FROM IMAGE SCHEMAS TO NARRATIVE STRUCTURES IN SCIENCE

A contribution to the Symposium on

Conceptual Metaphor and Embodied Cognition in Science Learning

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Abstract: Cognitive linguistics and the notion of an embodied mind tell us that human understanding and language make extensive use of figurative (imaginative, schematic) structures. Such structures range from the small-scale gestalts known as *image schemas* all the way to the large-scale structures of *story*, narrative, and history.

In this paper I will show how a pervasive medium-scale system—the *gestalt of forces of nature*—is structured in terms of image schemas and their metaphoric projections. This leads to the notion of agents (such as wind, water, earth, and fire) that are central elements of stories allowing us to give the phenomena in nature a narrative scientific form. These structures will be embedded in a feedback model of figurative structures ranging from small to large scales of experience.

Starting with a story about the character (agent) of cold holding a wintery town in its grip, I will identify a list of image schematic elements and show how their metaphoric projection leads to fleshing out of the character of the *force of cold*. This includes logical reasoning about what the agent is capable of. If care is taken to differentiate the aspects of the gestalt of a force in the course of education, we can hope to foster a solid understanding of natural phenomena in a child by using stories that can slowly evolve into more formal narratives.

The abstract structure of the gestalt of forces is a pervasive component of our conceptualization of *social, psychological, and natural forces* and forms the foundation of macroscopic physics. Therefore, the small to large-scale figurative structures used in a narrative approach to science for young learners are the same as those found in formal science. This observation allows me to claim that a science pedagogy based on figurative narrative structures of the human mind prepares learners for later formal education in the sciences.

Keywords: embodied mind, figurative structures, image schemas, metaphor, narrative, story, gestalt perception, forces of nature.

BACKGROUND AND OVERVIEW

In this paper, I will present models of embodied figurative structures of human engagement with and understanding of nature. These structures have been emerging during the construction of a novel dynamical theory of heat (Fuchs, 2010) and the development of a comprehensive primary school curriculum for Italy based on a narrative approach (Corni et al., 2012; Corni, 2013; Fuchs, 2011, 2013a).[1] To prepare us for a concrete case to talk about, I will briefly review a story written for children in early primary school in Section 3 and show some figurative elements it is made up of. Application of the ideas outlined in this paper to formal science is discussed in Fuchs (2013b).

The main model presented here is one of figurative schematic structures (*perceptual gestalts*) at different scales and their feedback interactions (see Sections 2 and 4). Such structures range from small-scale gestalts known as *image schemas* (Johnson, 1987; Hampe, 2005) and *force dynamic structures* (Talmy, 2000), to the medium-scale *gestalt of forces* (Fuchs, 2006, 2011), all the way to the large-scale structure of *story* and *narrative* (Mandler, 1984; Egan, 1986; Bruner, 1987) and beyond. The model (see Fig. 4 below) suggests how the process of *projection* (Turner, 1996) leads to metaphors (Lakoff and Johnson, 1980) and higher order schemas (i.e., systems of metaphors such as agent and story schemas) whose *inheritance* leads to fleshing out of the larger scale gestalts.

The interaction of structures at different scales explains the emergence of a narrative form of science as the conjunction of metaphoric projections of small-scale image schemas and the human propensity to see agents at work that are given a stage in stories and narratives. I will demonstrate how a pervasive medium-scale system—the *gestalt of forces of nature*[2] (Fuchs, 2006, 2011)—sits at the center of this figure building process of the human mind (Section 4). Forces lead to the notion of agents (such as wind, water, earth, and fire) that are active elements of stories and allow us to give the phenomena in nature and science a narrative form.

This point is important for science education. Research and development of narrative in science learning is largely confined to stories *about* science (the context of science, Klassen, 2006) and communication in the classroom (Kubli, 2001). In some limited cases—such as when we deal with singular and historical events in nature (i.e., evolution)—forms of narrative understanding may be useful for science itself (Norris et al., 2005). The products of science—models and theories—however, are not generally considered narrative structures even though a large body of research shows how scientists and children use metaphor and analogy to create and/or understand nature and science (Gentner and Gentner, 1983; Gentner et al., 1997). In the end, science and narrative are two different natural kinds (Bruner, 1987).

