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Jacek Woźny
University of Wrocław

The Prototype of the Linguistic Force Dynamics Schema

1. Introduction – force dynamics in cognitive linguistics

The notion of force dynamics is eminently present on the pre-conceptual, conceptual and linguistic level. In the following quotation Leonard Talmy wonders at the long absence of force dynamics in linguistic studies:

> In a way, it is remarkable that the semantic category of force dynamics had escaped notice until the present line of work, given the attention to concepts of force outside linguistics as well as their pervasiveness within language. Once recognized, however, it is widely evident and in fact must be acknowledged as one of the preeminent conceptual organizing categories in language. ... the linguistic force-dynamic system operates in a common way over the physical, psychological, social, inferential, discourse, and mental-model domains of reference and conception. (2000: 461)

Following L. Talmy's insight, the key importance of force dynamics has been recognized by all the leading cognitive linguists, including Mark Johnson (1987), Eve Sweetser (1990), Ronald Langacker (1999), George Lakoff (1990), and many others. Paul Deane stresses the psychological plausibility (one of the key notions in cognitive linguistics) of Talmy's theory of force dynamics:

> from a cognitive perspective, Talmy's theory is a striking example of a psychologically plausible theory of causation. Its key elements are such concepts as the (amount of) force exerted by an entity, the balance between two such forces, and the force vector which results from their interaction. Such concepts have an obvious base in ordinary motor activities: the brain must be able to calculate the force vector produced by muscular exertion, and calculate the probable outcome when that force is exerted against an object in the outside world. (1996: 56)

Force dynamics deserves to be thought of as one of the key schematic systems for a number of reasons. First of all, it serves as a generalization of the notion of the causative, allowing us to replace it with finer distinctions like letting, hindering, helping, obstructing, etc. (Talmy 2000: 409). Secondly, force dynamics organizes not only the closed-class elements but open-class elements as well, establishing clear-cut connections among them. Those lexical items refer not only to the exertion of physical force but, extended metaphorically, they may describe social and psychological interactions. Finally, and perhaps most importantly, force dynamics has its closed-class or 'grammar' representation among prepositions, conjunctions and, crucially for the present article, among the modals.

Leonard Talmy (2000: 466) proposed several constraints on the force dynamics, thus creating a model which he calls *the prototype of force dynamics* (cf. section 4). The main goal of this article is to verify this model. To this aim, a group of sentences containing 'root' ('non-epistemic') modal verbs (Mark Johnson 1987: 50), randomly chosen from the British National Corpus, were analyzed. The following sections present the method and the results of this analysis.

2. Forces and modal verbs

As it has been already pointed up above, forces play an important role on both linguistic and conceptual levels. The pre-conceptual *image schemas* (Johnson 1987: 45) of compulsion, removal of restraint and enablement, represented by the modal verbs *must*, *may* and *can*, could not be defined without applying the notion of force.

Must denotes a force (F) acting on an object at the moment of speaking. There may be other forces opposing F but if their sum is smaller than F then the movement in the direction of F will take place.

Figure 1. The compulsion schema

May indicates lowering of a barrier. There is a force but it is applied to the barrier and not to the subject of *may*.

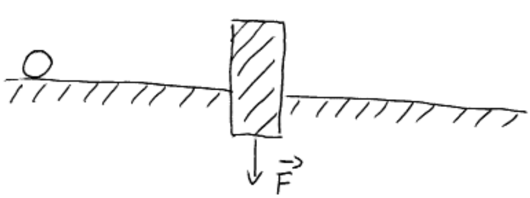


Figure 2. The removal of restraint schema

Can refers to a potential (possible in the future) force able to overcome a barrier. In contrast with *may*, the force acts on the subject of *can* and the barrier does not move.

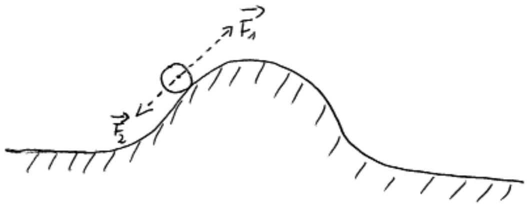


Figure 3. The enablement schema

Eve Sweetser (1990: 53) explains the force dynamics of *may* and *can* very clearly and convincingly by likening them to an open garage door and a full petrol tank, respectively.

