and visual representations [Roth, 2004].) I analyze utterances within the interview context, as produced in response to the interviewers' questions and as designed for them.

4.1. Interviews Produce and Reproduce Themselves as Recognizable Societal Activity Formations

At the outermost, most-encompassing level of analysis, an interview concretely produces and reproduces a societally motivated activity formation (interview as possible activity), and produces a text for analysis only at a secondary level. Without this outer level as a frame, discursive action cannot be understood. The utterance, "What time is it?" has a very different sense and leads to very different responses when directed (a) by one pedestrian in the street to another, (b) by a teacher in an elementary school class to her students who are to learn reading a clock, (c) by an attendee in a movie theatre during the performance to another attendee, or (d) by a student to the during a science lecture. In these four examples, possible hearings of the utterance are that of a genuine question, a formatted question, a nuisance, or an attempt to disrupt/bring to a close the lecture. There are then immediate consequences that follow from this joint orientation to the production and reproduction of the interview qua interview: (a) the conversation and its transcript have to be considered as a collaborative product that subsumes but cannot be reduced to individual contributions and (b) (discursive) actions on the part of the interviewer provide the interviewee with resources to interpret the extent to which an answer was sufficient. I use the following Fragment 3 to point out these dimensions in the way these are apparent in an interview conducted with a seven-year-old.

As shown above, to set up the episode, the interviewer has asked the child if she was willing to participate in an interview answering a few questions that he had about everyday phenomena. This set up, which is part of informing the potential participant and gaining informed consent cannot be recorded, nevertheless frames what comes thereafter. Thus, Fragment 3 (which actually includes and contextualizes Fragment 1) shows that this interview reproduces a typical pattern in which the interviewer asks the questions and the research participants respond. Here, the utterances are set up as questions by the

adverbs "why" and "what" (turns 01, 05, 09) and, sometimes, by the for questions typical upward movement of the pitch toward the end of an utterance unit (turn 09). The child *constitutes* the interviewer's utterances as questions by following with the adverb "[be]cause," which thereby also becomes a conjunctive in the constitution of a question–answer pair. That is, Fragment 3 first and foremost is about successfully producing and reproducing question–answer pairs "typical" of interview situations in the way that participants understand and presuppose the sharing of an understanding.

Fragment 3

```
→ 01  I:  so the question is very simple. (0.24) .hhh could you explain
          me:? 'why:: (0.55) 'why: we have day and why we have night;
  02      (1.28)
  03  AJ: kay (2.06) ((licks lips with smack)) be (0.16) cause .hhhh
          (0.84) we need 'day to pla:y: anweneed night to sleep. (0.69)
          .hhh and then if we dont have 'day we dont have the flash
          light or we can bump to <<dim>something or something>; (0.47)
          .hh=yea; (1.04) we can bump to something;
  04      (0.75)
→ 05  I:  'why is it hotter (0.19) in the summer.
  06      (0.67)
  07  AJ: because we orbit the ↑`sun
  08      (2.63)
→ 09  I:  what about the winter we dont orbit the sun? (0.35) during the
          winte:r?
  10      (0.23)
  11  AJ: no. (0.47) so the snow will melt.
```

It is precisely the set up of the situation as an interview that allows the participant to treat an interviewer utterance as a question even when it does not end—as is normal for questions—with a rising pitch, as can be seen in turns 01 and 05. Yet in both instances, competent speakers of English can hear AJ give a response, which means that here she does not merely respond but in fact *completes a question–answer pair*, and thereby renders the interviewer utterances into a question rather than something else. The

situation here is similar to that captured in the saying "It's nothing until I call it [a ball, strike]" attributed to the baseball umpire Bill Klem; from a discursive psychological perspective, a performance is nothing until the next performance indicates what it has done.

Some readers may think that this particular turn-taking routine goes without saying. But this is not the case as a recent study has shown, where questions from the "interviewee" turned an expert/expert study into a tutoring session (Roth & Middleton, 2006). Thus, although the reported sessions had begun consistent with (following) an interview/think-aloud protocol, the fact that a number of "interviewees" began to question the interviewer changed the nature of the sessions such that the interviewer became a tutor and the interviewees became tutees. This shows that we cannot take Fragment 3 as something that goes without saying, but that we have to take it as an *achievement* that requires the collaboration, even collusion, of the participants. The nature of the session precariously depends on the reproduction of the question–answer pairs distributed over pre-determined but unstable role assignments, which also are up for grabs, as the mentioned study has shown. The session is reproducing a conceptions/conceptual change protocol only under the condition that the participants collude to make it such and then *actively* produce it through the way in which they contribute, even though they cannot know what any of the future utterances will confront them with.

