CHAPTER 6

Eliminating causative entailments with the force-theoretic framework: The case of the Tohono O'odham frustrative *cem*

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6.1 Introduction

In many cases in natural language, causation must be treated as 'defeasible'—that is, one event is asserted or presupposed to normally cause a second event, but there is no entailment that the caused event actually occurs. To account for such cases, we propose that the arguments discovered by Davidson refer to forces instead of to events.

While the notion of 'force' is not commonly referred to in generative linguistic work, cognitive linguistics has long recognized that such a notion is relevant in linguistic semantics, starting from the commonsense insight that many lexical distinctions (*help, prevent,* etc.) are easily characterized in terms of force-dynamic interactions (Talmy 1976, 1981, 1985, 1988, 2000).[1] Working from a quite different theoretical perspective, computational linguists have modelled the development of events in time as 'sequences of snapshots', involving causal transitions between static representations of situations, as in motion pictures or comic books (Moens & Steedman 1988, Naumann 2001, Fernando 2005, ter Meulen 1990). Dahl (2007) also views events as transitions from one static situation to another.

We argue that these two approaches, taken together, can provide a simple answer to a central problem of standard event semantics: that of the defeasibility of causation. Intuitively, a force is an input of energy into a situation, causing a transition to another situation, as long as all else is equal—that is, as long as no stronger perturbing force intervenes to bring about a different result. Formally, we treat forces as functions from an initial situation to the situation that results *ceteris paribus* (all else being equal). This allows for the possibility that all else may not be equal, leading to the lack of a causative entailment. The key feature of the approach is that it allows a simple semantic characterization of a 'normal' result that does not entail the existence of that result. In existing event-based treatments, in contrast, possible worlds (Dowty 1979,

Tatevosov 2008, e.g.) or unanalyzed partial events (in the sense of Parsons (1990)) are used to defeat the equivalent entailment; the adoption of possible worlds over-complicates the semantics while the use of partial events glosses over the issue of how to link causes and results. This is not to say that events *must* be jettisoned to account for defeasible causation (see Copley & Wolff, this volume), however, it must be explained how either causation can be defeasible. Forces provide a natural way of achieving this goal.

To illustrate the application of the framework to natural language data, we sketch an analysis of non-culminating accomplishment predicates, and provide an in-depth analysis of 'frustrative' morphology in Tohono O'odham, an Uto-Aztecan language spoken in southern Arizona and northern Mexico. The resulting analysis sheds light on the representation of statives, plans, and prospective, imperfective, and perfective aspect.

In the first section of the chapter, we provide a quick review of the role of event arguments in semantic theory, sketching the development of the event-chaining view of event types involving transitions, and noting the difficulty with defeasible causation encountered in the general framework. The second section details the proposed force-theoretic framework, and in the third section, we show how the framework allows a straightforward analysis of the Tohono O'odham frustrative morpheme *cem* (pronounced [tʃɨ̰m]).

6.2 Davidsonian events and causation

The Davidsonian revolution in semantics reified the notion of 'event'. In his discussion of sentences like that in (1), Davidson (1967) proposes that there is an argument that the predicates *with a knife, in the kitchen,* and *at midnight* are all predicates of.

(1) Brutus killed Caesar with a knife in the kitchen at midnight.

Not only do events have spatial and temporal location, as in (1), but they can also be observed, and referred to with pronouns: *Brutus killed Caesar and I saw it happen*.

Neo-Davidsonian analysts saw a way to extend Davidson's proposal to characterize semantic subcomponents of predicates, such as theta roles. They proposed to extract core arguments from the main predicate and introduce them via two-place predicates such as Agent (x, e) and Theme(y, e). The main predicate is thus reduced to a one-place predicate of events, on a par with the event-modifying adjuncts in Davidson's schema (Castañeda, 1967 et. seq.).

