
Force Dynamic Gestalt, Metaphor, and Scientific Thought

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Natural science as taught in schools is difficult and formal and we commonly assume that the best a child can achieve is some superficial learning. As a consequence, we either do not teach any science worth that name in primary and secondary school, or we create simplified formal representations which a young person has no chance but to try to master by rote learning. By the time we reach adolescence or young adulthood, most of us have an understanding of natural processes ranging from very shaky to completely useless and our view of science learning has forever been tarnished.

I want to argue that science teaching and learning can follow a different model starting in early education. I want to show that humans possess a form of abstract thought that develops early in childhood and that is more than adequate for deep understanding of the world around us. This form of thought can be used to produce formal science.

At its core, our mind is narrative. We use abstract schemas and their metaphoric projections to create a sophisticated account of the world and how it operates. An important structure that can be found in human conceptualizations of social, psychological, and natural phenomena alike, is what I call the Force Dynamic Gestalt. We perceive a wide range of phenomena as wholes (gestalts) and then employ the schemas of (fluid) substance or quantity, intensity or quality, and power or force to introduce aspects and make sense of the underlying phenomena.

In this talk, I wish to formulate and defend the following hypotheses: (1) good learning about the world around us happens when we achieve a clear differentiation of quantity, intensity, and power of a phenomenon and understand their mutual relations; (2) we can help children learn and master this differentiation by strengthening their narrative skills.

The talk will be divided into four parts. First, I will tell a short story of winter that might be appropriate for small children. This story introduces the Force Dynamic Gestalt of cold which motivates the search for further examples of the FDG in Part 2. A more formal discussion of figurative structures of human thought will then be presented. It shows the elements an FDG consists of and it demonstrates the origin of a form of analogical reasoning in the physical sciences. In Part 4, I will summarize the observations and defend the idea that learning good narrative structures to talk about nature leads to good scientific reasoning.

1 A WINTER STORY

Stories are the largest scale figurative structures of the human mind. Much has been said, done, and researched in this field (Mandler, 1984; Dautenhahn, 2002). The importance of stories as a mode of thought different from scientific reasoning has been stressed (Bruner, 1989). Lately, however, it has become clear that narratives may serve as the vehicle not only of tales of human affairs but also of our understanding of nature (Corni, Giliberti, and Mariani, 2010).

In my view, stories weave together two basic schematic structures: the episodic (or temporal) form of a good story (Mandler, 1984) and the particular figurative (embodied) structures exhibited by the characters in the story (Fuchs, 2007). The former is well known and is sometimes called the story schema. The latter seems to be mentioned rarely as a constitutive element of narratives (however, see Egan, 1988, for a discussion of structures of thought in stories known from the oral tradition). The reason for this may be that, in contrast to a relatively simple story schema that allows a generic form or story line to be developed (Mandler, 1984), the characters and their actions are thought to be so many and so rich and varied that countless special contents can be created whose schematic structures are not readily apparent. However, all the work on schematic structures in cognitive linguistics points to the fact that a relatively simple architecture underlies this richness. I would like to speak of a *character schema* which the protagonists of stories have to follow. Note already that the character schema will itself be composed of smaller schemas, i.e., the schematic structures identified in linguistics and cognitive science in general, and the figurative structure I call Force Dynamic Gestalt in particular.

Here is a sketch of a story of the cold of winter that should be appropriate for small children. I want to tell it so you become aware of elements of thought that are important when we need to understand how the world works in detail—when what the characters of a story are capable of is as important as the story line. So the protagonist of this story is the cold of winter, a figure that exhibits a few basic forms which we will find again and again in many other figures as well.

A Winter Story

A small town called Little Hollow lay in a hollow surrounded by a high plain. People had settled in that place because small streams collected on the plain and flowed down into the hollow and through their town as a nice little river. This the people of Little Hollow liked a lot. But there was something they liked a lot less: Winters in Little Hollow were harsh.