If we take the assumption of an embodied mind seriously, though, we should be able to see in what sense science itself makes use of figurative structures and is narrative at its core. Therefore, stories appear in a new light: they are instruments of good teaching and good learning in and *of* science (Section 5). The model discussed in this paper constitutes the beginning of a generalized theory of schematic and narrative forms of science useful for education.

AN OVERVIEW OF STRUCTURES AT DIFFERENT SCALES

Before I present and analyze a short Winter Story in the next section, I would like to briefly introduce the idea of *figurative structures of the human mind at different scales*. This is not necessarily self-evident since the structures I am speaking of are experiential gestalts—as such they are all fundamentally simple. Still, we know intuitively that our experiences happen at vastly different scales from the simple stumbling and regaining one's balance to the hugely rich experience of living through a winter storm.

One way to think of the embodied human mind is to call it a *schematizing agent*. When interacting with the environment, bodies with their brains create *schemas of vastly different scales*—from small to medium to large to very large. Our mind is adept at seeing different scales and creating hierarchies or networks from (sub-)structures. One such schema of schemas is the apparent hierarchy leading from *image schemas* through *forces* to *stories* and *collages (assemblies* or *groupings) of stories* (Fig. 1).

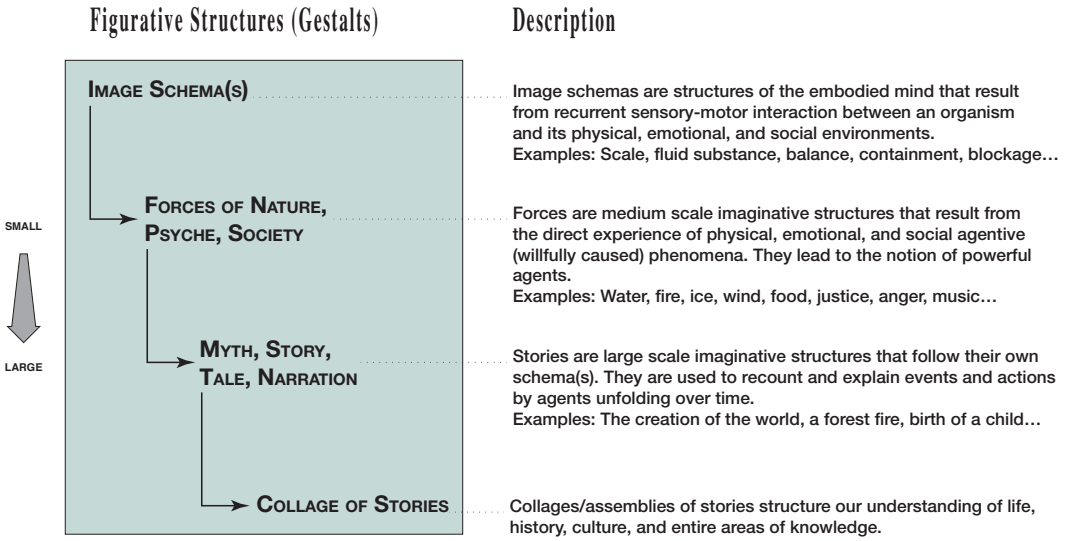

Figure 1. Representation of a hierarchical model of figurative structures of the human mind at various scales. Note that all entries refer to gestalts, not to particular entities (like a particular story).

We all know *stories* without having to define them. Actually, despite their importance as a figure of mind, and despite all the interest they have generated among educators, a detailed and general model of stories is missing. We know that stories have their own structure (we may speak of a *story schema* or a *narrative structure*; Mandler, 1984; Bruner, 1987; but note that story structure in western societies is quite different from that of Native Americans; St. Clair, 2003). Also, we count myths as examples of stories, but we still cannot quite agree upon the question of what myths are and what their origins and uses are (Kirk, 1970; Nixon, 2010). For our purpose here, let me consider *stories* the *explanatory narration of events and actions unfolding over time*—meaning the narration of relatively large-scale phenomena: this places stories toward the larger-scale end of the schema in Fig. 1.