The interview therefore has to be considered as an *achievement,* attributable to the work that participants muster to bring about the recognizable reproduction of a societal phenomenon; and they achieve this feat despite and in the face of all the pauses, restarts ("why? why" [turn 01], "bump to something" [turn 03], "the winter" [turn 09]), extended in- and out-breaths, unfinished (when compared to written) sentences, run-together sounds ("anweneed" [turn 03]), solecisms, half-pronounced words ("kay" [turn 03]), prosodic miscues (in turn 05, pitch drops as at end of proposition rather than rising, as in

question), ungrammaticalities (when compared to writing), and so on. Pragmatically and collectively, the participants achieve to produce what they and others recognize as a(n) (conception, conceptual change) interview even though any single one of these features threatens their mutual understanding. It is precisely because of these threats that the event has to be considered as *actively* produced and therefore as something achieved. It is precisely because any human being *always* can act otherwise that we need to theorize phenomena such as that in the fragments provided in this article as *actively* and *recognizably* reproducing interviews as and for what they are rather than as something else.

In interaction, role assignment does not causally determine what follows but itself requires the reproduction of the roles in and through talk. Participants actively orient toward the reproduction of these roles because any utterance has the potential to undermine it (Roth & Middleton, 2006). Because interviews require the collaboration (collusion) of the participant, the resulting (recorded and transcribed) text is a collective product that cannot automatically be reduced to individual contributions. (Researchers ought to be required to show empirically that they can make such reductions and the conditions under which such reductions are valid.) This is further evident from the fact that the interviewer orients and designs the question *for* the participant; and he does this in a way to facilitate the reproduction of the question–answer pair and the associated role assignment of interviewer–interviewee. The interviewees also orient their utterances to interviewers in ways that presuppose the intelligibility of their utterances. That is, what any participant says is *said for* the other generally and for the production of the present situation *as* interview specifically; whatever student participants in conceptual change interviews say is presupposed to be intelligible, and is understood by science educators even if it is subsequently categorized as misconception. That is, what students say is reasonable and intelligible even though learning scientists characterize a stretch of talk as misconception and even though teachers might penalize students with low marks for it.

To bring this point further into relief, consider the sequence from turn 05 to 11. Turns 05 and 07 constitute a typical question–answer pair, whereby the second utterance is an answer only because it relates to the previous utterance in a particular way. That is, AJ is not simply spilling the contents of her mind, but is collaborating/colluding in reproducing an interview situation, so that she says what the *situation* appears to require not what she might *want* to say. Similarly, the interviewer asks questions that make sense to conceptions/conceptual change researchers *and* to the interviewee, so that both reproduce phenomena that exist beyond them as general cultural possibilities of acting/talking within certain cultural settings. Because of this orientation of producing utterances *for the other*, the utterances and intentions of different speakers come to be enfolded—my own analogy is that of a mathematical convolution that takes the form $f * g = \int g(\tau) f(t-\tau) d\tau$—and no longer are independent. They therefore have to be studied from a unit of analysis that exceeds the individual.

Conversation analysts point out that researchers need to take turn pairs as the minimal unit of analysis (e.g., ten Have, 1999). This may not suffice, however, as the following considerations show. In producing turn 09, the interviewer does not only complete turn 07 as an answer that requires further elaboration but also sets up turn 11, the elaboration of the content AJ produces in turn 07. That is, the interviewer simultaneously *completes* the turn 07 and *sets up* turn 11. *He* therefore is doubly responsible for AJ's performance, first in completing her utterance as a response to a previous question *and* in proffering a first part of another question–answer pair. That is, because of the particular turn-taking routine and role assignment that the two reproduce throughout the session, AJ's performances are not independent from the interview situation in general, its temporal (i.e., contingent) unfolding, and the interview protocol in particular. It is because of this situation that interviewees come to talk about topics and concepts that they have never talked/thought about before and yet engage, for the purpose of reproducing the interview as such, talk about it even at length—an issue I take up in the next subsection.

