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Some Challenges in the Empirical Investigation of Conceptual Mappings and Embodied Cognition in Science Education: Commentary on Dreyfus, Gupta and Redish; and Close and Scherr

Rafael Núñez^a

^a Department of Cognitive Science, University of California, San Diego, CA, USA

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Some Challenges in the Empirical Investigation of Conceptual Mappings and Embodied Cognition in Science Education: Commentary on Dreyfus, Gupta and Redish; and Close and Scherr

Rafael Núñez*

Department of Cognitive Science, University of California, San Diego, CA, USA

The last couple of decades have seen an enormous development in the study of embodied cognition through the investigation of conceptual mappings, such as conceptual metaphor (Lakoff & Johnson, 1980/2003) and conceptual blending (Fauconnier & Turner, 2002). Initially, this progress was achieved at a theoretical level, and more recently through empirical research in basic science—from psycholinguistics, to cross-cultural and developmental studies, to cognitive neuroscience (for a collection of review chapters, see, for example, Gibbs, 2008; see also, Fauconnier & Turner, 2002; Lakoff & Núñez, 2000). These advancements have begun to be applied to domains such as literary criticism (Turner, 1998), advertising (Joy, Sherry, & Deschenes, 2009), law and courtroom settings (Pascual, 2008), theater (Cook, 2007), and, importantly, they have reached the critical sphere of education in mathematics (e.g. Edwards, 2009; Zandieh, Roh, & Knapp, 2014) and science (Hrepic, Zollman, & Rebello, 2010). The present issue constitutes an excellent example of how science education is reaching new levels of research maturity and sophistication, bringing advances from contemporary cognitive science to the study of the richness and complexity involved in the teaching and learning of science—a laudable endeavor. Beyond the already multilayered practice of teaching and implementing educational curricula, taking the step of conducting empirical research in the domain of embodied cognition and conceptual mappings in educational

*Corresponding author. Department of Cognitive Science, University of California, 9500 Gilman drive, La Jolla, San Diego, CA 92093-0515, USA. Email: rnunez@ucsd.edu

settings brings new challenges and difficulties. Here I will analyze some of these difficulties, hoping that they make a contribution to the design and implementation of future empirical research in these domains. Although I will refer specifically to two articles of this special issue (Dreyfus, Gupta, & Redish, 2015; Close & Scherr, 2015), the discussion should be generic enough so that it can be applied to other research settings that investigate embodied cognition, conceptual mappings and gesture in mathematics and science education.

The papers by Dreyfus et al., and by Close and Scherr, share several features. Both articles investigate the relationship between embodied cognition, conceptual mappings, and gesture production in the domain of energy as studied in college physics. And, methodologically, both present studies conducted in the descriptive and interpretive tradition, and both choose to focus their analysis on two episodes carefully selected from a remarkably large video-recorded database. These papers analyze in detail the ENERGY AS A SUBSTANCE¹ conceptual metaphor, and its relation to other conceptual mappings, gesture production, and notation systems. Dreyfus et al. study how the inferential organization of the ENERGY AS A SUBSTANCE metaphor might interact with a conceptual metaphor they call ENERGY AS VERTICAL LOCATION, both being orchestrated via an encompassing conceptual blend. Close and Scherr, working with teachers involved in a professional development program, study the ENERGY AS A SUBSTANCE metaphor in the context of an ‘Energy Theater’, a pedagogical setting that builds on a role-playing situation in which teacher–learners/actors explore and enact the role of various relevant entities involving energy transfers and transformations. Both these articles do a wonderful job of describing the fundamentals of conceptual metaphor and conceptual blending, and I applaud their efforts in describing, explaining, and engaging with, these subtle and sophisticated theories, applying them to specific contexts of physics education. Indeed, these papers provide excellent examples of how complex multi-modal processes involving abstract technical conceptual systems, language, communication and bodily actions unfold in real time, enacting dynamic sense-making in real-world scenarios. The empirical investigation of such complex phenomena is, of course, far from easy, as they involve a great deal of methodological and theoretical problems when it comes to designing studies, operationalizing relevant variables, and gathering, analyzing, and interpreting data. In the spirit of constructive criticism, I raise here a few points that are problematic in these papers, which usually present difficulties when investigating embodied cognition, conceptual mappings, and gesture production in general.

What is in a Domain or Input Space of a Conceptual Mapping?