Histories of an era or a people, or bodies of knowledge, are typically made up of a collection of stories of various nature and size—I call the corresponding experiential gestalt a *collage of stories*. In other words, history or other bodies of knowledge have their own schematic structure.

Stories are driven by *characters* or *agents* so we may look upon stories as made up of (a number of) interacting agents. The human mind sees *forces* at work—in the soul, in society, and in nature—and gives these forces the shape of powerful agents (Fuchs, 2006, 2011). In the scheme of Fig. 1, forces are included as medium-scale structures. They constitute some of the most important elements of stories.

Forces have their own structure. We will go into this in more detail below (see Section 4). In brief, much of the structure of forces of nature (or the psyche or society) is created by the metaphoric projection of *image schemas*. Put in different words, forces are conceptualized as groups (systems) of basic *conceptual metaphors*.

A WINTER STORY: NARRATIVE AND SCIENCE

To make the following discussion of models more practical and concrete, let me quickly recount a story that was written for children in early primary school (Fuchs, 2011). Winter approaches in the town of Little Hollow and we hear about what the *cold* of Winter does to nature, to the homes people live in, and to the people themselves—and how cold is finally driven out of Little Hollow by Spring.

If we analyze this story about the character (*agent*) of cold holding a wintery town in its grip, we can identify a list of *image schematic elements* and show how their *metaphoric projection* leads to fleshing out of the *character* or *agent of the force of cold* (Table 1). This includes logical reasoning about what the agent is capable of (figurative thought is the mother of formal logic).

There are three fundamental schemas that structure forces: *intensity*, *object* or (fluid) *substance*, and *power*. Intensity follows directly from a polarity—typically as the difference of two values along the scale of the polarity. Note that the SCALE schema is turned into a vertical scale (such as when the nominalizing concept of temperature emerges): the structuring of intensity is derived from the image schema of verticality (see Amin, 2001). OBJECT and SUBSTANCE are image schemas, and POWER is structured in terms of the gestalt of direct manipulation (Lakoff and Johnson, 1980) that includes the notion of agent, patient, and energy.

There are subsidiary schemas not listed here such as CONTAINER, PATH, BALANCE, PROCESS, LETTING, BLOCKING, RESISTING, FLOW, etc. that are used to build the logic in the relations between the basic schemas of *intensity*, *quantity*, and *power*. To give a couple of examples, quantities flow into and out of containers and are also stored there. More of the stored quantity will lead to a higher intensity of that quantity in the store. A flow of a quantity is driven by a difference of intensities and hindered by a resistance.

The logic of the gestalts of image schemas is transferred by *metaphoric projection* onto the desired targets: the agents of the forces of fluids, electricity, heat, motion, and substances. Since the different phenomena are structured in the same manner, they appear similar to the (conscious) mind and thus allow for the application of analogical reasoning in the form of structure mapping (Gentner, 1983; Fuchs, 2006).

Table 1

Metaphors for Cold in a Winter Story

METAPHORS	LINGUISTIC METAPHORIC EXPRESSIONS
(THE DEGREE OF) COLD IS A THERMAL LANDSCAPE	And it got colder and colder as the winter grew stronger. The temperature fell and fell. When it had become terribly cold and the temperature was very, very low…
COLD IS A (FLUID) (MOVING) SUBSTANCE/OBJECT	The cold found its way into the area and spread out. It could flow into the hollow… it could collect there… The cold could sneak in through tiny cracks between walls and windows…
COLD IS A POWERFUL AGENT (MOVING FORCE)	The cold of winter knew a good place where it could do its job of making everything and everybody cold… It went into the snow lying on the ground to make it very cold as well and this made the snow drier and harder to work with. The fires in the furnaces had to work very hard to fight the cold.

Note that there is a larger-scale schematic structure in the story—namely, the *story schema* that introduces the notion of events unfolding over time. It gives stories their distinctive form and character. It is clearly present in the Winter Story.

GENERATION OF NARRATIVES OF FORCES OF NATURE

In the hierarchical schema of figurative structures in Fig. 1, there are at least two steps to be taken from image schemas to narrative. These steps are more like interactions—influences going both ways—creating feedback structures. Some of these interactions will be fleshed out in this section.