The unfolding event provides the interviewee with resources for understanding whether an utterance has fulfilled attendant expectations or not. This, too, is apparent from Fragment 3. Thus, after AJ has completed the utterance that constitutes turn 02, which accomplishes turns 01/03 as a question–answer pair, the interviewer moves to a different topic. In so doing, he does more than simply move to the next question prescribed in the protocol. He also indicates to the interviewee that whatever she has done was sufficient for the purposes at hand and that therefore the event can proceed to its next stage. The converse is the case in the turn pair 07/09. Here, the second turn of the pair questions the veracity or general applicability of the previous turn, and therefore its completeness. Thus, AJ proposes "because we orbit the sun" as a candidate answer to the (from-the-*A-Private Universe*-derived) question, "Why is it hotter in the summer?" (turn 05). The interviewer then offers a contrasting season (i.e., winter) in the context of which the orbiting as reason for the summer heat is to be evaluated. In so doing, the interviewer directly questions the applicability of the previous reason for explaining the temperature during all seasons. For the purposes of the interview, turn 07 is rendered incomplete or insufficient by the follow-up question, thereby telling AJ that more is required to complete the sought-for question–answer pair. After turn 11, the interviewer moves to yet another topic, thereby again telling AJ that now her response was sufficient, having completed the question–answer pair. Depending on the situation, such continuation can be understood as signaling satisfaction not only in terms of completing a turn pair but also in terms of the correctness of the statement proffered.

To summarize: In this section I show how interviews not only elicit information but also, and especially, produce and reproduce themselves; this reproduction, to be successful in the face of all the possible threats, requires the collaboration (collusion) of the participants. This collusion leads to orderly turn-taking patterns, collective rather than individual elaboration of some rather than other topics, orientation to and language use for the other, and implicit evaluations of performances. The upshot of this analysis is the

fact that performances (utterances) mutually constitute each other and cannot be taken apart—in my mathematical analogy, the equivalent process is a *deconvolution*—into independent contributions.

4.2. First-time Talk about Topic

Conceptions and conceptual change researchers assume that it takes a conception ("mental structure") to produce talk; each suitable instance of talk is used as a piece of evidence for an underlying conception. (All other stretches of talk from an interview that do not map on an existing conception are discarded.) In everyday life, including interviews, human beings participate in conversations on topics that they have not talked (thought) about before, and about which they cannot therefore have a conception. That is, talking about a topic does not necessarily mean that there is an underlying conception. In fact, the discursive psychological position appears more parsimonious, as it only assumes that people participate in interactions and they do so in ways that maintain the activity (conversation among friends, school talk, interview), including the production and reproduction of topics. When necessary, they provide advance warnings (e.g., "I have not thought about this before" or "this may sound stupid but . . .") or retrospective evaluations (e.g., "I may be wrong" or "I may not have answered your question") for the potential inadequacies of what they have said. This is apparent in the following interview fragments.

Mary is a female adult graduate student at a Canadian university who speaks English as a second language. During the interview and prior to Fragment 4, Mary talks about the movement of the sun. The interviewer picks up on her statement and asks for clarification (turn 08). Mary responds by saying, "in the morning it should be in the east" (turn 10). Again, the interviewer asks for an elaboration in the form of a reason for what was said (turn 12), upon which Mary responds that she never has thought about that, yet immediately continues to elaborate a response (turn 14).

Fragment 4

```
  08  I:  yea (0.86) a:nd which? direction. (0.30) maybe east? or north?
          o:r-
  09      (0.33)
→ 10  M:  `o:h:: ((hand moves up to the chin, eyes move upward gaze
          toward ceiling, "pensive")) (0.26) in the morning it should be
          in the east.
  11      (0.17)
  12  I:  yea:. why?
  13      (1.06)
→ 14  M:  <<pp>uh> why::? (1.70) <<p>uh: i never think about that.> i
          ^thi:nk (0.33) i:ts=a becau:se (0.24) of the movement of the
          ↑`sun.
```

