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The Language of Everyday Verbal Analogies

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Abstract

Verbal analogies produced during naturally occurring instructional discourse in mathematics were explored using techniques borrowed from studies of language in use (see Wortham & Rymes, 2003). Close examination of two eighth-grade instructional analogies reveals that the language practices of analogy are instrumental in shaping recipients' relational re-representation of objects being compared, in particular through markers of indexicality and poetic parallel structure. At the same time, close examination of the communicative interactions reveals that these devices may reduce the burden on recipients' reasoning to the point that they may appear successful at solving the verbal analogy, but their responses can be explained by facility in verbal interaction rather than in mathematical reasoning. These data provide thereby new insights into the "analogical paradox," the finding that analogies are commonly successful as vehicles for interactionally producing and displaying understanding of new information in everyday contexts but generally problematic when measured for their effects on reasoning in controlled laboratory settings (Dunbar, 1998). We identify a tension between interactional and cognitive success of everyday communicative analogies, meaning that those that are most likely to be interactionally successful may lead to less cognitive engagement for analogy recipients.

Keywords: analogy; analogical reasoning; language, linguistic anthropology

Introduction

Analogy is the process of identifying shared relational similarities across contexts or representations, and has been theorized as integral to humans' everyday flexibility and higher order adaptive thinking (Doumas & Hummel, 2012). Analogy has also been empirically identified as a regular practice within everyday communication in contexts including scientific biology laboratories (Dunbar, 1995, 1999), political discourse (Blanchette & Dunbar, 1997, 2001) and classrooms (English, 2004; Richland, Holyoak & Stigler, 2004; Richland, Zur & Holyoak, 2007).

At the same time, basic analogical problem solving and transfer in the laboratory is notoriously unreliable and often unsuccessful (e.g., Gick & Holyoak, 1980, 1983). These differences between analogy production

in the lab and in everyday interaction led Dunbar (1998) to speculate about the "analogical paradox," the insight that analogy is often rare and difficult to produce in the laboratory, but frequent and effective in everyday talk.

The current paper draws on linguistic anthropological methods for studying the empirical details of everyday interactions to better understand this paradox. The analysis uses techniques borrowed from the linguistic anthropology of education (Wortham & Rymes, 2003), applying studies of language-in-use to educational discourse. Following this, language is conceptualized here as a performative activity that carries pragmatic as well as referentio-semantic meaning (Austin, 1962; Hymes, 1972.). In using analogies, teachers in mathematics instruction provide not only information regarding the denotational and other forms of semantic content of the lexical and grammatical structures of the talk they use. They also, simultaneously, signal to their student-audiences how, in the specific and actual moments of their use, their talk is to be understood as a move in the turn-by-turn exchange that is constituting the particular instructional discourse of which it is a part, and to which they will be expected to respond "appropriately." Most often, in instructional discourses using analogies, the "appropriate" student response will also be a response that is treated by the instructor as proof of the student's effective "correct" (referentio-semantic) understanding and reasoning based on the analogy's denotational content. But sometimes the pragmatically appropriate response is not the same as referentio-semantically "correct" one, revealing how the student in such exchanges is orienting and responding to two orders of meaning at once.

For example, consider an instructional analogy that is initially expressed as: "Lets say that I loaned you twenty five dollars and then I loaned you twenty five more dollars, what would you owe me?" Such an analogy source pragmatically indicates that the learner should not encode the analogs as a truthful representation of the facts as they exist in the context of use but rather as a proposed hypothetical situation shared between the teacher and student. In a classroom context involving an elementary school teacher instructing his student about negative numbers, a student might respond in a pragmatically adequate and

semantically “correct” manner with the same answer, “I’d be down fifty dollars.” But in an ethics classroom in high school, in which the teacher was instructing about coercion, a semantically “correct” answer “I’d be down fifty dollars,” may not be pragmatically adequate.

Linguistic anthropology of education builds from this notion of language in use to demonstrate that many instructional activities rely upon not only the linguistic production of educational content but also the form and participatory patterns of the construction. Lexical form, grammatico-syntactical structures, and the phenomenal features of speech and text as produced in real time can simultaneously signal social, political, discursive, participatory and other kinds of meaning to participants in a social interaction (e.g. Duranti, 1997). The use of such linguistic devices enables the speaker to provide pragmatic and metapragmatic cues, which simultaneously constitute the speech, while at the same time informing recipients how they should be interpreting that speech and preparing to respond to it (Goffman, 1974; 1981, Hymes 1972, Silverstein 1979, 1993). In educational contexts this is particularly important because classroom interaction not only affects the relationships between classroom actors, but it also impacts the cognitive activity performed by students during learning situations.