Traditionally, conceptual metaphor and blending theories would postulate the existence of source and target domains of conceptual metaphors or input spaces, respectively, based on linguistic data—that is, actual figurative linguistic expressions. For instance, metaphorical expressions, such as *this theory has weak foundations*, would suggest that their semantics draw from the inferential organization provided by a

systematic mapping from entities in a source domain of Buildings onto elements in the target domain of Theories, hence the name of the conceptual metaphor THEORIES ARE BUILDINGS (Lakoff & Johnson, 1980/2003). Researchers in cognitive linguistics were quick to point out, however, that many elements of the domain of Buildings do not get mapped onto Theories: restrooms, elevators, and so on (Grady, 1997). Thus, an important area of research in conceptual mappings became the precise characterization of what exactly constitutes a domain (or input space) structuring the inferential organization of the mapping, and on what bases should the researcher decide what the domain (or input) spaces are supposed to be. This problem comes up, in Dreyfus et al.'s paper. The authors want to show how a 'single blended mental space' (p. 1) blends two ontological metaphors: ENERGY AS A SUBSTANCE and ENERGY AS A VERTICAL LOCATION. Although both conceptual metaphors share the same target domain of ENERGY, one wonders what exactly constitutes the source domain of the latter: VERTICAL LOCATION. A quick look at the authors' reported video data reveals that this source domain is not just about the ontology of a generic ordinary 'vertical location' as in a person's height or the elevation of a hill, but that it largely (if not entirely) relies on the technical conceptual system (and notational apparatus) of the Cartesian Plane and Analytic Geometry, with specific variables mapped on the *x*- and *y*-axes (distance between atoms and energy, respectively). The blended space that the authors are trying to analyze is therefore, not between two ontological everyday-like conceptual metaphors involving a generic ordinary notion of 'substance' and of 'vertical location', but in the case of the latter, one that involves a highly technical domain mediated by notation, graphic conventions, and further abstracted concepts. 'Vertical location' here is not just a location in space standing apart from the bodily experienced ground, but a specific construal based on *y*-coordinates of points depicted graphically on an external medium such as a classroom board. This distinction is not purely formal, as it points to the difference between the ontology of metaphorical source domains based on ordinary everyday bodily experience (e.g. people's height) and technical domains that are mediated by specific conceptual systems (e.g. Analytic Geometry and the Cartesian Plane) constrained and regulated by highly conventionalized norms, notations, and inscriptions. These two types of domains have quite different inferential organization and range of applicability. In fact, any domain—not just energy—that is susceptible to be analyzed in terms of graphically depicted functions in the Cartesian Plane—stock markets, number of infected people in pandemics, rainfalls, cholesterol levels, and so on, would essentially support similar forms of reasoning and sense-making in terms of 'ups' and 'downs'. Thus, the statement from a physics professor—Prof. Farnsworth—quoted in Dreyfus et al.'s paper (p. 16) in which, he utters, as he refers to a graph depicted on the board, '[the energy levels of two atoms] *drop down to here*', does not primarily express energy concepts in terms of a source domain of bodily grounded (vertical) space, but rather in terms of a conceptual algebraic-geometric technicalized domain determined by the Cartesian Plane, depicted in an external medium. Importantly, it is this distinction that allows us to understand (1) what is the role of certain types of gestures in conceptual blending, and (2) why the putative metaphor ENERGY AS

VERTICAL LOCATION elicits such an abundant amount of utterances that involve demonstratives (e.g. ‘this’ and ‘that’), deictic terms (e.g. ‘here’ and ‘there’), and specific types of indexical gestures (i.e. pointings). Let us analyze these observations in the next section.

Gestures as Evidence of Mappings? Or as Constituting Input Spaces? Or as Doing Something Else?

Both the article by Dreyfus et al., and the one by Close and Scherr describe interesting instances of gestures co-produced with rich conceptual elaborations. Close and Scherr analyze gestures in which the teachers–learners/actors in the ‘Energy Theater’ take on the role of energy units in a problem scenario. Not only the theater context calls for a conceptual blend that involves a degree of personification (i.e. teachers–learners ‘being’ energy units; see ‘Drama connectors’ in Fauconnier & Turner, 2002), but, interestingly, it also prompts occasional opportunistic impersonations outside of the rules of the game, which must be managed at a meta-discursive/conceptual level. During brief passages, teachers–learners *are not* units of energy, but some other invoked characters or entities. Thus, we see teacher–learner Andy spontaneously impersonating a scuba diver who pushes the walls of a container with a gas in it, and teacher–learner Sally making a machine-like gesture—a simulation of ‘the pumping action of locomotive wheels with bent arms pumping forward and backward close to the body’ (p. 32), which is a gesture with iconic content that participants have agreed to use to refer to ‘kinetic energy’. In the gesture studies literature, these types of gesture are called ‘pantomimes’ (McNeill, 2000), which are characterized by having a first person perspective, by extensively using parts of the body (or all of it), and by displaying macro movements in space that portray some prominent features of the entities or characters being invoked. When pantomimes—spontaneous and conventionalized—are produced in the context of theater scenarios, it is relatively straightforward to follow arguments that explain their enactment in terms of blended spaces—with an input space constituted by the actual individual who produces bodily actions in his/her surrounding space (e.g. the teachers–learners Andy and Sally), and an input space constituted by the character being impersonated (e.g. the scuba diver, and a locomotive displaying the pumping action of its wheels, respectively). It is in the blended space that one can interpret the bodily actions of actors as being those from the character being played (Cook, 2007; Fauconnier & Turner, 2002). Thus, in Close and Scherr’s paper, for instance, we unproblematically read (p. 32): With ‘embodied actions’ Andy (a teacher–learner) ‘pretends to be Scuba Steve and push wall inward’.