3. Linguistic calculus – how to measure forces in random sentences?

The verification of Talmy's restrictive and precise physical constraints requires a method of gauging forces because the force-dynamic interactions expressed by modal verbs can fall into so many varieties, like for example "physical, parental, peer pressure and moral authority" (Johnson 1987: 52). We have to find a way to establish all five characteristics of any force: its source, direction, sense, magnitude and temporal change. For example, if a policeman says, "I must give you a fine," where is the force, undoubtedly exerted by him, applied? What is its sense, direction and magnitude? Does the force direction change? How can we carry on a precise reverse mapping from the target domain of a given sentence back into the domain of physical forces? Fortunately, the answer lies in Newtonian Dynamics which establishes a precise, mathematical link between force, geometry and movement. For example, the Second Law of Dynamics defines force as the second time derivative of the location vector multiplied by the mass (also: first derivative of momentum). All that needs to be done then is to map the target domain of a given sentence into the domain of geometry and movement and then use Newtonian Dynamics for precise gauging of the force.

Let us present this method with regard to the basic characteristics of any force: source, direction, sense, magnitude and temporal changeability (in the next section we will see that those characteristics precisely correspond to the five Talmy's constraints).

1) Source. The notion of the source or the agent is not at all different from the one used by physicists, i.e. whatever or whoever acts or exerts a force.

2) Direction. The problem becomes much more interesting, as far as direction is concerned, because it is a geometrical term. Direction is a line and in Euclidean geometry it is defined by two points. For metaphorical extension of a point we chose a state.

3) Sense. Since the direction is defined by two ‘points’ or states *A* and *B*, it is easy to discern two senses: *AB* and *BA*.

4) Magnitude. It is impossible, of course, to measure the force of, say, moral authority in Newtons (SI units of force); however, fortunately, Newtonian Dynamics and its first law in particular come to our aid here. For example, it follows from the First Law of Dynamics that if a body remains motionless, the forces acting on it must cancel each other, i.e. if there are two opposing forces, they must be of equal magnitude. If the object on each of the forces act does not ‘move’ from state *A* to *B*, the forces acting on it must be of equal magnitude. It is still impossible to measure the magnitude of the extended force precisely, but at least we can compare magnitudes.

5) Temporal changeability. Given that the extended notions of direction, sense and magnitude have been precisely defined, extended temporal changeability does not differ at all from its source domain counterpart.

A detailed analysis of different types of modal sentences with the use of the above method will be presented after introducing Talmy’s constraints on the linguistic forces (the prototype) in the next section.

4. Leonard Talmy’s prototype of force dynamics

Talmy’s force-dynamic prototype (2000: 467) comprises the following five constraints:

a) Two forces, not more (constraint on the sources of the force).

b) Two forces acting along the same line (constraint on the direction of the forces).

c) Two forces opposing each other (constraint on the ‘sense’ of the forces).

d) Two unequal forces (constraint on the magnitude of the forces).

e) Two directionally constant forces (constraint on temporal changeability of the forces).

The better to explain Talmy’s constraints, let us consider two examples of sentences with *can*, using the method of gauging forces described in the previous section:

(1) Can English be dethroned?
(2) What can you do with an English degree?

Analysis of Talmy’s five constraints for example (1):

a) Two forces not more. We have two contestants here, English (Agent *x*) and an unspecified language like Spanish or Chinese (Agent *y*) vying for global primacy, therefore the first constraint seems to be satisfied.

b) Two forces acting along the same line. The two points or two states needed to define a line here are: State A: English not dethroned and State B: English dethroned. Constraint *b* is, therefore, fulfilled.

c) Two forces opposing each other. Again: Agent *y* acts from A to B while Agent *x* in the opposite direction from B to A. Constraint *c* checks.

d) Two unequal forces. It is not very easy to gauge a metaphorically extended force acting on or exerted by metaphorically extended language like 'English' or 'Spanish' but it's not impossible. We can perhaps agree that the 'force' exerted by a 'language' can be measured by the number of its speakers; it is, therefore, unlikely that the two forces will ever be exactly equal. Constraint *d* is fulfilled.

e) No changes of force direction. Since we have only two points or two states defined here, no change of direction seems possible. Constraint *e* is satisfied.

Let's consider example (2) now, constraint by constraint.

a) Two forces, not more. When the forces finally start acting, when the event time comes, we have the force of English degree on one hand and an unspecified barrier exerting a counterforce on the subject of *can*. The number of forces is two.

b) Two forces acting along the same line. Exactly the same reasoning as above with State A: thing done (goal achieved), State B: thing not done (goal not achieved).

c) Two forces opposing each other. Agent *y* (the barrier, a demanding recruitment officer, for example) acts from A to B, while Agent *x* (the proud holder of an English degree) acts along the same line but from B to A.

d) Two unequal forces. The recruitment process must finally end and either state B or A achieved, proving the magnitude of F_{AB} respectively greater or smaller than F_{BA}.

e) No other states apart from state A or B are present in (2), no change of direction of either F_{AB} or F_{BA} is possible.