From Image Schemas to Forces of Nature

In Section 3, we saw important elements of the interaction between image schemas and the gestalt of a force. Details discussed there are represented graphically in Fig. 2. Metaphoric projection leads to a process of *gestalt structuring* (Taverniers, 2002)—namely, the structuring of the gestalt of the force of cold in terms of metaphors[3] such as the DEGREE OF COLD IS A VERTICAL SCALE (or more generally, a thermal landscape), COLD IS A FLUID SUBSTANCE, COLD IS A POWERFUL AGENT, etc.. These metaphors result from the metaphoric projection of image schemas onto aspects of the gestalt of a force.

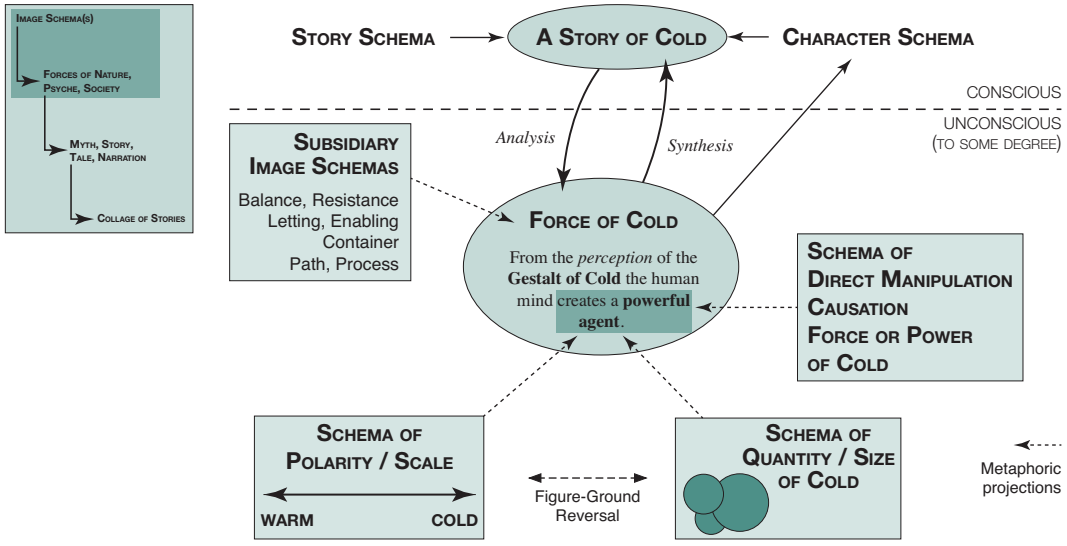

Figure 2. Metaphoric projection of the schemas of polarity (scale), quantity or size, force, etc., leads to the structuring (conceptualizing) of the gestalt of a force. Note that the schemas of scale and of quantity are related by a figure-ground reversal process. Stories are fleshed-out narratives of one or several forces interacting and leading to events and action. While stories have their own overall story-schema, the schema of characters created by the gestalt structuring of forces gives them life.

From Forces to Stories to Forces

To arrive at stories from image schemas, a second interaction between levels is required, this time between forces and stories (Fig. 3). The simple answer as to the nature of the relationship between these levels is this: Since stories are explanatory narratives of events unfolding over time and leading to change, we see them made up of agents which cause these events and changes. Put differently, stories not only have a story-schema, they are also structured in terms of the nature of agents that follow their own character schema.

This answer is too simple because it explains the relationship between forces (agents) and stories as a unidirectional building of the larger-scale from the smaller-scale structure. It appears quite reasonable, however, to assume that there is a feedback—that the perception (hearing, reading) of a story influences the perception of forces (of nature, society, or the psyche). The act of perception of forces through stories rather than directly in an organism interacting with its environment, enlists additional image schemas for metaphoric projection such as SOURCE-PATH-GOAL, PROCESS, or CYCLE.[4] These influences upon our conceptualizing of forces were not included in Fig. 2. Including them now in Fig. 3 leads to a better understanding of an even richer gestalt of forces than was evident before.

Moreover, as shown on the left of Fig. 3, the story schema enlists image schemas for its own structure. This means we are confronted with a projection spanning two levels in the model of structures at different scales (Fig. 1).

