Building bridges: verb semantics, frames and events*

Anja Goldschmidt

Utrecht Institute of Linguistics
A.Goldschmidt@uu.nl

1 Verb semantics, frames and events

This paper explores the links between Event Semantics (Davidson 1967, Parsons 1990, Maienborn & Schäfer 2011 and many others) and Frame Semantics (Barsalou 1992 Petersen 2007 Löbner 2014 and others) on the example of force verbs. Force verbs are interesting in this respect, because they have a rich lexical structure. This structure needs to be represented in detail if effects of language composition are to be modelled, such as the preposition or adverb selection by force verbs, illustrated in (1) and (2).

(1) a. (i) Joanne schlägt **auf** den Nagel.
Joanne hits on the nail
(ii) *Joanne schlägt **an** dem Nagel.
Joanne hits on the nail
b. (i) Joanne zieht **an** der Wurzel.
Joanne pulls on the root
(ii) *Joanne zieht **auf** der Wurzel.
Joanne pulls on the root

(2) a. Joanne berührt Mary **leicht** an der Schulter.
Joanne touches Mary lightly on the shoulder
b. *Joanne berührt Mary **hart** an der Schulter.
Joanne touches Mary hard on the shoulder

In the following, I will first give an overview of the lexical components of force verbs, cf. Section 2, and then show in Section 3 how the effects observed in the sentences in (1) and (2) can accurately be modelled in Event Semantics, based on a detailed representation of the rich lexical semantics of force verbs. In Section 4, I will model the same sentences in Frame Semantics and focus on the links between the two frameworks, as well as their respective advantages and disadvantages.

*This paper is based largely on Goldschmidt & Zwarts (2016), Goldschmidt, Gamerschlag, Petersen, Gabrovska & Geuder (2017) and Goldschmidt (2018).

2 The lexical semantics of force verbs

Force verbs are defined as "any verb of which the root can occur in a sentence that describes a situation in which an object A exerts a physical force through contact on another object B without necessarily implying a change in the properties of B, yet while allowing for that change" (Goldschmidt 2018: 114).

This definition includes the verbs in sentences (1) and (2) above: *s*chlagen (to hit), *z*iehen (to pull) and *b*erühren (to touch) all describe situations of force exertion through contact. They all allow for a change of state or position of the object on which the force is exerted, but they do not require it.

Force verbs can be further classified according to their directional, aspectual and intensity specifications. The verbs *s*chlagen and *b*erühren both describe a situation in which the force is directed towards the object on which it is applied. Compare this to *z*iehen, which describes the exertion of a force away from the object on which it is applied. Verbs like *s*chlagen and *b*erühren thus differ from verbs like *z*iehen with respect to directionality. *B*erühren differs from *s*chlagen and *z*iehen with respect to the force magnitude. While *s*chlagen and *z*iehen are lexically unspecified with respect to a specific magnitude (and get their high force magnitude reading through a process of implicature, cf. Goldschmidt et.al. 2017, Goldschmidt 2018), *b*erühren is lexically specified for a low force magnitude and can thus not be used to express a high amount of force. *S*chlagen and *z*iehen also differ from each other with respect to aspect or the duration of the force exertion. While *s*chlagen describes a momentary or punctual contact through which the force is exerted, *z*iehen describes a continuous force exertion.

These lexical distinctions can influence a verb's compositional behaviour. The ungrammaticality of the sentences in (1-a-ii), (1-b-ii) and (2-b) are due to incompatible directional and intensity requirements of the verbs and prepositions/adverbs. I will now show how force verbs can be modelled in Event Semantics.

3 Force verbs in Event Semantics

Event Semantics as developed by Davidson (1967) and elaborated on by Parsons (1990) and many others analyses verbs as predicates over an underlying event variable. Adverbs and prepositional phrases are seen as providing extra information about that event. However, even if one were to assign a force component to the event, such an analysis is not enough to capture the distinctions between force verbs.

In order to accurately model the directional, aspectual and intensity distinctions illustrated above, a more detailed representation of the force component is necessary. This can be achieved by incorporating insights from vector-based models such as that of Zwarts & Winter (2000) into a force dynamic approach like that by Wolff (2007). I propose that the force that the force exerter (terminology following Goldschmidt (2018)) exerts on the force recipient is modelled via (force) vectors. At each moment during the run time of the event, a unique force vector represents the force that is exerted on the force recipient at that moment: $p(t_i)$. Non-zero force vectors have a magnitude, an origin and a direction. Zero force vectors have no magnitude or direction, but an origin; zero force vectors are thus points.