For both examples all five force-dynamic constraints are fulfilled. Naturally, it is not always the case. The following example was analysed by Mark Johnson (1987: 52):

(3) You must cover your eyes, or they'll be burned.

Sentence (3) lends itself easily to force-dynamic analysis, since it expresses physical compulsion; however, the forces involved are not as easily analysable as, for example, those acting on a ball rolling across a billiard table. Again, let us consider all five constraints respectively:

a) Two forces, not more. Constraint *a* may not be fulfilled because the only force indicated in the sentence is exerted by the speaker who is compelling the addressee to move the eyelids; the other possible source of force may be the addressee himself who is perhaps feeling the discomfort and is, therefore, willing to cover his or her eyes. On the other hand, the addressee may, for example, for different reasons, feel the aversion to wearing glasses. Furthermore, he or she may be utterly indifferent and neutral as far as wearing glasses is concerned. In the considered example then, constraint *a* cannot be confirmed.

b) Two forces acting along the same line. As has been already stated, we are not describing billiard balls here, therefore the notion of force needs to be metaphorically extended into more general and abstract notion of a factor able to change state A into state B. The direction of this vector can be described as AB or BA. State A in our case means 'eyes covered ' and state B 'eyes not covered.' The force exerted by the speaker acts 'from B to A,' while the other forces indicated above (if present) would act either 'from A to B' (the addressee unwilling to wear glasses) or 'from B to A' (the addressee willing to wear glasses). Constraint *b* is thus fulfilled.

c) Two forces opposing each other. As is already apparent from the above considerations, constraint *c* cannot be confirmed as the second force may be absent or might even act in concord with the force exerted by the speaker.

d) Two unequal forces. Again, since the number of forces is not established, it is very difficult to compare their magnitude; however, the possibility of the second force (were it present) being of equal magnitude to the force exerted by the speaker cannot be ruled out.

e) Two directionally constant forces. The number of forces may possibly be different than two but it seems that the forces mentioned in *a*, if they were present, would be directionally constant.

Summing up the case of sentence 3, only constraints *b* and *e* of Talmy's prototype are confirmed. We could not rule out the remaining three constraints, we were just not able to confirm them. Let's imagine a force-dynamically ideal case (all five constraints fulfilled) when the addressee resents the idea of wearing sunglasses but ultimately accepts the authority of the speaker. In such a case, we could discern two agents and two states:

Agent *x* : the speaker
Agent *y*: the addressee
State A: eyes covered
State B: eyes not covered

Force F*y* (exerted by *y*) acts in the direction AB while a greater force F*x* (*x* is its source) acts in the opposite direction BA. Both forces of constant magnitude act on the addressee (the subject of *must*) at the speech-act time (Fig. 4).

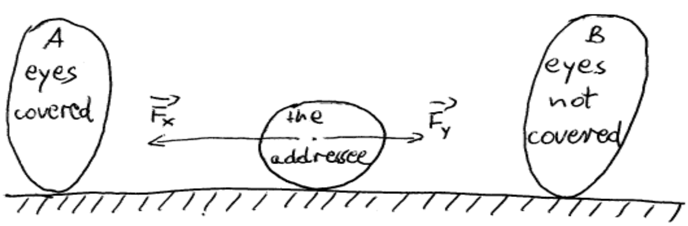


Figure 4. Two unequal forces opposing each other along a single line

It is perhaps worth pointing out here that Talmy's constraints do not specify the time at which we describe or 'measure' the forces. In the case of *must* in its root meaning, it is rather simple because the event time and the speech-act time are usually the same; however, in the case of *may* and *can*, the forces may not act at the speech-act time. If we are to describe (or to measure) the forces, compare them and find out their direction, sense and magnitude, we have to take a snapshot of them at a given moment, which may as well be the speech-act time ('point of speech'(S) in Reichenbach's (1947) terms or 'base' in Fauconnier's (1985)).

The significance of this force-dynamic 'prototype' is summed by its creator as follows, "It is deviations from this prototype that have minimal linguistic representation" (Talmy 2000: 467). The formula, then, for checking the validity of Talmy's constraints is very simple: analyse a number of random sentences and find the percentage of constraints fulfilled in them.