A separate line of analysis investigating the internal structure of events produced a consensus that certain events—Vendlerian Accomplishments, most saliently—are in fact composed of two sub-events, chained together in a causal relationship: *John opened the door*, for example, has a causing sub-event e_1, and a result sub-event e_2. Pustejovsky (1995) and Higginbotham (2000) proposed novel rules of composition to link events causally, allowing a straightforward expression of the insight that *John* is the Agent of only the first, causing, sub-event, e_1; this event then is 'chained' with e_2, of which the Theme is predicated. Kratzer (2005) and Ramchand (2008) moved the work of causally chaining e_1 and e_2 to the denotation of a functional head.

Cases of defeasible causation pose a challenge to the event-chaining account of complex events, however. The event-chaining hypothesis entails that e_2 is an inevitable consequence of e_1. However, there are many cases in natural language where there is an Agent *doing* something (e_1) which would normally be the causing sub-event of a second *happening* sub-event, but the *happening* (e_2) is non-existent, or the wrong kind of happening. In effect, these are cases where Brutus does something with the intention of killing Caesar, but Caesar does not end up dead. The

most well-studied such effect is the imperfective paradox (Dowty 1979, Parsons 1989, 1990, Landman 1992, Portner 1998, a.o.)[2] but there are others, two of which we will illustrate here.

In many languages, unmarked telic predicates often fail to have a causative entailment; these constructions are called in the literature 'non-culminating accomplishments'.[3] For example, Malagasy has an agentive infix, *-an-*, which indicates the presence of an initiating event and an active Agent, but the *-an-* infixed form does not entail successful completion of the caused event—it is implied, but defeasible, as described by Travis (2000), and illustrated in in (2) below.[4]

(2) namory ny ankizy ny mpampianatra
past.*Agent.*meet the children the teachers

...nefa tsy nanana fotoana izy.
...but NEG PAST.have time they
'The teachers gathered the children but they didn't have time.'
(Travis 2000: 172)

This phenomenon is not a parameter at the level of the language, but occurs in various forms cross-linguistically. For example, the neutral form of the verb in Tagalog does not entail completion (Schachter & Otanes 1972, Dell 1987); the completion can be explicitly contradicted.[5]

(3) Inalis ko ang mantas,
N-PERF-remove GEN-I NOM stain,

pero naubusan ako kaagad ng sabon, kaya hindi ko naalis.
but run-out-of NOM-I rapidly gen soap hence not GEN-I A-PERF-remove
'I tried to remove (lit. 'I removed') the stain, but I ran out of soap, and couldn't.'
(Dell 1987: 186)

Similar examples are found in a number of languages, for example in the Salish languages St'át'imcets and Skwxwú7mesh of the Pacific Northwest (Bar-el, Davis & Matthewson, 2005), in Karachay-Balkar, a Turkic language spoken in Russia, (Tatevosov, 2008), in Hindi (Singh, 1998) and in Mandarin (Koenig & Chief, 2008). In all of these cases, the agent *does* something but is unsuccessful in getting the intended result to *happen*.[6] As Dell puts it, 'the lexical meaning of the [verb] root … involves two distinct ideas. One has to do with the agent's engaging in a certain action or "Maneuver"… and the other has to do with a certain "Result" that may (but need not) be brought about by that Maneuver.' (Dell, 1987: 181)

Another especially striking example in which the intention and the result of the action diverge is in the case of so-called 'frustratives'. Descriptively speaking, sentences with frustratives can express the fact that the subject intended to do something that is not realized; that subject does something in vain; that a situation is unsatisfactory or does not develop as expected, or that a state does not continue. For example, the frustrative marker *-pana-* in Amahuaca, a Panoan language spoken in parts of Peru, can be used to express that the subject was going to do something but was foiled, as in (4).[7]

(4) Xau vuchi-pana-x-mun hun hovi hi-cain

turtle look.for-FRUS-NOM-TH me rain do-NONSQ(DS)

ca-yama-vahii-ha-hqui-nu.

go-NEG-all.day-COMPL.PAST-ACT-DECL

'I was going to look for a turtle, but it rained and I did not go all day.'