The sequence of force vectors that represent the force exerted at each moment during the event form a path. For example, if the force exerter is moving towards the force recipient (e.g. the phase before contact is made in situations described by *s*chlagen as in (1-a-i)), a sequence of zero force vectors are generated, each with a different origin. This sequence of points, or

path, allows tracing the movement of the force exerter. Force vectors, both zero and non-zero, thus do double duty: they represent the magnitude and direction of the force exerted on the force recipient, and they represent the movement or spatial position of the force exerter via their origin.

The different directional, aspectual and intensity components of force verbs can now accurately be modelled by posing conditions on the magnitude or direction of the force vectors, or on the quantity of non-zero force vectors. This allows for a detailed representation of the semantics of force verbs, cf. (3), (4) and (5), taken from Goldschmidt (2018: 153/154, ex(32,33,36)).

(3) SCHLAGEN = $\lambda e.\exists p$ [p = PATH(e) $\wedge$ PUNCTUAL(p) $\wedge$ INTR(p, FORCE RECIPIENT(e))]

(4) ZIEHEN = $\lambda e.\exists p$ [p = PATH(e) $\wedge$ CONTINUOUS(p) $\wedge$ EXTR(p, FORCE RECIPIENT(e))]

(5) BERÜHREN=$\lambda e.\exists p$[p=PATH(e) $\wedge$ INTR(p,FORCE RECIPIENT(e)) $\wedge$ NON-INTENSIVE(p)]

The verb *s*chlagen is punctual, i.e. it expresses only a momentary contact (one non-zero force vector), and internally directed (the force vectors point towards the force recipient). *Z*iehen is continuous, i.e. it expresses a continuous force exertion (only non-zero force vectors), and externally directed (the force vectors point away from the force recipient). *B*erühren is internally directed and non-intensive, i.e. the non-zero force vectors need to have a magnitude below a certain average for comparison.

Please note that not the event, but the path is said to be continuous/momentary, internal/external or non-intensive. By analysing prepositions and adverbs as predicates over paths, their force dynamic requirements can be analysed in the same way as those of the verbs. The ungrammaticality of the sentences in (1-a-ii), (1-b-ii) and (2-b) can now be explained by incompatible force vector requirements. *S*chlagen requires internally directed force vectors, *a*n (on) requires externally directed force vectors. This is the other way around for *z*iehen and *a*uf (on). And *b*erühren requires force vectors with a magnitude below a certain average for comparison (and above zero), while *h*art (hard) requires force vectors with a magnitude above a certain average.

By modelling the rich lexical semantics of force verbs in such great detail, the ungrammaticality of the sentences in (1-a-ii), (1-b-ii) and (2-b) can satisfactorily be explained within the framework of Event Semantics. I will now show how the same lexical structure can be modelled in Frame Semantics.

4 Force verbs in Frame Semantics

In Frame Semantics as originated by Barsalou (1992) and further developed by a.o. Petersen (2007) and Löbner (2014), meaning is modelled by making explicit the underlying conceptual structure. A bike, for example, has the attribute COLOUR which can take as its values e.g. **blue**, **red** or **black**. This is visualised as a connected graphs, with the values represented as nodes and the attributes as labelled arcs.

Force verbs can be represented in a similar way, cf. Figure 1, based on Goldschmidt's Figure 7.11 (Goldschmidt 2018: 198), which is a representation of the sentence in (2-a).

The frame takes the verb *b*erühren (to touch) as its central node, marked by the double circle and referring to the set of all *b*erühren-events. The agent is Joanne and the patient is Mary (the fact that only Mary's shoulder is touched is abreviated here by making *M*ary's shoulder the patient). The verb is characterised by a force component and a movement component,