In this fragment, Mary repeatedly produces markers for the fact that she has not thought about *this* topic before. First, when asked about the direction of the sun, she initially moves her eyes toward the ceiling, brings her hand to the mouth in what a culturally competent person might see as a "pensive moment." Second, she then suggests, in the conditional, that the sun "should be in the east." In this, Mary articulates that she is not certain about the content of the statement, but that for whatever reason, the sun *should* be in the east. Third, when asked to articulate a reason for the sky position—an indicative of insufficiency from the interviewer's part that requires further clarification—Mary produces the interjection "uh" and an interrogative ("why") with a sharply rising pitch, features that together are heard (by any competent speaker of English) as surprise. Finally, Mary explicitly states that she has never thought about the topic of the question. She then formulates what she is doing, "I think," and, in doing so *aloud*, makes available what she now thinks *for a first time*. But if she thinks this for a first time, she cannot have a conceptual framework that is at the origin of and therefore causally determines the utterance; such frameworks are, in conceptual change theory, the *outcome* of intentional constructive processes so that Mary likely would have remembered having built the conception together. There are other indicators, often subtle, that participants use to mark

the fact that they have not thought/talked about a topic. Requested by the interviewer (Fragment 5, turn 64), Mary begins by producing an explication for not having sunshine with a conjunctive ("because") that introduces the reason for something that preceded it, but then slows down to produce an interjection; then there is a pause, before marking that she has heard before what she is going to say. Here, she formulates by deferring to someone else, and then appropriates what she reports to have heard to make it an instance of her own thinking (turn 66).

Fragment 5

```
61  I:  so do you think 'why we have day an:: night.
62      (0.42)
63  M:  because of t-the movement of the sen (0.68) and uh in the
        evening we couldnt a get ta ta the sunshine <<dim>so thats the
        reason we have that.>
64  I:  yea: but ↑`why we didnt have the sunshine.
65      (1.18)
→ 66  M:  because we are at ah (0.22) i heard (0.14) i think because of
        (0.62) the other half of the earth (0.14) have the sunshine
67      (0.72)
68  I:  the other (0.33) half of the earth
```

By flagging the content of future speech as the speech of someone else, Mary defers to someone else the agency for having figured out the reasons for the absence of sunshine; and then she takes ownership by formulating the instance as one of her thinking. In this instance, in the absence of further evidence, saying that she is thinking for the purpose of this interview—which may be thinking for the first time—requires fewer presuppositions than saying that she has a conceptual framework, for the existence of which there is more negative rather than positive evidence. In the last turn (68), the interviewer acknowledges Mary's answer as sufficient for that part of the discussion: she not only repeats Mary's statement, but also does not require any more elaboration from her.

A similar situation, where a new topic enters the conversation and to which apparently the interviewee has not given consideration before, occurs during the interview with AJ. In the following fragment, the interviewer has asked AJ whether she has studied the earth, sun, and planets. The interviewer then requests her to answer the questions of an online test in the children's version (*A Private Universe* [www.learner.org/teacherslab/pup/surveys.html]). AJ has already responded to the question about the nature of the orbiting body with "moon" and "planet," both with rising intonation, which flags the words as possible answers presented in the form of questions rather than as affirmative statements. In Fragment 6, there are three more pointers to the fact that AJ has not thought (talked) about the attendant issues before and therefore that she cannot have a corresponding mental framework constructed on some previous occasion; and yet, she participates in the interview and produces answers that some might be tempted to interpret as evidence for underlying conceptions.

Fragment 6

```
   01  I:  so which one you think (0.93) uh p mo show (0.61) the shape of
           the orbit?
→  02      (2.29)
   03      if you dont know its fine. you just say i dont know- (0.72)
           o:r- uh;
   04      (0.18)
→  05  AJ: <<pp>i> <<p>think this one.
   06      (0.27)
   07  I:  thisoneletter,
   08      (0.45)
   09  AJ: <<dim>be::.>
   10  I:  letter be. (0.20) okay, just write (.) be for me there. (0.63)
           or make an ex next to it. (0.19) okay. (1.08) oh, okay. .hh
           (.) 'why (0.22) 'why do you think be is the right answer.
           (0.69) s:there a reason for that?
→  11  AJ: .h um no h .Hh i dont know, ↑i dont think so.
   12      (1.21)
```

```
13  I:  ^okay.
```

After the interviewer's question about the shape of the orbit of the earth around the sun, there is a long pause (turn 02); the interviewer than says that it is fine not to know and to indicate so (turn 03). That is, the interviewer treats (for all of us to see in the transcript) the pause to mean that AJ might not have a response and does not know the answer to his question. Modifying her answer with an "I think," AJ then points to one of the drawings (turn 05) and, following the interviewer's invitation, articulates the answer in terms of the letter "b" that denotes one of the answer choices. Here again, uncertainty is made available in the modifying formulation of what she does as "I think," which makes what comes thereafter less than certain and possibly makes it an instance of thinking-aloud rather than a recall from certain memory. This uncertainty is further evidenced when AJ is asked about a reason for the particular drawing to be the right answer for the question about the orbit. AJ responds that she does not know and that she does not think so (turn 11). Here again, the child participates in the interview, responds to the forced-choice item, and has her responses taken into account in the online survey, although there is a lot of evidence that she does not know (i.e., does not have a conceptual framework) and has not talked/thought about the topic previously and beforehand. In any case, AJ's response proves to be satisfactory to the interviewer, who marks the end of that part of the interaction with a simply agreement to what he heard from AJ ("Okay" turn 13).