The current manuscript describes analyses of two classroom analogies that were identified from a larger corpus as illustrative of the verbal analogies produced in instruction. They are transcribed using conventions borrowed from conversation analysis (Sacks, Schegloff & Jefferson, 1974). Within those transcripts, two linguistic resources were identified as both common to and particularly meaningful of the production of the verbal structure-mapping: indexicality and parallel structure.

Indexicality. All linguistic features, when used, have the capacity to index, or point to, aspects of their contexts of use as ways of shaping their conceptual meaning to competent members of a speech community (Ochs, 1992). Deictic indexes are those such as, “you,” that have minimal semantic meaning aside from the precise context of the talk (Hanks, 1992, see also Silverstein 1976; Horn, 1988). As phrased by Hanks: “their basic communicative function is to individuate or single out objects of reference or address in terms of their relation to the current interactive context in which the utterance occurs” (1992: 47).

Thus the use of deictics makes the semantic meaning of an utterance inexplicable without the immediate context, which imposes a further burden on interaction participants to comprehend the multiple levels of meaning intended by the speaker. For instance, the use of the word “you” in the following phrase, “If you are having trouble, raise your hand” carries 1) semantic meaning – that the speech in question is intended to be directed to someone else (second person, not marked as singular or plural in

English) who is proposed as its addressee, and 2) a contextually specific, interactional meaning – the teacher is inviting those in the presumed range of hearing – here perhaps a group or subgroup of classroom students – to take up the position of addressee, and to respond, provided they interpret the qualification “having trouble” as applicable to them.

This study will examine the role of indexicality in teachers’ discursive work to help students produce certain constrained representations of information in order to create comparable analogs. This carefully crafted relational re-representation is essential, because the major identified problem in doing analogy is noticing the relevance of mapping the relational structure from one analog to another (see Gick & Holyoak, 1980, 1983). Thus if one’s mental representation of a particular object in the world does not align with another system, the reasoner will likely fail to notice the relevant higher order structure mapping between them. Indexes that mark the unreal, or hypothetical nature of the source representation are illustrated in the first analogy described below. In so doing, and much as in the “Let’s say...” example used above, the interacting students in the first analogy described are invited by the teacher to construct a particular source analog that does not have to reflect all the perceptual and relational characteristics of reality, but rather to isolate and highlight the key relationship depicted in the discourse.

Competent members of a speech community are highly skilled at interpreting indexical talk, though participants who are not fully members of that speech community (e.g., English Language Learner students), or students under high processing load to hold mathematical representations in mind, may find this a challenge that reduces their available resources to interpret a conceptually demanding analogy.

Poetic Structure. Second, this analysis takes up the reflexive capacity of language to serve, simultaneously as both the content of communication and commentary upon that content, particularly in the ways in which aesthetic forms such as rhyming, prosody, and even tempo can shape how semantico-referential content is to be interpreted and responded to by recipients and addressees (Lucy, 1993, 1999). One such example is discerned in the parallel structuring of discursive clauses in sequences of moments of actual speech and textual production, deploying what some have called the poetic dimension of meaning-making in language. (Jakobson, 1960; Silverstein, 1985) The notion of poetic structure and its regular and repeated occurrence in verbal analogy is particularly relevant to the current analysis, insofar as it offers yet another discursive channel for conveying the intended comparison between two systems of similarly structured relationships. In this sense, the poetic dimension of parallel structuring in verbal analogy becomes iconic of the semantic content of the speech, and the proposed

relationship between source and target that the instructor endeavors to produce by it. Parallel structure of speech serves as a pragmatic index for the analogical structure mapping itself.

The forthcoming analysis more closely examines the affordances and routines of indexicality and parallel structure within the discourse structures of analogy speech events. The paper will attempt to show that language mediates the activity of analogy in classroom mathematics instruction. In particular, it shows how the resources of indexicality and parallel structure are frequently instrumental in the outcomes of students' learning experiences during instructional analogies. The analysis will explore how teachers use indexicality and parallel structure to draw students into creating mental re-representations of the source and target objects as distinct relational systems by situating them in hypothetical, temporally defined, and/or spatial worlds that are then systematically aligned and mapped together. These can produce the dual, conflicting functions of drawing recipients' attention to relational similarity and increasing the likelihood that they will notice and successfully complete analogical structure mapping. At the same time, the high levels of structure provided by the language can reduce the mathematical, semantic learning potential for students.