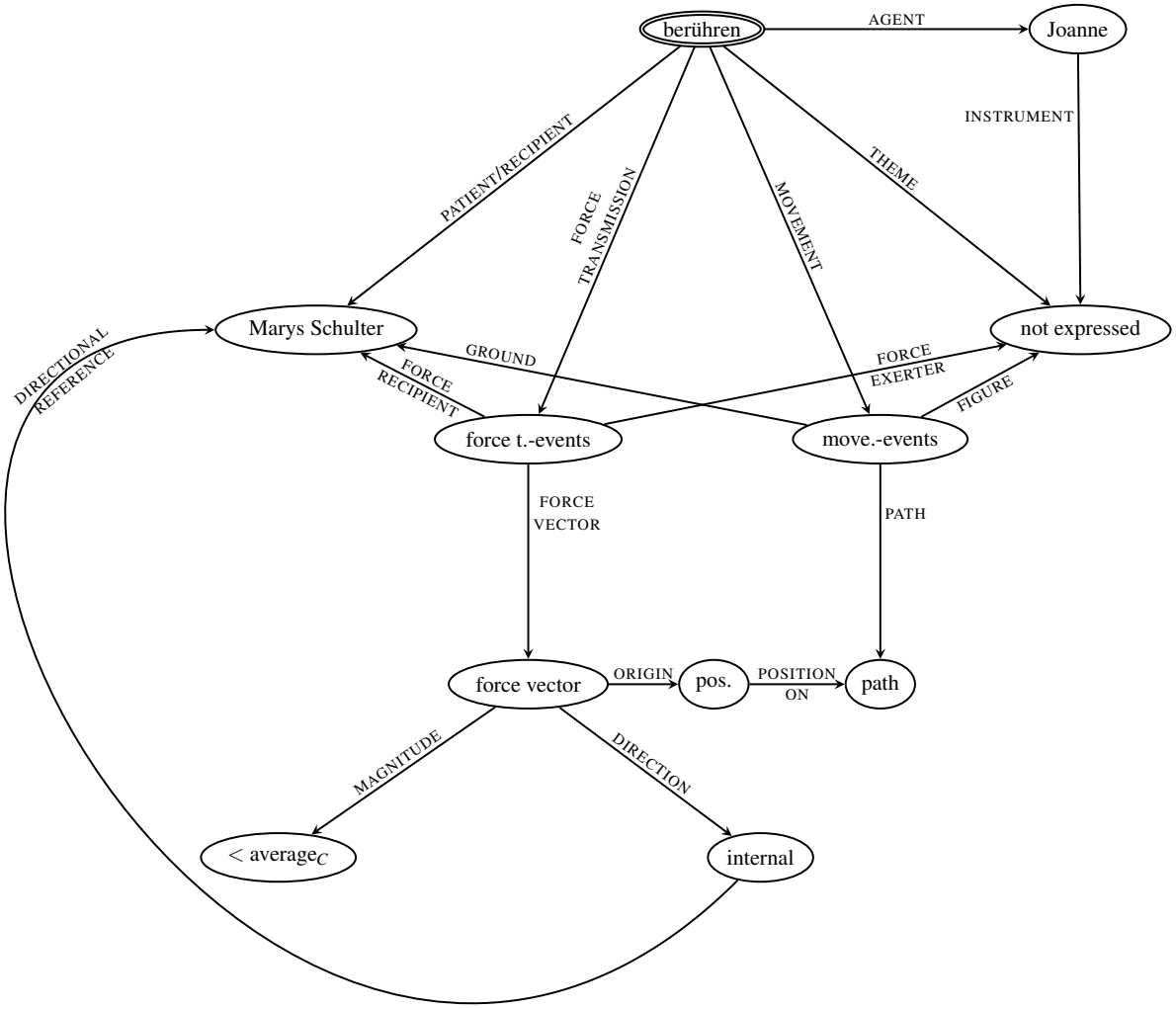

Figure 1: The frame representation of *J*oanne berührt Maria leicht an der Schulter (Joanne touches Mary lightly on the shoulder).

represented as sets of force transmission and movement events respectively. The force component models the force that is exerted on the force recipient and assigns the argument roles FORCE EXERTER and FORCE RECIPIENT (Joanne and Mary/Mary's shoulder respectively). The movement component models the movement of the force exerter towards the force recipient. It assigns the argument roles FIGURE, the moving entity, Joanne or some part of her in this case, and GROUND, the entity with respect to which the movement is described, Mary or her shoulder in this case.

Please note that the force component and movement component at this stage are modelled as two separate components. The double duty of the force vectors as explained in Section 3 above becomes visible further down in the frame structure. The force component has an attribute FORCE VECTOR, which takes as value the set of all force vectors, and the movement component has an attribute PATH which takes as value the set of all paths. Force vectors are characterised via the attributes MAGNITUDE, DIRECTION and ORIGIN, the specific values of which restrict the set of force vectors. The origin is a position on the path, hence the node **position** refers to specific positions on the path. The direction of a force vector is internal, i.e. towards the force recipient/Mary. This is made explicit by the attribute DIRECTIONAL REFERENCE. Finally, the fact that Joanne touched Mary lightly is expressed by the value $<$ **average**$_c$. The magnitude of the (set of) force vector(s) is below a certain average for comparison (but above zero).