The gestures described by Dreyfus et al., however, present some challenges. The authors describe gestures produced by the physics professor, Farnsworth, while teaching, and those produced during an interview by an undergraduate pre-medical student taking his class. And they explicitly declare that they use ‘gestures as evidence for an underlying conceptual blend rather than considering the gestures themselves as an input to the blend’ (p. 11). Certain types of gestures do in fact

contribute to providing evidence of an underlying conceptual blend. Such is the case of the pantomimes described above, as well as that of spontaneous gestures that bring semantic structure that is not expressed in the speech modality (Cienki, 1998), for instance when someone utters ‘in my childhood’ while pointing backwards. In such case, ‘childhood’ is brought as a temporal entity that, in itself, does not have spatial (metaphorical) content, and the backwards pointing is a motor action that indexes a physical space behind the speaker. It is the blended ensemble that reveals the specificities of the spatial construal of the temporal entity ‘childhood’ as metaphorically located behind the speaker. But most of the gestures reported and described by Dreyfus et al. are of a different nature and demand extra caution in the analysis. Many of these gestures are pointings that co-occur with demonstratives and deictic terms, co-produced with utterances such as ‘and drop down to *here*’, ‘and release *that* much energy’, ‘and *that* negative energy’, ‘come in at *this* energy’, ‘you gotta put in *this* much’, ‘the difference between *here* and *here*’, and so on (pp. 17–21; italics added). To state that these gestures provide evidence for an underlying conceptual blend of ontological metaphors ‘where the predicate from one ontological category is accompanied by gestures from another’ (p. 19) is misleading and problematic. To illustrate the special status of pointings co-produced with demonstratives (or deictic terms), consider a case in which someone utters ‘I prefer this one over that one’. In the pure speech/linguistic track, the utterance is completely underspecified such that almost no coherent meaning can be enacted. Collections of utterances of this sort, therefore, cannot constitute a (source or input) domain for a conceptual mapping, let alone an ontological domain. Indeed, in everyday communication, utterances of this sort *never* occur without some type of co-produced bodily action: hand or tool pointings, eye-gaze, etc. And if, for some reason, they do occur (e.g. because of inattention on the part of the speaker) they are remedied right away in the communicative process. As we saw in the previous section, the content involving the putative ENERGY AS A VERTICAL LOCATION in Dreyfus et al.’s data is in fact specified by the Cartesian Plane and mediated by the graphs and inscriptions that are externalized on the board. The demonstratives (this and that) and deictic terms (here and there) that appear in the speech modality actually index specific technical entities depicted or written on the board, and therefore, the observed co-occurring pointings are not manifestations of gestures from an ontological domain to be blended. Rather, they are specific types of gestures whose function is to make the indexation process unambiguous. These indexical gestures (but not their morphologies), therefore, are entirely inscription- and notation-dependent, and therefore they cannot be taken as evidence of a conceptual blending of ontological metaphors. They need to be handled with care when it comes to analyze them in terms of embodied cognition and conceptual mappings.

Closing Remarks on Methods, Research Issues, and Theory Building

Historically, conceptual metaphor theory, which initially developed on the basis of linguistic and theoretical analysis, ended up benefiting from criticism from the empirical