Methods

Sample

The analogies analyzed in this paper are a subset of verbal analogies identified and coded in larger studies of classroom teachers' use of relational comparisons in videotaped U.S., Japanese, and Hong Kong Chinese eighth-grade mathematics lessons (Richland, Holyoak & Stigler, 2004; Richland, Zur & Holyoak, 2007). A randomized probability sample of all 8th grade mathematics lessons taught in the United States was videotaped as part of the Third International Mathematics and Science Study (Stigler et al, 1999). In a secondary analyses of these data, a random subset of the U.S. lessons were further analyzed by trained and reliable coders to identify and categorize analogy usage using frequency coding. Key representative analogies within these units of analysis were transcribed using conventions of conversation analysis (Sacks, Schegloff & Jefferson, 1974).

Indexicality and parallel structure are analyzed in two analogies selected from this corpus of data. These analogies were selected because they are typical of the 298 U.S. analogies identified and coded, and for their clarity in revealing common and potentially consequential discursive constructions. They were not selected for their mathematical sophistication or efficacy, and should not be construed as ideal examples of the potential for analogy to support classroom mathematics learning. Many of the more mathematically sophisticated analogies follow similar

patterns but included more extended discussion, making their length prohibitive for a paper-length analysis of several examples. The first analogy demonstrates how parallel structure can provide a poetic representation of the analogical structure mapping itself. The second analogy also invokes parallel structure, but further reveals the role of indexicality in constructing source representations and structure-mapping during production of analogies by drawing on irrealis, space, and time, and the second

Analogy Segment 1: Poetic Structure

Analogy 1 demonstrates how the linguistic form of an analogy can generate participation and model conceptual mapping. This teacher aligns the mathematical concepts of generating equivalence across the equal sign with converting fractions to like denominators. These are different concept areas within algebra, though procedures used for manipulating these structures are similar. The analogy arises while the teacher is at the chalkboard instructing students about how to make fractions equivalent. She is teaching the rule that when one multiplies the bottom number of a fraction times a number, one must multiply the top number times the same number to retain the same fraction. She depicts this on the board in an example, where she multiplies both the numerator and the denominator times four to determine that $\frac{2}{4}$ is equivalent to $\frac{8}{16}$. The analogy the teacher makes between these concept areas is fairly procedural and does not engage in the relationship between the deep mathematical structure of these concepts, however it is interactionally successful and students are able to complete the teachers' designedly incomplete utterances throughout the analogy (Koshik, 2001).

The organizational structure of language, beyond its denotational and indexical meaning, can play an important role in the interactional and conceptual consequences of language in use (e.g. Jakobson, 1960; 1971[1966]). One constitutive factor of Jakobson's (1960) model of a speech event, is the *poetic* feature of language. He uses this category to foreground the aesthetic or perceptual features of talk, arguing that these carry their own functionality. The role of parallel structure is particularly relevant to analogy in use, since the conceptual basis for analogy is the development of relevant parallels between the conceptual structure of source and target objects. Teachers regularly invoked parallel structure in the lexical and grammatical construction of the analogical mappings, thus creating grammatical metaphors for the conceptual mapping being constructed. Parallel structure within the discursive form in this way may thus serve as reflexive language cues to listeners, such that the form of the structural parallelism within the utterance serve a guiding function, leading talk recipients to infer that the

ensuing talk should be mentally represented as a set of parallel structures (Lucy, 1999).

On board:

$$\frac{2(4)}{4(4)} = \frac{x}{16}$$

x =

```

1 T: Okay - just like equations (.)
2 whatever you do [to one side
3 [(gesturing to her left)
4 (you have to do (..) [(.) to the other.
5 [(gestures to right, emphasis on "other")
6 Ss: [to the other
7 Ss: [(other)
8 T: [Whatever you do to the denominator,
9 [(curls hands inwards, gesturing toward herself))
10 you have to [do to the (..) [numerator.
11 [(uncurls hands to bend fingers out away
12 from herself))
13 Ss: num[erator
14 T: Okay (.) Now

```

Figure 1. Analogy between operating on equations and fractions.

The teacher begins this analogy following a procedural explanation of how to multiply the same number to the denominator and the numerator in order to produce an equivalent fraction with a new denominator. The teacher begins with the token “okay,” marking a transition between the prior expository talk and the ensuing discourse. This indicates that this is a distinct unit of talk. She then indexes that she is designing a comparison with the comparative marker “just like,” followed by the referent “equations” to signal the source of the comparison.