5. Corpus analysis

This section contains a detailed force-dynamic analysis of 120 random sentences, 40 for each of the three modal verbs. Each sentence has been checked with respect to Talmy's model of force dynamics. The sentences were selected with the use of *The British National Corpus*, version 2 (BNC World, 2001) distributed by *Oxford University Computing Services*, on behalf of the *BNC Consortium* (http://www.natcorp.ox.ac.uk), and *SARA* (*SGML Aware Retrieval Application*) programme version 0.941 licensed by *Chancellor, Masters and Scholars of Oxford University* (1995–7).

Figure 5. The main window of SARA version 0.941 programme

After opening the *File* menu (Figure 5) and choosing the following options: *new query*, *phrase*, *'can'* (*ignore case*), *download random set*, *100 hits* (Figure 6) a set (a *query*) of 100 random text samples with *can* is created. The query can be then saved using the *File* menu again.

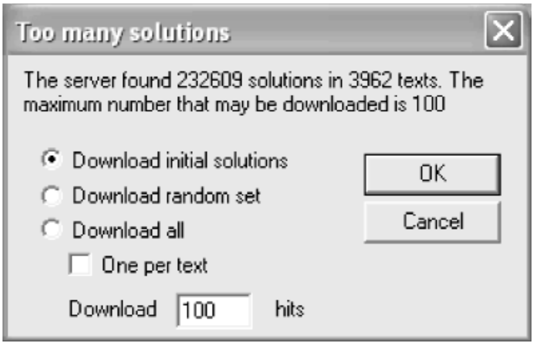
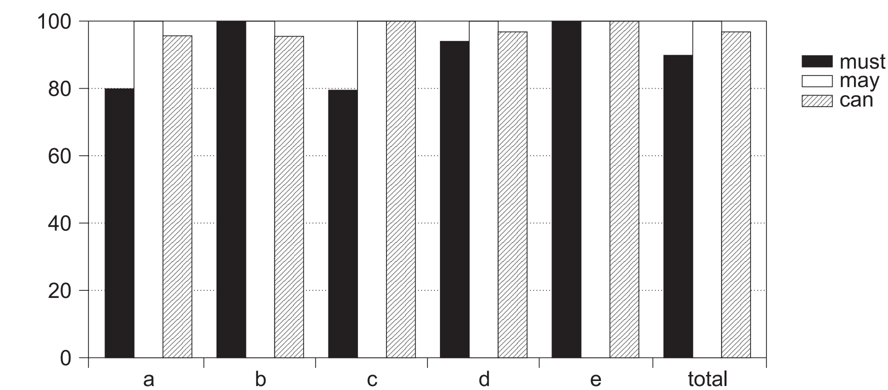


Figure 6. Choosing the query options

The *SARA* programme offers many additional options of viewing the query. For example, *scope* (the volume of the viewed text) which can be set to *sentence* or to *max* depending on how much 'surrounding' text is to be shown. In most cases, the former, default option is sufficient for the force-dynamic analysis. Nevertheless, in less clear cases, the *scope* has to be set to *max* to allow for a more precise scrutiny.



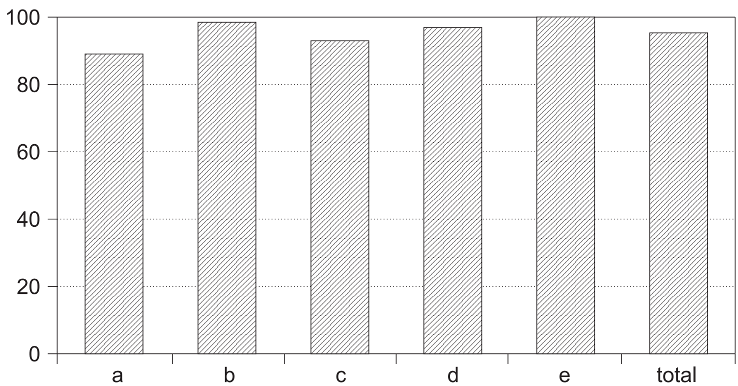
	a	b	c	d	e	total
must	78±8%	100%	78±8%	93±5%	100%	90±3%
may	100%	100%	100%	100%	100%	100%
can	95±4%	95±4%	100%	97±3%	100%	97±1%

Figure 7. The percentage of Talmy's constraints fulfilled by sentences with *must*, *may* and *can*

Figure 7 contains a summary chart comparing the percentage of *must*, *may* and *can* sentences fulfilling Talmy's constraints *a*, *b*, *c*, *d*, *e*. We notice that the first constraint (two forces, not more) is most often (22%) violated by the *must* sentences, much more rarely (5%) by the *can* sentences and, of course, never violated in sentences containing the root meaning of *may*. It may be explained by the fact that *must* indicates one compelling force which is not necessarily opposed by a counterforce, as it is usually the case with *can*. The *may* sentences comply with constraint *a*, as well as with all the remaining constraints, due to the fact that *may* indicates one-dimensional (up or down) movement of a barrier. Constraint *b* (two forces acting along the same line) was not fulfilled by only 5% of *can* sentences, which is due to the fact that there was more than one counterforce acting from different directions.