sciences for its ultimate development. Psychologists, early in the process, argued that if the theory was supposed to be not just about ‘verbal’ or ‘linguistic’ metaphors, but about concepts, thought, and reasoning, then specific evidence had to be provided to claim that when, say, a woman tells her partner *we have been walking through life together* she is *actually* cognitively operating with the LOVE IS A JOURNEY metaphor (Murphy, 1996). In the late nineties, scores of experiments began to be conducted to test, beyond purely linguistic expressions and etymologies, the ‘psychological reality’ of many of the postulated conceptual metaphors. Initially, these studies involved carefully controlled psycholinguistic experiments in the laboratory (e.g. Gentner & Wolff, 1997), and later they were extended to fieldwork and cross-cultural settings involving other methods such as gesture analysis (e.g. Núñez & Sweetser, 2006). As a result, a deeper and more detailed understanding of metaphorical thinking was fostered. In most of these studies, researchers exploited the fact that metaphorical mappings are essentially unidirectional—they go from a source domain to a target domain—making experimentation with conceptual metaphors empirically manageable. For instance, using priming studies, researchers could experimentally manipulate (i.e. ‘prime’) the source domain of a spatio-temporal mapping (e.g. by exposing participants to certain types of *spatial* material), and proceed to empirically test predictions about what *temporal* inferences in the target domain participants would make as a result of the manipulation (e.g. Núñez, Motz, & Teuscher, 2006). With respect to conceptual blending, however, the experimental investigation of the mappings has been much more difficult to conceive, to design, and to conduct. The underlying problems are largely due to the fact that, unlike conceptual metaphor, blending mappings are essentially non-directional, and the postulated networks of mappings are often complex and hard to deal with operationally. To partially remedy the situation, some improvements have come from gesture studies (e.g. Parrill & Sweetser, 2004), which have broadened the range of available empirical methods. But there is still much more to be done to put conceptual blending theory (and conceptual mappings in general) on firm empirical grounds.

Considering the difficulties that cognitive linguists and cognitive scientists have encountered in empirically testing hypotheses involving conceptual mappings, one can only praise the efforts deployed by Dreyfus et al. and Close and Scherr in their insightful and perceptive studies in science education. In order to make progress in the future, however, it would be highly advisable if more efforts were put to (1) move from purely *interpretive* studies to more methodologically rigorous ones, (2) move from a mainly *confirmatory* approach designed to corroborate pre-existing beliefs, to an approach that attempts also to *disconfirm* alternative explanatory proposals, and, ultimately, (3) define more precise standards for what count as *evidence* in research. We read in Dreyfus et al., for example, that although ‘the episodes selected for analysis are intended to be illustrative of what ontological blending looks like’ (p. 12), they nonetheless reach the conclusion that ‘this analysis yields evidence that speakers are blending the substance and location ontologies into a single mental space’ (p. 1). But, is there really evidence of that? Similarly, based also on a purely interpretive method, Close and Scherr affirm that they ‘demonstrate

that a particular blended learning space is especially productive in developing understanding of energy transfers and transformations' (p. 1). While the authors' assertions may not be incorrect, it is not clear, on empirical grounds, that their interpretations constitute evidence proper, or that they hold because of the reasons (or explanations) the authors provide. The 'Energy Theater' scenario of Close and Scherr, for instance, may be productive not because of the 'acting' blend of teachers–learners, but because of underlying attentional and motivational factors that could operate also on other, non-first person-driven blends, such as external impersonations using wooden toys. These may be questions that originate theoretically or from extended professional experience with teaching, but ultimately, they are empirical questions that could be answered by carefully designing studies that attempt to explain phenomena not only by confirming cases, but crucially, by excluding or *disconfirming* alternative explanatory possibilities. From this perspective, 'evidence' may not necessarily be constituted by a cherry-picked example that confirms the researchers' beliefs, but by an exhaustive analysis of cases through which alternative hypotheses, explanations, and interpretations are excluded. The papers analyzed here present two pairs of carefully picked episodes taken from large video databases. It would therefore be desirable that the analyses are conducted not just on two ad-hoc examples that confirm or illustrate the authors' opinions and impressions, but on a larger collection of episodes that might shed light on alternative explanatory proposals. Dreyfus et al., for example, overtly write 'our analysis of gestures is interpretive rather than following a systematic coding scheme . . . In lieu of that, we provide enough details in the data analysis so that readers can draw their conclusions and evaluate our gesture analysis' (p. 14). While the authors might be right that a systematic coding scheme may be unnecessary for their purposes, it is not the case that the readers can freely draw conclusions that might interpret the data differently, because they only have access to the two transcribed episodes picked by the authors and not to the rich video-recorded database where they might find alternative explanations to the reported phenomena. It is healthy for young fields of investigation, such as embodied cognition and conceptual mappings, to pass through an extended period describing phenomena in detail. Dreyfus et al.'s and Close and Scherr's papers give us excellent examples of subtle, perceptive, and insightful studies that investigate conceptual mappings, embodied cognition and gestures in the context of science education. But it is also important to consider the future of research in these areas. For that, in order to achieve maturity with respect to explanatory power and theory development, a field of research must go beyond purely descriptive approaches, and gradually incorporate empirical research methods that, seeking for causes and explanations, rigorously constrain the universe of potential interpretations (Núñez, 2012). The present special issue provides wonderful examples of nuanced and thoughtful high-quality descriptive studies in embodied cognition and conceptual mappings in science education. Now the time seems ripe for taking the empirical research in this domain to exciting new territories, using the very scientific method constitutive of the subject matter of *science* education.