4.3. Language: From the Other, For the Other

In discursive psychology, as in other fields where real-time talk is of interest, the notion of *recipient design* is used to theorize the fact that speakers do not just produce solipsistic utterance (i.e., they do not "speak in tongues"), nor choose any possible way of

articulating a topic.[7] Rather, speakers *design* their talk for the intended recipient. Thus, a science education or learning science professor returning from work talks differently about her day to her husband (who is not in the field) than she talks to her daughter; and to both she talks differently than she would if she talked to fellow science educators who have come over for a dinner party. In the same way, interviewer and interviewee (consciously and unconsciously) *design* their talk *for* the other and *for* the purposes of *this* activity, here interviews. They do so with a language that is not their own, that they have received from the other, and which they are using to address the other. The contents of an interview transcript therefore cannot be thought in terms of the result of a singular person, but the content, form, and function of the said is thoroughly social, inherently general and singular simultaneously. The *universe* that the Harvard graduates talked about therefore is not so *private* after all, but constitutes a possible universe that each of them shares with all of us. Consider Fragment 7, for instance, which I extracted from the interview with Mary. Previously, Mary and the interviewer had been talking about day and night.

Fragment 7

```
  88  I:  okay; (0.13) then why:- (0.14) why there (.) there is a (0.42)
          you know this kind of; (0.75) uh ^phenomena;
  89      (1.58)
  90  M:  u:m::: (0.39) (aday?) (0.38) i think because uh (0.68) when
          therisa (0.72) the earth and sun move together?
  91      (0.24)
  92  I:  uh hm=
→ 93  M:  ((Looks emptily into the room rather than at interviewer,))
          =there is the 'point h that=uh (1.53) that=u::h (0.17) the
          s::::: (0.34) the earth ((faces interviewer)) will face the
          'sunshine (0.25) the sun:
```

[7] Recipient design also exists in the dialogic approaches ("dialogy") of Mikhail Bakhtin and Valentin Voloshinov; it is a central to Jacques Derrida's (1998) philosophy of language, which shares many features with dialogy.

```
  94      (0.22)
  95  I:  uh [hm:::   ]
→ 96  M:     [and then] again the sunshine a[n the] other half
  97  I:                                    [uh hm]
  98      (0.18)
  99  I:  uh hm=
→ 100 M:  =isa not facing the sunshine
  101 I:  [uh hm    ]
→ 102 M:  [an is not] facing the sun;
  103 I:  uh hm=
→ 104 M:  =so they <<dim>couldnt get the sunlight> (0.25)
          thats [the reason.]
```

Figure 1. Mary produces a gesture simultaneously with her utterances in which the left-hand gesture is aligned with "earth" and the right-hand gesture with "sunshine"; the backside of the left hand literally is facing away from the window and is dark.

A few seconds prior to the fragment, Mary tells the interviewer that she has not previously thought about the issues that they currently are talking about. The interviewer nevertheless asks her about reasons for having day and night (turn 88). Mary formulates that she is thinking aloud (turn 90) and then, in a stop-and-go fashion, hypothesizes that the joint movement of earth and sun may produce it. (The "I think" and the rising pitch at the end, which signals a question, and the slow production, all can be taken as evidence that she is thinking-aloud, for the first time.) Mary then describes the earth as "facing the sunshine" while holding the left hand, to which the right hand approaches forming an

arrow configuration. Subsequently, she uses her right hand to point in the reverse direction while saying "the other half" (like the back of her left hand) and describes it as "not facing the sun(shine)" (turns 100, 102). She then draws a conclusion: "they couldn't get the sunlight" (turn 104).