By modelling force verbs and the sentences they appear in within Frame Semantics, the rich conceptual structure of force verbs becomes visible at one glance. Furthermore, the (co-) dependencies are immediately visible in this connected graph structure, such as the fact that Mary is both the force recipient and the ground, as well as the patient of the overall event. In order to accurately model the aspectual distinctions between e.g. *z*iehen and *sch*lagen, however, a more elaborate system than that presented here is needed (as in e.g. Gamerschlag et. al. 2014).

5 Events, frames, or both?

In Sections 1 and 2, I have argued that the rich lexical structure of force verbs needs to be modelled in detail to account for the ungrammaticality of the sentences in (1-a-ii), (1-b-ii) and (2-b). In Section 3, the meaning components of force verbs are modelled in an enriched Event Semantics framework, where the origin, magnitude and direction of force vectors represent the force-related distinctions as well as allow tracing the movement of the force exerter. In Section 4 I have presented an analysis of force verbs in Frame Semantics, where the rich conceptual structure is represented in a connected graph that immediately makes visible the relations between the meaning components of force verbs.

While force verbs can be accurately modelled in both frameworks, they both have their specific advantages and disadvantages. In Event Semantics, the specific notions of forces, paths, events and so on can be precisely defined as the model-theoretic building blocks that are the input to the analysis. These then reappear in the lexical entries for the verbs as in (3), (4) and (5), but the relations between them are lost in this representation. In order to recover them, one needs to "unpack" the lexical entries to retrieve the model-theoretic building blocks (as done in Goldschmidt 2018). In Frame Semantics, the relations between the meaning components of force verbs are immediately visible, as shown in Figure 1. But some of the model-theoretic building blocks are harder to represent in frames, as is the case with for example the aspectual distinctions between force verbs.

Both frameworks thus focus on different aspects of meaning: While the Event Semantics account presented here puts the focus on incorporating model-theoretic building blocks into the analysis of force verbs, the Frame Semantics account focuses on explicitly modelling the meaning components and their relations.

References

[1] Barsalou, L.W. 1992. Frames, concepts and conceptual fields. In A. Lehrer & E.F. Kittay (eds.), *F*rames, Fields, and Contrasts: New Essays in Semantic and Lexical Organization, 21-74. Hillsdale, New Jersey: Erlbaum.

[2] Davidson, D. 1967. The logical form of action sentences. In N. Rescher & A.R. Anderson (eds.), *T*he Logic of Decision and Action, 81Ű95. Pittsburgh: University of Pittsburgh Press.

[3] Gamerschlag, T., W. Geuder & W. Petersen. 2014. Glück auf, der Steiger kommt: A frame account of extensional and intensional *s*teigen. In D. Gerland et.al. (eds.), *M*eaning and Grammar of Nouns and Verbs, 115-144. Düsseldorf: dup.

[4] Goldschmidt, A. 2018. *H*itting Playfully But Hard: Conceptual Effects of Verb-Adverb Modification in the Domain of Force 505. Utrecht, the Netherlands: LOT - Landelijke Onderzoekschool Taalwetenschap.

[5] Goldschmidt, A., T. Gamerschlag, W. Petersen, E. Gabrovska & W. Geuder. 2017. Towards verb modification in frames: A case study on German *s*chlagen (to hit). In H.H. Hansen et.al. (eds.), *L*ogic, Language and Computation: 11th International Tbilisi Symposium 2015, Revised Selected Papers, 18-36. Berlin: Springer.

[6] Goldschmidt, A. & J. Zwarts. 2016. Hitting the nail on the head: Force vectors in verb semantics. In M. Moroney et.al. (eds.), *P*roceedings of the 26th Semantics and Linguistic Theory Conference, 433-450. Washington, DC: Linguistic Society of America.

[7] Löbner, Sebastian. 2014. Evidence for frames from human language. In T. Gamerschlag et.al. (eds.), *F*rames and Concept Types: Applications in Language and Philosophy, chap. 2, 23-68. Heidelberg, New York: Springer.

[8] Maienborn, C. & M. Schäfer. 2011. Adverbs and adverbials. In C. Maienborn et.al. (eds.), *S*emantics. An International Handbook of Natural Language Meaning.

[9] Parsons, T. 1990. *E*vents in the Semantics of English. Cambridge, MA: MIT Press.

[10] Petersen, W. 2007. Representation of concepts as frames. In J. Skilters et.al. (eds.), *C*omplex Cognition and Qualitative Science, 151-170. Riga: University of Latvia.

[11] Wolff, P. 2007. Representing causation. *J*ournal of Experimental Psychology: General 136(1). 82-111.

[12] Zwarts, J. & Y. Winter. 2000. Vector space semantics: A model-theoretic analysis of locative prepositions. *J*ournal of Logic, Language and Information 9(2). 171-213.