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Note

1. Following a convention in cognitive linguistics, here I denote the name of a conceptual metaphor in small capitals, as in AFFECTION IS WARMTH, so it can be distinguished from specific linguistic instantiations—metaphorical expressions—such as *send her my warm hellos*, which I will denote in italics.

References

- Cienki, A. (1998). Metaphoric gestures and some of their relations to verbal metaphoric counterparts. In J.-P. Koenig (Ed.), *Discourse and cognition: Bridging the gap* (pp. 189–205). Stanford, CA: CSLI.
- Close, H. G., & Scherr, R. E. (2015). Enacting conceptual metaphor through blending: Learning activities embodying the substance metaphor for energy. *International Journal of Science Education*. doi:10.1080/09500693.2015.1025307
- Cook, A. (2007). Interplay: The method and potential of a cognitive scientific approach to theatre. *Theatre Journal*, 59(4), 579–594.
- Dreyfus, B. W., Gupta, A., & Redish, E. F. (2015). Applying conceptual blending to model coordinated use of multiple ontological metaphors. *International Journal of Science Education*. doi:10.1080/09500693.2015.1025306
- Edwards, L. D. (2009). Gestures and conceptual integration in mathematical talk. *Educational Studies in Mathematics*, 70(2), 127–141.
- Fauconnier, G., & Turner, M. (2002). *The way we think: Conceptual blending and the mind's hidden complexities*. New York: Basic Books.
- Gentner, D., & Wolff, P. (1997). Alignment in the processing of metaphor. *Journal of Memory and Language*, 37(3), 331–355.
- Gibbs Jr, R. W. (Ed.). (2008). *The Cambridge handbook of metaphor and thought*. Cambridge: Cambridge University Press.
- Grady, J. E. (1997). Theories are buildings revisited. *Cognitive Linguistics (includes Cognitive Linguistic Bibliography)*, 8(4), 267–290.
- Hrepic, Z., Zollman, D. A., & Rebello, N. S. (2010). Identifying students' mental models of sound propagation: The role of conceptual blending in understanding conceptual change. *Physical Review Special Topics-Physics Education Research*, 6(2), 020114.
- Joy, A., Sherry, J. F., & Deschenes, J. (2009). Conceptual blending in advertising. *Journal of business research*, 62(1), 39–49.
- Lakoff, G., & Johnson, M. (1980/2003). *Metaphors we live by*. Chicago: University of Chicago Press.
- Lakoff, G., & Núñez, R. E. (2000). *Where mathematics comes from: How the embodied mind brings mathematics into being*. New York: Basic books.
- McNeill, D. (Ed.). (2000). *Language and gesture* (Vol. 2). Cambridge: Cambridge University Press.
- Murphy, G. L. (1996). On metaphoric representation. *Cognition*, 60(2), 173–204.
- Núñez, R. (2012). On the science of embodied cognition in the 2010s: Research questions, appropriate reductionism, and testable explanations. *Journal of the Learning Sciences*, 21(2), 324–336.
- Núñez, R. E., Motz, B. A., & Teuscher, U. (2006). Time after time: The psychological reality of the ego-and time-reference-point distinction in metaphorical construals of time. *Metaphor and Symbol*, 21(3), 133–146.

- Núñez, R. E., & Sweetser, E. (2006). With the future behind them: Convergent evidence from Aymara language and gesture in the crosslinguistic comparison of spatial construals of time. *Cognitive Science*, 30(3), 401–450.
- Parrill, F., & Sweetser, E. (2004). What we mean by meaning: Conceptual integration in gesture analysis and transcription. *Gesture*, 4(2), 197–219.
- Pascual, E. (2008). Fictive interaction blends in everyday life and courtroom settings. In T. Oakley & A. Hougaard (Eds.), *Mental spaces in discourse and interaction* (pp. 79–108). Amsterdam: John Benjamins Publishing Company.
- Turner, M. (1998). *The literary mind: The origins of thought and language*. Oxford: Oxford University Press.
- Zandieh, M., Roh, K. H., & Knapp, J. (2014). Conceptual blending: Student reasoning when proving “conditional implies conditional” statements. *The Journal of Mathematical Behavior*, 33(March), 209–229.