Even though she has not thought about the issues before, Mary produces an answer. The English language she uses provides her with resources from which to draw inferences. The possibility space constituted by the known expressions and the inferences that can be drawn from them likely is not unlimited, which does not make it surprising that researchers find only a limited number of cognitive models (Vosniadou & Brewer, 1994). Here, from the expression "facing the sun," anyone can infer that there is another side not facing the sun without ever having thought about this before. The left hand exhibits precisely those features. Held up, the palm is pointed toward the window and light falls on it, whereas the backhand side is darker, "not facing the sun." The situation itself, brightly lit palm and darker backside of the hand, exposes a model even though Mary has not thought about it before. Similarly, from the expression "one half," anyone can conclude that there is "another half." What we see here therefore is the realization of a number of tropes, which are resources that can be used to make further inferences. Mary, therefore, realizes in a concrete way possibilities afforded by the English language she speaks—and about which she does not even have to know explicitly any syntactic or semantic rules. (In fact, children make such inferences without knowing any formal grammar whatsoever.)

The language Mary uses is not hers; in a sense, she borrows it from the Anglo-Saxon culture in the same way that Anglo-Saxons borrow it from their own culture. More so, Mary does not merely use a language that has come to her from the other, but she also uses it *for the other* and she does so in a way (implicitly) deemed suitable for the occasion at hand—an interview about sun, earth, day, and night. That is, when Mary speaks, she concretely realizes *cultural* possibilities of talk, and she speaks in a way that

presupposes the intelligibility of the said, not only to *this* interviewer but also to the generalized others who constitute the community of which the interviewer is part. If this were not such, no researcher would be able to analyze interviews, because the analysis presupposes precisely the same kind of discursive competence from the analyst that the two interview participants exhibit to each other and which they require to be able to do the interview in the first place.

I conclude, therefore, that what Mary and AJ produce are not just singular (solipsist) utterances, but, in addition to being bound to the contextual particulars of the interview, these are texts that through and through are framed and mediated by a language that neither is their language nor is it a language just *in itself* and *for themselves*. What is being said—in addition to how it is said—inherently is *from* the other (i.e., culture) and *for* the other, realizing possibilities, which by their very nature exceed the singularity of (in each case and each time) *this* speaker. If language and the societally mediated text and content are *cultural* possibilities, then the latter cannot be ascribed and reduced to characteristics of individuals. Interview participants reproduce cultural possibilities for language and conversational topics, so that the misconceptions—if we want to go that far—are not their own but are misconceptions that exist in the culture and are understood by non-scientists and scientists alike. Science educators interested in "eradicating" misconceptions about the sun, earth, day, and night therefore tell us that they want to remove culturally enabled ways of talking. It is precisely because these ways of talking are cultural possibilities that even astronomers can marvel at a "beautiful sunrise"; and in so doing they concretely realize and reproduce (i.e., keep alive) the cultural possibility to talk about the sun as the agent of movement.

In a sense, then, it is language rather than people that exposes itself and its sense in and through interactions, and individual speakers are but the means by which the possibilities of language are realized in concrete ways. No individual owns this language, which has possibilities that always are beyond all currently existing concrete realizations.

Every poem, every new way of talking about a phenomenon, every new concept testifies to the fact that there are possibilities that until this very moment have not been realized before; but in using this word, the speaker already assumes realizing in and with it a possibility, for otherwise the word could not be understood and would not have a function (though it might take a while for others to realize it as such).

5. Individually-Owned Conceptions Deconstructed

In this article, I propose a discursive psychological perspective on forms of talk that other science educators have taken as evidence for underlying individually held conceptual frameworks. Discourse psychology distinguishes itself from socio*linguistics*, for example, in that it takes discourse and its pragmatic realization for the purpose at hand as topics rather than language and linguistic structure per se (Edwards & Potter, 1992). It has been rightly noted that concepts are not out there, in the ideal, purified world of pure concepts as Plato has thought (Lemke, 1990); but some past research from the sociolinguistic perspective has overlooked the fact that there are possibilities in language that frame what and how people can engage in discourse, and in this sense, concrete discursive acts realize *real, concretely existing* possibilities and therefore possible concepts. Furthermore, from a discursive psychological perspective, grammar and other features of talk are themselves practical and interactive achievements *for the purpose of* making the current activity what it is (McNeill, 1992; Ochs, Schegloff, & Thompson, 1996) rather than—as other linguistic analyses appear to suggest—something that can be taken *a priori* as determinant of talk. Through the fragments presented as illustrative examples and also from the analysis of these fragments of interviews, science educators and other learning scientists can take that human beings do not depend on an original cognitive framework *inside* their minds to speak their thoughts, but their talk and explanations is spontaneous and contextualized within interviews and for the interviewers,

both producing and reproducing cultural forms with the use of a certain language, and also realizing he activity per se, that is, the interview.