As the last of the warmth of late Fall left the plain surrounding Little Hollow, cold found its way into the area and spread out. Because the plain was so wide, the cold of winter had to spread pretty thinly, so it was not all that cold up there. Moreover, even in the midst of winter, the Sun managed to send some warming rays onto the plain. The snow that fell on the plain was not so cold either, but it was plenty, and the people of Little Hollow loved to go up to the plain for cross country skiing. The little kids went there to build beautiful snowmen.

But in Little Hollow, things were different. The cold of winter knew a good place where it could do its job of making everything and everybody cold much more easily. It could flow into the hollow where the town had been built. It could collect there and it knew it would not be driven out so easily by a little bit of wind as could hap-

pen on the plain. And the Sun could not reach the town that easily, also because of fog that often lay over Little Hollow and made everything gray. More and more cold could collect in Little Hollow, and it got colder and colder as the winter grew stronger. The temperature fell and fell.

The people of Little Hollow cursed winter and its cold. They knew that the cold would find its way into their homes if they were not careful to close windows and doors. The cold could even sneak in through tiny cracks between walls and windows, so the people had learned to build their homes well to make it hard for cold to flow in. Still, without the sophisticated and strong heaters in their homes, people knew they could never survive winter. At times when much cold had collected in their town, when it had become terribly cold and the temperature was very, very low, the fires in the furnaces had to work very hard to fight the cold. The people in their homes made sure that the heat produced by the furnaces would always balance the cold so that their homes felt comfortably warm.

For the children of Little Hollow, the cold of winter was not so bad. They dressed warmly so their body heat would be conserved, and played hard when they were outside. But even for them, the thick cold of winter had mischief in mind. 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 children could not form snowballs, and it was much more difficult to build snowmen. They had to wait until winter had grown somewhat tired, and the cold was slowly driven out of Little Hollow. When there was less cold and the temperature was a little higher, the snow became warmer and much more fun to play with.

When that happened the cold of winter knew its time had come. The warmth of early Spring would grow stronger and drive the cold out of the hollow. The cold knew it had to accept its defeat but it also knew very well it would be back...

This story might serve as a first example for small children. In the course of education, the number and sophistication of such narratives need to increase. As children get older, they should be able to make more and deeper use of the stories (tell and write their own stories, identify elements, describe their understanding of the characters, etc.). From a purely scientific viewpoint, the present story needs clarifications. In particular, older children will become able to understand that we do not need two concepts (characters), namely heat and cold, to understand thermal processes; one of them—heat—suffices. Children should learn to rewrite the present narrative in these new terms.

As mentioned before, the story integrates two parallel structures. First, there is the episodic structure identified in studies of story grammar (Mandler, 1984). Second, the characters in the

story (heat and cold) behave in a way we might readily call “natural.” This naturalness of the behavior is exhibited by the figurative structures found in human thought. Some of these embodied forms will now be investigated.

2 FORCE DYNAMIC GESTALT: THREE EXAMPLES

It has become a well established idea that humans initially perceive their world as simple wholes, so called gestalts. Perception is an active and creative process, not a passive receptive one. The act of perception is one of abstraction (see for example Arnheim, 1969), products of perception are abstractions (gestalts, patterns, configurations) where the whole is simpler than the sum of its parts. In acts of thinking and speaking, we endow the gestalts with aspects which makes them rich constructs and allows us to deal productively with what they originally stand for. To give an example, we all know when we have an experience of justice (or injustice)—we do not really need to describe it to know it. However, in human society, the gestalt of justice is differentiated into many aspects leading to a rich, complex concept that structures our understanding of justice and the justice system.

The following observation is at the heart of my argument. Gestalts of phenomena that have the potential to become rich concepts appear to be differentiated with the help of a few basic schematic structures (Talmy, 2000, Johnson 1987, 2007, Lakoff 1987, Hampe 2005), and the same schemas are applied to vastly different realms of experience. First among the schematic structures that are used recurrently are *quantity* or *size*, *quality* or *intensity*, and *power* or *force* (Fuchs 2006, 2007). The schemas identified by Talmy (2000) in his theory of Force Dynamics should be added to the list of structures that make up the language of causation associated with a phenomenon. To sum up these observations, I have proposed the concept of *Force Dynamic Gestalt* to be applied to a number of important phenomena ranging from psychological to social to natural (Fuchs 2007). Let us see how these structures show up in the language we use to describe the phenomena of food, justice, and heat.