The teacher then constructs parallel structure between the utterances in lines 2-4 and lines 8-10. Analogies are frequently formalized as A:B::C:D (“A” is to “B” as “C” is to “D”), and this teacher implements that formal relationship in the following pattern of talk: “whatever you do to (A) you have to do to (B)” and “whatever you do to (C) you have to do to (D).” The statements are lexically identical around the arguments (A, B, C, D), which are conceptually similar objects. “Whatever you do to one side, you have to do to the other, whatever you do to the numerator, you have to do to the denominator.”

The parallel structure is further supported by the teacher’s gesture that builds on culturally standard spatial representations of fractions and equations. For equations, “one side,” “and the other” are typically depicted as horizontal objects to the left or right of the other. For fractions, “denominator” and “numerator” are vertical objects, one below and above the other.

These symbolic representations are reiterated by the teacher’s gestures. In accordance with her verbalization of the source “whatever you do to one side you have to do to the other” she moves her hands to her left and then her right. In construction of the target she mirrors the opposing movements to signal the numerator and the denominator, and moves her hands from towards herself to away from herself. The teacher first designs

the relationship between the A and B components of the source (one side of an equation and the other) and then the relationship between the C and D components of the target (the numerator and the denominator). The overarching lesson has been focusing on equivalence, so it is clear from the setting of this talk that “have to” implies ‘have to in order to maintain equivalence between the two sides.’

The parallel structure is compelling to the analogy recipients and they demonstrate uptake of the parallel structure and appropriate inferences based on acquisition of the relational structure of the talk. The teacher leaves a micro-pause as invitation to participation for students in lines 4 and 10, requesting their participation in generating the B and D terms of the parallel structure. In both cases multiple students within the classroom enter the discourse, and in both cases the audible set of students respond appropriately with the correct lexical item to complete the conceptual relationship signaled by the parallel structure. In line six students also demonstrated acquisition of the parallel structure, and overlapped with the teacher in production of the completion of the phrase using the modifier “to” preceding “the other”.

These utterances provide evidence that these students are participating actively in the parallel structure, as well as the corresponding mathematically relevant relational mapping designed by the teacher. Their answers are not necessarily based on problem solving, though, but rather they may be mapping the structure highlighted by the teacher’s gesture and parallel discursive structure from a known source object to a corresponding target.

Analogy Segment 2: Indexicality

The following transcript, shown in Figure 2, provides a second example of the role of hypothetical contexts in construction of analogy. Of particular interest in this analogy is the teacher’s persistence in indexing an alternative context that is familiar to her student recipients.

The teacher initiates this analogy to help a student determine whether the summation of two negative numbers results in a negative or a positive sign in front of the solution number. Answering this question is the target of this analogy, and the teacher invokes the familiar schema of losing money as a source.

This is a one-on-one interaction between one student and the teacher during the seatwork portion of this lesson. The student has raised her hand and indicated difficulty to the teacher, who then comes to her assistance. Approximately half of the analogies identified in the coding study were constructed following students’ demonstration of difficulty with the mathematics. Many of these looked similar to this analogy.

10 T: You're- you're saying
 11 (...) what's a, negative eighty eight if you lose
 12 (...) let's say you have um (...) **you're playing marb-**
 13 **well, uh people don't play marbles anymore.**
 14 T: **Let's say you're (...) you got money, all right,**
 15 **and you lose eighty eight cents**
 16 **and then you lose five cents.**
 17 T: What have you **lost altogether?**
 18 S: Ninety three cents.
 19 T: Right.
 20 T: **So you wouldn't want to say plus ninety three.**
 21 S: Want to **subtract** ninety three.

Figure 2. Analogy between losing money and subtracting negative numbers.

In lines 1 through 8 the student is voicing her confusion, though the details of the language are difficult to capture in the recording. In line 10 this teacher begins to signal that she is going to re-represent the question entered by the student. She begins with “you’re – you’re saying” which suggests a reformulation of the students’ question, but then after a brief pause she begins again with: “what’s a, negative eighty eight if you lose...” The lexical item “lose” indexes possession and change of that status, and is not a mathematical term. This choice of term signals that she is representing the students’ mathematical question in an alternative domain. Next she pauses briefly and begins again. This time the teacher uses a plural pronoun “let’s” indexing that both she and the student will participate in the reformulation of the student’s mathematical question and uses the frame “lets say you have um.” The teacher indexes the hypothetical (irrealis) frame through the lexical item “say,” indicating that this is a reformulation in a world not exactly the same as the one inhabited by the student’s initial question. Again, however, she aborts this reconstruction and after a brief pause reformulates with the frame “you’re playing marb-.”