5.1. Knowing, Learning, and Teaching

One of the main aporias for the conceptual change approach has been the resilience of (mis-, alternative, pre-, preinstructional, prior, naïve, canonical, non-standard) conceptions to instructions (Chi, 2005; Duit & Treagust, 1998). Thus, even students who have taken several high school courses in physics do not change their ways of talking leading researchers to suggest that the (mis-, alternative, pre-, preinstructional, prior, naïve, canonical, non-standard) conceptions have persisted. This resistance has proven to exist even when extraordinary efforts have gone into the construction of curricula based on analogies involving leading advocates of the approach in the design (Duit et al., 2001). That is, *because* students use their *everyday* language and experiences as sources and resources for building analogies—which includes theories implicit in everyday language—these are inconsistent with the scientific canon. That is, the discursive approach in the Duit et al. explained *why* the analogy-based approach to conceptual change did not work. This comes as little surprise from a discursive psychological perspective, where language is thought of as providing the very resources (the tools) with which to conduct societal formations (the terrain, participants), including interviews about scientific phenomena and concepts. In the discursive psychological account, language always is considered to be both that of the person and that of the culture: from my, the speaker's perspective, the language I speak always is both mine and not mine, always from the other and for the other (Derrida, 1998). At the very moment I express myself, I draw on a language that is not mine. Even if I cogitate in privacy, pursuing my own most private conversations with myself, I peruse a language that is not mine—in fact, these private conversations presuppose that I have had similar conversations with others in everyday societal contexts that now are internalized (Vygotsky, 1978). Ways of

talking, however, constitute cultural possibilities: they inherently are collective phenomena that cannot be eradicated by instructing this or that child. These can be eradicated only when the cultural possibilities themselves are eradicated, that is, when part of the discursive possibilities available in a culture is cut off from discourse. This is as unlikely to happen in the same way that school rules interdicting swearing actually eradicate this discursive phenomenon even in school hallways, let alone in the everyday lives of the students.

The perspective from discursive psychology has considerable consequences for teaching science. As science educators, we no longer can expect students to restructure something in their minds—which may happen more or less suddenly—but have to put up with the painstaking reconfiguration of ways of talking to make it appropriate to different kinds of situations. This is shown in science education research that followed physics students in real time, from one second to the next, over periods that range from several weeks to several months and in different content domains (Roth, 2001; Roth & Duit, 2003). Thus, saying that the sun rises in the morning, moves across the sky, and sets in the evening is appropriate in many settings, social situations, and textual productions (novels, poetry, sitting with a loved one on a beach facing west), but it is inappropriate in others, including science classrooms and interviews about scientific conceptions. Educators involved in language learning know that it takes years to become even a rudimentary speaker of a foreign language; and this is the case, as my own research shows, even after students have spent eight years in immersion classrooms where the language of instruction *is* the foreign language. From this perspective, then, why would (science) educators expect students to fluently talk science concerning some phenomena within the days, weeks, or months allotted to a topic? More so, the perspective from discursive psychology renders evident that talk has specific, pragmatic purposes; this dimension of discourse heretofore has not been taken into account both in research using interviews and in the teaching of scientific ways of talking—in both situations,

conceptions are thought to exist in the head and independent of the sociocultural and cultural-historical setting. The discursive psychological perspective, on the other hand, predisposes us to instructional forms in which students get to talk not just about certain (scientific) topics but get to talk science *for the purposes of* successfully realizing the ongoing activity, satisfactorily and completely discussing the topic at hand, and using scientifically appropriate forms of talk.

5.2. Reflexive Nature of Discursive Psychology

To identify conceptions and conceptual change in any talk, many assumptions have to be made about the nature of talk (individual production rather than collective phenomenon), the methodical question of the unit of analysis, from the abstracted talk attributed to an individual to an underlying conceptual framework. Discursive psychology is a useful method because it also is concerned with its own construction of concepts. That is, an important aspect of discursive psychology is its reflexive orientation. It can be used as a method to analyze itself: it treats psychology generally and the study of cognition particularly "as an object *in and for interaction*" (Potter, 2005, p. 739). That is, it is a method that can be used in two ways. First, it can be used to describe and explain how science educators (cognitive, developmental, educational psychologists) construct versions of what it is to know concepts and how conceptual change is proposed and produced. It is a method that ultimately can be used on this text I have produced, which proposes discursive psychology as a theory and method for studying conceptions and conceptual change. Second, it is an approach for understanding psychology from the position of participants, considering "*their* practical and situation constructions, terms, orientations and displays" (Potter, 2005, p. 740). As an object, discursive psychology "is *practical, accountable, situated, embodied* and *displayed*" (p. 740), and therefore something that professional and lay participants (researchers and everyday folk alike) can take as constituting their objective reality.