Food. Food is not just a substance, a stuff; rather, it is an example of an important phenomenon for an animal. I have chosen it because the way we speak about food is so well-known and ubiquitous that I am sure I do not have to convince you of the following. We speak of food in terms of quantity and quality, and we know that food has many effects for an animal—it has force or power over its well-being. Food can be produced, destroyed, transported, stored. Differences in quality lead to important consequences, we need to balance our food intake, etc. etc. And the idea that a combination of quantity and quality of food is responsible for its power, its influence for our health, is certainly not far-fetched. I have listed a number of expressions having to do with food in the Appendix.

Justice. We are likely to consider justice an abstract concept compared to the phenomenon of food. Still, we use the same structures to speak about—and probably also think about—justice as we do in the case of food. We structure the gestalt of justice (and injustice) in terms of quantity, quality or intensity, and power (again, I have listed a number of common expressions in the Appendix). In addition, schemas of balance, container, letting and hindering, etc. appear in our expressions. Note that the concept of justice is a polarity—there is a polarity between justice and injustice.

Heat. Common every-day language concerning the phenomenon of heat testifies to the fact that we think of heat (and cold) in terms of quantity, intensity, and power. Expressions such as “there is a lot of heat in this place”, “the cold was intense this winter”, “the fire was so strong that it destroyed the home”, are clearly common. We allow heat to flow, hinder cold to come in, balance heat between different bodies, and use heat to drive engines. Again, the idea that a combination of quantity and intensity of heat is responsible for the magnitude of its effects is anything but far-fetched (Carnot, 1824; Fuchs, 2010a,b). As in the case of justice we deal here with a polarity, this time between heat and cold.

3 SCHEMATIC STRUCTURES, METAPHORS, AND ANALOGY

Modern cognitive science in general, and cognitive linguistics in particular, provide us with a theoretical background for the meaning of what we have observed in the examples of food, justice, and heat discussed in Section 1. In much of recent cognitive science it has been assumed that the mind is embodied (Lakoff and Johnson, 1999; Johnson, 1987, 2007; Tucker, 2007; Chemero, 2009) and language and understanding must be figurative. In this section, I will briefly list some figurative structures of the human mind and show how they let us understand the roots of theories physical processes. More details of the application of cognitive linguistics to physics can be found in Fuchs (2007).

Image schemas and other schematic structures. An individual creates abstract embodied mental structures, so-called image schemas, through recurrent interaction with the environment (Johnson, 1987; Lakoff, 1987; Hampe, 2005). The list of image schemas includes (fluid) substance, container, path, scale, verticality, balance, and many more. Image schemas are gestalts or non-propositional forms having enough internal structure for creating rich meaning. They are applied to a target field by metaphoric projection (see below). Another important schematic structure is the gestalt of direct manipulation introduced by Lakoff and Johnson (1980) which can be understood as the basis of our causal reasoning.

Metaphoric projection. Cognitive linguistics introduced the notion of conceptual metaphors. Metaphors are projections of (the structure of) a source domain onto a target domain. A meta-

phor is a mental structure that commonly leads to many possible linguistic expressions (a single expression such as “His theory is well founded” is not itself a metaphor; the example given here would be a linguistic expression for the conceptual metaphor A THEORY IS A BUILDING). It is assumed that metaphors reveal structures of the human mind.

Some of the simplest metaphors are created when image schemas are projected onto targets. For example, the expression “The temperature has been rising” originates from the projection of the schema of verticality onto the perception of hot and cold. An expression such as “Momentum is transferred in this collision” reveals that we project the schema of fluid substance onto phenomena of motion.

Structuring of the Force Dynamic Gestalt. It appears that the schemas of (fluid) substance and verticality (or alternatively, the scale schema) and the gestalt of direct manipulation are projected onto phenomena such as fluids, heat, electricity, chemical processes, or motion (see Figure 1). The schema of fluid substance is employed to give metaphoric sense to the aspect of quantity of the FDG of a phenomenon, whereas the schema of verticality is used to structure our understanding of the aspect of intensity. The gestalt of direct manipulation, and all its elements that underlie our notions of causation, can be turned into the concept of energy in physical processes (Fuchs, 2007, 2010a).