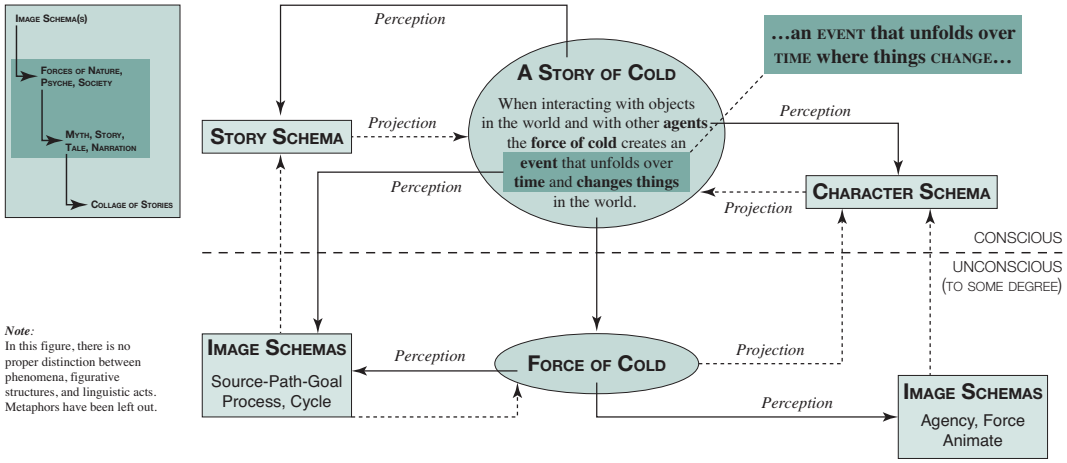

Figure 3. A story is defined as the narration of an event that unfolds over time and leads to change. The interaction between forces (agents, characters) and stories reveals the importance of feedbacks: larger-scale structures are not just assembled from smaller building blocks; they give the smaller-scale elements their character through the process of perceptual analysis that enlists suitable (image) schemas.

The feedback-cycle from story to force and back to story describes an act of learning through stories and is an important element of education. The dividing line in Figs. 2 and 3 between the level of forces and that of story (which I labeled *conscious/unconscious*) obtains new meaning in that it shows what the human mind adds to what animals are capable of. Animals certainly experience forces of nature, emotion, and social structures, they form image schemas, but these structures—fundamentally important for living in a world—remain largely unconscious. Stories and collages (assemblies/groupings) of stories are structures added by humans who enlist the power of language. It seems reasonable to assume that language and the building of the larger scale figurative structures in Fig. 1 accompany the development of consciousness that must feed back onto the structures existing before.

A Feedback Model of Structures at Different Levels

I can now give a more detailed picture of the schema of imaginative structures at different scales introduced in Fig. 1 (see Fig. 4). We understand at least some of the details of the relationships between scales: we know that the relations are bi-directional in general, leading to feedback structures. We recognize the importance of the gestalts of stories and forces lying between small-scale schematic structures such as image schemas and large-scale phenomena such as (structured) collages of stories.

In Fig. 4, the central box represents structures of the human mind. Note that it is sandwiched between two external worlds: the world of *phenomena* created by nature (including our bodies), social groups, and our psyche; and the world consisting of our *linguistic acts* (spoken and written). Our mind interacts with these worlds. The interaction constitutes feedback cycles: we act (create linguistic acts and manipulate the world of phenomena), and the world feeds back upon us through perceptual analysis.

Let us consider an example by starting at the point where a child hears a Winter Story being told (Story/Myth in the third column of Fig. 4). This story follows a schema, speaks of agents, and contains metaphors. Therefore, it activates these elements in the mind of the child. The child already recognizes the gestalts of story and forces because she has lived through events and has been subject to forces; maybe she has just experienced a winter day outside. Furthermore, the child has access to image schemas that formed through small-scale sensorimotor interactions with the world, so she understands metaphoric expressions such as "The cold could sneak in through tiny cracks between walls and windows…" even if she has never thought about it before in these terms.[5] Through these metaphors, the gestalt of cold is fleshed out—the child knows first hand or learns through the story that cold is a powerful agent (the story creates an instance of a phenomenon that can be experienced like a phenomenon in the outside world). This understanding of the nature of agents fleshes out the gestalt of stories and finally, the child becomes able to tell her own version of a Winter Story.