In articulating a discursive psychological perspective on conceptions and conceptual change, in focusing on how these are constituted in talk and how these are expressions inherent in language, which is not the language of the speaker (alone), I inevitably raise issues about how the learning sciences (science education; cognitive, developmental, educational psychology) construct their truths about conceptions and conceptual change. That is, to arrive at the identification of conceptions and conceptual change, researchers have to enact multiple levels of reductions. First, the text about phenomena and conceptions has to be uncoupled from the reproduction of the interview as cultural-historical form of activity. Second, performances have to be uncoupled from the turn-sequences and have to be ascribed to individuals who independently (without being confounded) produce the utterances. Third, the now individual utterances involving particular concept words and concept word constellations are flattened to *one* mental structure. Fourth, language is reduced to a tool that serves the articulation of an underlying structure rather than being the relevant phenomenon itself—discourse (language) as the contested terrain and tool for the articulation of topics (concepts, phenomena). Whether these reductions and presuppositions are valid and useful is in part a paradigmatic issue and that therefore cannot be resolved across paradigms; it is also an empirical issue the possibility of which ought to be demonstrated rather than taken for granted. In this article, I describe cases that provide evidence that the reductions and presuppositions lead to insurmountable aporias—ascribing a conception to an individual who has never thought or talked about a phenomenon is scientifically unsound, as is attributing to individuals what inherently and irreducible is the product of a collective effort.

6. Coda

In this article, I am concerned with the phenomenon of conceptions, in particular with raising issues that run counter to the idea that conceptions and conceptual change in the

head are relevant phenomena and theories for learning scientists (science educators, [cognitive, educational, developmental] psychologists). However, similar issues can be raised concerning beliefs, attitudes, or identity, which, from the perspective of discursive psychology, also are phenomena that are discursively and pragmatically constituted in talk, mostly interviews and questionnaires. As such, they are subject to the same constraints elaborated here, which do not permit ascription of these phenomena to individuals but require us to see and theorize them as sociocultural and cultural-historical phenomena through and through. There are cultural-historical ways and possibilities of talking about beliefs, attitudes, and identity; and these ways and possibilities are concretely realized, recognizably produced and reproduced in societal formations (lessons, interviews) as actional resources for others. Once learning scientists adopt a discursive psychological approach, new, fruitful agendas open up for researching in new ways many of the difficult and unanswered questions and aporias that face our disciplines today. In conceptual change speak, discursive psychology not only provides an intelligible alternative that addresses some of the obstinate and persistent problems but also promises to be fruitful by opening up new areas and topics for science education and learning science researchers. For me, this is so because what teachers and students make available to one another is talk. Whereas there are numerous reasons (intentions) and formal frameworks that might explain what a person says and why she says it, discursive psychology is more concerned with the phenomenon that interaction participants themselves encounter: language-in-interaction, which is practical, accountable, situated, embodied, and displayed (Potter, 2005). By "[m]aking psychology relevant" (Potter, 2005), discursive psychology theorizes language-in-interaction as phenomenon, which, to me, has a greater potential to lead to knowledge useful to language users themselves.

The relevance question has both practical and theoretical dimensions. For conceptual change researchers, discursive psychology offers new ways of understanding, for example, the production of "(mis-, alternative, pre-, preinstructional, prior, naïve,

canonical, non-standard) conceptions" from and with the *very same linguistic resources* that in some later stage allow the person to produce scientific conceptions. Teachers may find the discursive psychological approach more useful as they do not have to think about hidden frameworks and intentions but are provided with a theory of the phenomenon as they encounter it. The approach may also be useful in other school contexts, for example, in a school counseling session designed to mediate between students who have gotten into a fight, it may turn out more productive to assist the involved students in understanding how discourse is used to create effects rather than reflecting on hidden intentions and understandings.

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