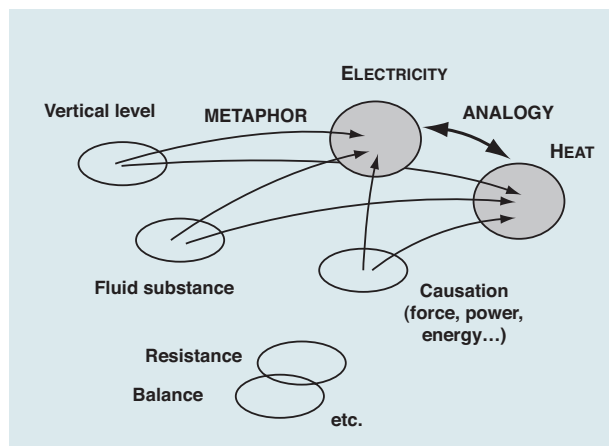


Figure 1: Applying the same FDG with its metaphoric projections to different physical phenomena leads to analogical structures (the metaphoric structure of one subject can be mapped upon another field).

Analogy. When, as in the examples of physical processes, different phenomena are structured with the help of the same projections, i.e., if they all are perceived as a Force Dynamic Gestalt, they become similar to the human mind. There is no objective similarity between electricity and

heat, for example, but our mind makes them similar. This similarity is then used to create analogical structures (Figure 1; Fuchs, 2010a). The use of analogy rests upon structure mapping (Gentner, 1983) from one field to another. This is a conscious two-way processes in contrast to metaphoric projection which is a largely unconscious phenomenon and is a unidirectional mapping.

4 SPEAKING AND WRITING WELL ABOUT NATURE

The winter story outlined above in Part 1 will no doubt be criticized as bad formal science by physicists and engineers. They may grant us the right to speak about cold and heat in this form to little children, but it is just as clear to them that a true and correct science of heat will have to take a completely different form conceptually, structurally, and formally.

There are indeed aspects of the story that will change when it is made into theory of heat. Most importantly, we will learn that we do not need two concepts—those of heat and cold—to understand thermal phenomena, one is enough. Interestingly, though, the bulk of the conceptual structure will not change at all. Today, we construct a formal science of the dynamics of heat on the basis of the concepts that underlie the Force Dynamic Gestalt of heat: quantity, intensity, and power, and the associated schematic structures of containment, flow, letting, hindering, forcing, balancing, etc. (Fuchs 1996, 2010b).

So, here is my thesis: Learning about the Force Dynamic Gestalt of natural processes will lead to good science. Indeed, not being able to distinguish between quantity and intensity of heat, or between quantity or intensity and power, leads to bad science (Fuchs 2010b, Introduction).

If we wish good (physical) science to take place in school, we can help children create an awareness of the structure of our concepts of natural processes early on by developing their power of using good language and good qualitative thinking. An important tool in this process will be narratives that incorporate the elements of the Force Dynamic Gestalt of natural, social, and psychological phenomena alike. Interestingly, this may lead of a pedagogy that unites rather than divides the humanities and the sciences. Speaking and writing well about natural phenomena will be the first step toward a useful conceptualization of the processes of nature. As I have tried to make clear, the concepts we use to understand nature are not singular and specialized, they are the same we use in other fields of human experience.

The narratives should begin as good stories and should incorporate more formal structures only very slowly and deliberately. This will most likely be a long process lasting over a period of many years for a child, but the effort should be worthwhile. Forcing the process to proceed faster may in the end do more harm than good.