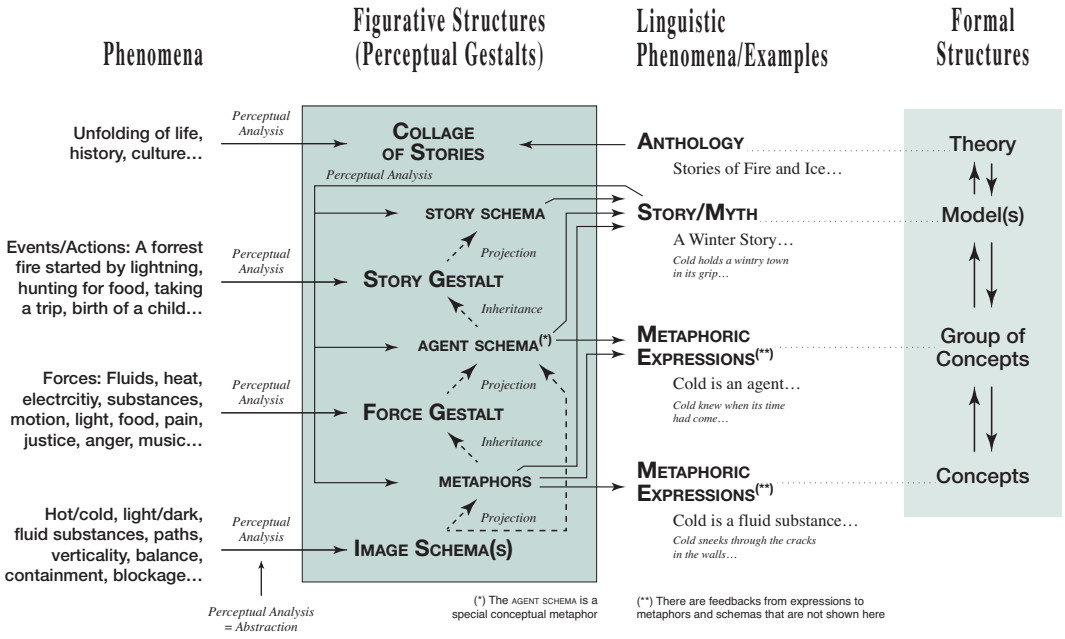

Figure 4. A feedback model of figurative structures at different scales. The elements in the main box denote gestalts, and arrows symbolize relationships and processes (such as projection as in metaphoric projection of image schemas; not all possible relations are contained in the figure). The contents of the box represent a model of the human mind. Note that the mind is interacting both with a material world (*Phenomena* on the left) and the products of language (*Linguistic Acts* on the right). It appears that we can associate different types of phenomena (and their perception) with the formation of the figurative structures at small to large scales. In science, concepts, models, and theories correspond to metaphoric expressions, stories, and anthologies, respectively.

The main result of this model is that there is a dynamic (feed-back) relation between forces and stories (via the worlds of phenomena and linguistic products) central to how

the human mind works. This cycle has much to do with learning and its details can inform us about instructional processes not only in the humanities but also in the sciences—after all, many of the forces we perceive are forces of nature. If we look upon science as humans learning to understand forces, we can use the current model for structuring science pedagogy.

A NARRATIVE APPROACH TO SCIENCE PEDAGOGY

Note that we can create a correspondence between metaphoric expressions and *concepts*, stories and *models*, and collage or assembly of stories and *theory*, respectively (column on the right in Fig. 4). If we accept a model of an embodied mind we can argue that this correspondence goes deeper than an analogy: a concept, for examples, is not just the analogue of a metaphoric expression in the schema of Fig. 4, it is *constituted by the metaphor*. The same holds for models which *are* stories structured in terms of metaphors and agent schemas (concepts and systems of concepts) detailing events and processes unfolding over time.

This means that *science content is figurative* in general and narrative in particular (for a technical example, see a discussion of the narrative structure of continuum thermodynamics, Fuchs, 2013c). We can create good science content in story-form and use it to educate teachers who in turn become good narrators of forces of nature (Corni et al., 2013). As I have stressed before, narrative understanding in science need not be restricted to affective aspects (context of science) or the history of nature—science is narrative at its core.