Not surprisingly, the result for constraint *c* (two opposing forces) for *must* sentences is the same as the result for constraint *a* because if there is only one force present, the second (absent) force cannot oppose it. Constraint *d* (two unequal forces) is not fulfilled in 7% of the *must* sentences and also in 3% of the *can* sentences, but the latter result is not significant as its statistical uncertainty is also 3%. The last column of the table in Figure 7 allows us to compare the summary fulfilment of Talmy's constraints by the 3 sets of analysed random sentences. While *may* and *can* seem to comply with Talmy's model almost ideally, *must* shows a 10% deviation from Talmy's constraints.

Figure 8 presents the summary results without the division into separate modal verbs. Again, the most significant deviation from the Talmy's model is apparent for the correlated constraints *a* (two forces) and *c* (opposing forces). The deviations of constraints *b* (single direction) and *d* (unequal magnitudes), 2% and 3% respectively, are not significant as they almost fall within the limits of their statistical uncertainty. The last constraint, *e* (constant forces), shows full concurrence with Talmy's model.



a	b	c	d	e	total
92±3%	98±1%	94±2%	97±2%	100%	96±1%

Figure 8. The percentage of Talmy's constraints fulfilled by all random sentences without the division into separate modals

The last column of the table in Figure 8 contains the crucial finding of this paper, whose main object was to check the viability of Leonard Talmy's model of force dynamics for the root meanings of *must*, *may* and *can.* Of the 420 cases considered (number of non-epistemic sentences multiplied by the number of constraints), 96 ± 1% concur with Leonard Talmy's model.

6. Conclusion

Talmy's *prototype* of force dynamics has been confirmed in 96 ± 1% of cases, for *root* modal verbs *can*, *may* and *must*. This astonishingly high result is an average calculated for all three modal verbs: 90% for *must*, 97% for *can* and 100% for *may.* Even the lowest result – 90% for *must* is remarkably high, given the restrictiveness of Talmy's *prototype*, which is the force-dynamic equivalent of a car pulling a trailer along a straight line (restrictions *a*, *b* and *c*), the force exerted by the car overcoming the friction of the trailer (restriction *d*). Talmy's model excludes the possibility of the car moving along a curved line or the wind blowing at an angle to the road; any bumps in the road are out of the question and the car cannot stop or even move with constant velocity – it must either accelerate or brake with constant force (restriction *e*). And yet, on average, in 96% of the cases analysed, the restrictions were fulfilled, which suggests the possibility of replacing (at least for the three modal verbs considered) all the force-dynamic image schemas (compulsion, enablement, removal of restraint, blockage, etc.) with just one simple schema represented by Figure 9.

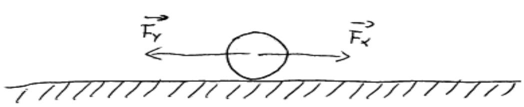


Figure 9. The universal force-dynamic schema

The present paper is a modest proof that Talmy's *prototype* of the force-dynamic system lends itself to corpus-based analysis, which allows for further research of the subject, including checking it against, for example, Polish modal verbs, other lexical items like *want* (Polish *chcieć*), future tense, causality and speech-acts, all of which are linguistic *correlates* of force dynamics (Libura 2000: 159–255).

The notional clarity and completeness of the Newtonian mathematic method of describing and diagramming forces greatly facilitates any force-dynamic considerations. For example, it allows us to avoid the mistake made by Johnson (1987: 46), who confuses force and velocity (momentum) while describing the diversion schema. Also, the correlation of forces and space-time geometry, which is the essence of Newtonian Dynamics, makes it possible to gauge the forces in random sentences (cf. section 3).

Though very limited in scope, this work has shown that Newtonian Dynamics can be applied in cognitive linguistics or, more precisely, in what Mark Johnson described as "putting the body back into the mind" (1987: xxxvi). If we believe that our experience of force and movement influences language and cognition, then why not use the mathematically precise language and models of physics to describe this experience? Coming back to Paul Deanne (1996 : 56) quoted in the introduction, cognitive linguistics should perhaps create models of language that are not only *psychologically* but also *physically* plausible.

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