Development of the human mind. In this talk I have almost completely left out an important

aspect of the pedagogy which I am advocating here: the development of the mind of the growing child. I have concentrated on structures that develop very early in an individual (and are old in terms of human history; see Egan, 1988, 1997, and Donald 1991 on mythic culture and mythic thinking). Naturally, these structures are the foundation of what is to follow, and they should stay with the growing child, but they are not enough to ensure proper development later on. According to Egan (1997) we should be mindful of what he calls the romantic and philosophic (formal, theoretic) phases of development. Only the latter of these introduces forms of thought which we commonly associate with formal science. The former is instrumental in developing a sense of the reality and diversity of the outside world alongside with the cognitive tools of early literacy. If we do not allow this phase to develop properly, we forgo an opportunity to build another important foundation of our understanding of the world.

If we force too many of the elements of formal science into early education, we make a fundamental mistake, leaving behind fragmented minds. We will never build mature personalities whose reasoning power has been allowed to put down roots in the soil from which the human mind grew.

Notes

There is a physics course that basically uses the conceptualization described here as Force Dynamic Gestalt and its aspects. This is the *Karlsruhe Physics Course* (Herrmann, 2010) for middle school and high school. Already in its middle school form, it uses a relatively formal representation, so it needs translating to the narrative form advocated here for the very young learners.

Another course concept is worth mentioning: the curriculum called *Energy and Change* (Boohan and Ogborn, 1996) picks as its central theme the notion of differences that cause change. It uses some aspects of the ideas discussed here and is fairly informal, but it has not been worked out in great detail.

A slightly different approach to the idea of schematic structures in children's thought has been described by Joan Bliss. She identifies physical reasoning schemes such as movement, action/force/effort, container, carrier, support, fall, barrier, resistance, space, flow, break/not break, rigidity, stretch/squash and balance. Obviously, they bear some semblance to image schemas.

Analogical reasoning, especially as used by children, can be more spontaneous as the form discussed here in Part 3. This may be an important aspect of thinking worth a deeper investigation (see the thesis by Atkins, 2004).

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APPENDIX

I have collected a number of short expressions and sentences concerning how we speak about food or justice from the Internet. They show the schemas used. In particular, they demonstrate that the aspects of the Force Dynamic Gestalt are always present.

Food

- (1) The problem is not that there is too little food. The problem is the way in that food is distributed.
- (2) Does food stored in a metal container poison you?
- (3) Transporting food into the city from often distant locations...
- (4) The crops are destroyed, and all our stored food is destroyed.
- (5) Quantity and quality of food had a significant effect on body growth rate.
- (6) Wildlife space requirements vary by species, but generally, the amount of space required is determined by the quantity and quality of food...
- (7) Job growth will stem primarily from efforts to increase the quantity and quality of food produced for a growing population.
- (8) That poor quality of food leads to the problem of constant or chronic inflammation.
- (9) The lack of physical activity combined with the poor quality of food leads to obesity.
- (10) This big gap between rearing experiments and field observations seems to be caused by the difference of quality of food.
- (11) I knew that if I were to maintain a balance between good and bad food...
- (12) In many regions it will become harder to produce food
- (13) By letting food grow in its natural setting...
- (14) We learn about a certain Malthusian theory, which states that the quantity of food grows slowly.
- (15) Fast food makes people impatient.
- (16) It is proposed that the power of food lies in its material and symbolic functions.
- (17) Let your food be your medicine.
- (18) How to use the healing power of food to reverse the effects of years of diets.
- (19) Tell us how good food leads to a good life.

Justice

- (1) I don't think there is much justice in the world.
- (2) The source of justice.
- (3) Justice denied anywhere diminishes justice everywhere. (Martin Luther King, Jr.)
- (4) The quality of justice in capital cases.
- (5) Harsh justice puts lives in the balance.
- (6) The weak justice system led to a climate of insecurity.
- (7) I have always found that mercy bears richer fruits than strict justice. (A. Lincoln)
- (8) The healing power of justice.
- (9) Justice compels us to help this state find a way to serve all its people...
- (10) Hence justice hinders theft of another's property.
- (11) Create a terrible imbalance in our criminal justice system...
- (12) Justice is a proper, harmonious relationship between the warring parts of a person.
- (13) How to distinguish justice from injustice in our characters.
- (14) What justice and the reality of injustice demand of us.
- (15) He got the justice he deserved.
- (16) With this move we are coming closer to true justice.