It is certainly true that models in science contain elements and procedures we would not find in a corresponding story for a child. There are aspects such as collecting and listing of rich detail about the physical world, measuring and graphing, and enlisting formal languages (mathematics) that a child has to learn if she wants to go on with her education in the sciences. In particular, she may learn how to express the stories of forces and events (the models) in mathematical language.

However, this does not change what I have said in the previous paragraphs. It simply means that there is more to science than the figurative explanatory structures that can be told in natural language. These elements can be added to one's repertoire in due time. If we have learned about processes in nature through explanatory stories making use of our basic forms of thought, our further education will be based upon a solid foundation of human understanding that integrates body and mind.

SUMMARY

In this paper, I have outlined a model of figurative/imaginative/embodied gestalt-structures that explains important aspects of the relationship between image schemas (as used by cognitive linguists) and narrative. Most importantly, it shows that scientific structures (especially models) have a narrative character created by the perception of the gestalts of stories and forces of nature.

Looking at human understanding of nature in this manner brings us closer to a narrative form of science. The elements of narrative—contrary to the traditional view (Bruner, 1987)—are not foreign to both qualitative and formal scientific understanding (Fuchs,

2012, 2013c). Story goes much further in science than has been assumed in previous studies (Kubli, 2001; Klassen, 2006; Norris et al., 2005). The basic structure of forces of nature is a central element of stories (in the form of agents created by the perception of forces). While a typical story for young children builds mainly on elements supporting affective meaning—structured by the *story schema*—agents representing forces are already present. These agents create a *character schema* or *agent schema* in parallel to the classical story schema. In the course of education, the character schema is formalized until stories have evolved into more formal narratives, i.e., models (Fuchs, 2013b).

The abstract structure of the gestalt of forces is a pervasive component of our conceptualization of social, psychological, and natural forces and forms the foundation of macroscopic physics (Fuchs, 2010). Therefore, the small to large-scale figurative structures used in a narrative approach to science for young learners are the same as those found in formal science. This observation leads me to claim that a science pedagogy based on figurative narrative structures of the human mind prepares learners for later formal education in the sciences (Fuchs, 2012) and it helps teachers to appreciate their own understanding of science and become confident writers and narrators of stories of forces of nature (Corni et al., 2012).

NOTES

1. Theories of cognitive linguistics and of narrative have been used to lay bare the figurative cognitive structures found in science (Fuchs, 2006, 2007, 2013). Cognitive linguistics and the notion of an embodied mind inform us that human understanding and language are based on figurative structures (Lakoff and Johnson, 1999; Evans and Green, 2005; Tucker, 2007). If we take the current science of the human mind seriously, we arrive at a new understanding of human sense making. Science and science learning attain a novel character: science is not the representation of truths independent of mind but rather is a result of the growth and differentiation of imaginative structures that originate in the child and in the childhood of humanity in oral mythic cultures (Fuchs, 2012).
2. Note that I use the term *force* not in the sense of mechanics proper but in its primitive sense of phenomena that are endowed with power. Heat, wind, justice, language, pain, love, electricity, music, the market, etc. are forces or powers in this sense (music has been described as, but not named, a *force* by Johnson (2007, Chapter 11)). Macroscopic physical science grows from the notion of *forces of nature* (Fuchs, 2010).
3. When speaking of metaphors (at least in the conceptual metaphor theory of cognitive linguistics), it is important to distinguish between three different uses of the word *metaphor*: (1) Special *linguistic metaphoric expressions* (such as those found in the right column of Table 1), (2) *metaphors* proper (left column in Table 1) which constitute a conceptual structure (a gestalt), and (3) *metaphor* as the process of metaphoric projection (from a source to a target domain), i.e., a gestalt-structuring process that creates a metaphor according to the second (proper) sense.

4. Note that the image schemas PROCESS and CYCLE are directly related to the dual concept of time as directional or cyclic known for example from ancient Egypt or from North American natives.
5. In the story, the child hears concrete examples of metaphoric expressions. This experience together with the ability of projecting image schemas leads to the creation of a conceptual metaphor such as COLD IS A FLUID SUBSTANCE in the mind of the child.

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