Once again the teacher decides to discontinue this representation and the setting of marbles because, as she states, “people don’t play marbles anymore.” This statement reveals that it is important to her that the context she indexes as a frame for her reformulation of the students’ question is one that the student regularly inhabits or is familiar with. After several attempts to initiate this representation of the student’s original question, the teacher signals an alternative context through a shift in semantic as well as indexical word use, and settles on a hypothetical reformulation.

In lines 15 through 17 the teacher completes her representation of the irrealis source analog. She says “let’s say you’re (...) you got money,” and indexes the student’s nonverbal concurrence with the phrase “all right.” Once again the teacher uses the plural “lets say” construction to signal that this is a reformulation of the original math problem, and that this is instead of the marble-playing context referenced immediately prior. The teacher continues by embedding the student’s

original mathematical question in the context she is building in which the student’s possession of money is the relevant feature “you lose eighty eight cents and then you lose five cents.” She develops the source context as a hypothetical world in which the important point is that the student has money. The construction “lets say you’re, you got money” suggests that regardless of whether this student actually has money, the teacher is indexing this possible world in which this student has 88 cents and loses 5 cents. These are the same numerical amounts as in the original target problem, yet they are situated within this hypothetical frame.

The question “what have you lost altogether” in line 18 is a reformulation of the target and requires the same mathematical computation, but the contextualization and the lexical item “lost” indexes that this problem is distinct from the mathematical problem and is located within the domain of money.

In line 19 the student answers appropriately to the hypothetical context of the source analog using the monetary unit, “cents” to describe the numerical solution. She indicates that she is embodying the “you” from inside the hypothetical possible world represented by the teacher, as she answers the questions “what have you lost altogether” without hesitation and with the correct number.

Finally, the teacher guides the student in transitioning from her facility with the hypothetical world of her monetary loss to the veridical world of the math problem. Still using the student as a reference point, in line 21 she says “so you wouldn’t want to say plus ninety-three.” The teacher’s use of the term “plus” and the transitional item “so” index the mathematical world, and appropriately the student responds with: “want to subtract ninety-three.” This correct answer is stated without markers of money, and specifically the term “subtract” is used for the same computational meaning as “lost” was in the earlier line 18. Thus the student has made the relevant conceptual inference – that adding negatives results in a negative number, and she has made the interactional inference that she is now in the realm of the math problem, where she had previously inferred the context of her monetary loss.

Thus in this analogy, like in the prior example, the teacher’s language denotatively constructs an analogy between a familiar and an unknown context, but her discourse also indexes both interactional and semantic mappings. Thus the student must exercise conceptual mapping and inferences at multiple levels. She must interpret her role in the analogy, as well as multiple levels of the mathematical comparison. The teacher indexes levels of comparison between the numbers as well as hypothetical to veridical worlds, and between a world where the student is within the context to where she external to the math and writes a mathematical

answer. The teacher's work to find a source context that is familiar and a realistic hypothetical situation may facilitate these levels of inference, enabling the student to draw inferences from the more familiar space to the more novel space.

The source analog of losing money thus provides a meaningful structure for this student to interpret the nature of addition between negative numbers, a concept that is currently unfamiliar to her. Her success within a few seconds demonstrates that this is a striking resource for meaning-making. The conceptual structure of negative numbers is typically challenging for learners, and this teacher has led to an extremely rapid successful completion of a target problem following confusion.

At the same time, this rapid transformation is somewhat troubling from a learning standpoint. The mathematical nature of this analogy is not deeply conceptual, nor is it clear that the student will be able to generalize this understanding to a new problem in which the teacher has not highly designed a source analog for the student. The student herself will have to relationally re-represent the current problem as a source for a subsequent problem, and her ability to do so remains to be seen.

This reveals a powerful tension between the interactional success of an analogy produced in conversation, and the goal to produce deep thinking and conceptual abstraction from an analogy. The teachers' highly constrained representations of the source analogs improve the likelihood that recipients will use the alignment they have been provided. At the same time, this may limit the need for effortful relational integration and structure mapping on the part of students, potentially limiting future ability for transfer and generalization.

Overall, these examples are both successful interactions in which students reason analogically to respond as pragmatically and mathematically intended by their instructor. Regarding learning, however, the pragmatic and referentio-semantic efficacy of the interaction are impossible to disentangle. The interactions may have prompted minimally effortful relational integration because the source objects were highly relationally re-represented by the teacher. That relational re-representation in the first example created a parallel poetic structure between the source and target representations, which required structure-mapping but could be accomplished through attention to the pragmatics, rather than only referentio-semantic/mathematical content as one might suppose if solely examining the source and target representations being compared. This suggests that the analogical paradox may be at least partly explained by the grammatical, interactional pragmatics of everyday verbal analogies.

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