(Sparing-Chávez 2003: 5)

To our knowledge, frustratives remain relatively underexplored. The particular frustrative we will discuss in detail below is the morpheme *cem* (Hale 1969, Devens 1972, Copley 2005a) in Tohono O'odham, a Uto-Aztecan language spoken in southern Arizona and northern Mexico:

(5) Huan 'o cem kukpi'ok g pualt.

Juan aux-IMPF FRUS open DET door

'Juan pulled on the door but failed to open it.'

The *cem* sentence in (5) expresses the notion that the forces that Juan has brought to bear on the situation are inadequate to produce the intended effect of opening the door. We will see below that *cem* also interacts with aspectual meanings (perfective, imperfective, and prospective) to express the particular nature of the inadequacy of Juan's effort.

These data highlight the difficulty that event chaining has with events that fail to culminate as expected. What is the status of the event (e_1) of which Juan is an agent? Whatever it is, it is not necessarily an event that causes e_2. The event-chaining framework as it stands merely stipulates that there is a causal relationship between e_1 and e_2 . As things stand, we don't have

any understanding of how e_1 might cause e_2, or how e_2 might possibly fail to occur even in the presence of an apparently appropriate e_1. Indeed, the usual unselective existential binding of open event variables within a verb phrase in event-chaining formulae *entails* the existence of the result event e_2.

This problem has been addressed in two ways by existing accounts of defeasibility. The

first is through the use of possible worlds: e_2 does occur, but only in certain possible worlds, the "inertia worlds" where things proceed normally and nothing else intervenes. This approach was first proposed in Dowty's (1979) treatment of the English progressive, with many others refining the account (Landman 1992, Portner 1998, among many others). Non-culminating accomplishments have been accounted for in this way by Matthewson (2004) and Tatevosov (2008), while *cem* itself has been given a possible worlds treatment in Copley (2005a).

Another way that the problem of defeasibility has been addressed has been to give up on causation altogether, and adduce a subpart relation between partial and culminated events. Parsons' (1990) treatment of the English progressive is one such theory; see also Singh (1998) for a partial theta role approach to non-culminating accomplishments that is linked to Krifka's (1989, 1992) use of partial and complete events.

As discussed in Copley & Wolff (this volume), there are likely to be other ways to alter event theory to account for defeasible causation. However, there is a reason to think that events are not quite the right intuitive notion. In cases of defeasible causation, something intervenes to interrupt the normal course of events. But events are typically understood as changes (Cleland, 1991). If this is so, it is plausible to think that changes, strictly speaking, can't interact, intervene, or be defeasible. Forces, on the other hand, can do all of the above.

Our goal in this paper is to use the notion of *force* to address the issues for Davidsonian event semantics described above. Forces in physical systems interact with each other in

predictable and well-understood ways, such that a given force may produce varied, or even null, results, depending on what other forces are active in the situation. We claim that implementing an abstract version of this notion in a semantic system allows us to understand grammatical expressions of defeasible causation. The problem of the missing causative entailment is solved by not generating these entailments in the first place.

6.3 Forces

Above, we have seen two kinds of data—non-culminating accomplishments and frustratives— whose key similarity lies in the fact that there is an e_1 and an e_2, where e_1 is expected or supposed to cause e_2 , but e_2 does not occur. We turn now to the task of defining a force-based model that builds this into the representations.

The only formalist approaches to systematically employ the concept of 'force' as such that we are aware of is extensive work by van Lambalgen & Hamm (2003, 2005). These authors share several convictions with the present approach, including the idea that the concept of *inertia*—our *ceteris paribus*, below—is central to the treatment of events and should be treated directly in the model, instead of with the additional machinery of possible worlds. However, van Lambalgen and Hamm introduce forces as a supplement to the familiar machinery of events, processes and results. In our framework, forces are irreducibly central to the cognitive and grammatical representation of events.[8]

This task begins with deciding what forces are, and how to model them. We then present the framework of causal chains of situations that emerges from this picture, and consider what this account means for branching time. In addition, we discuss how something like gravity might be represented and what such a representation has to do with non-spatiotemporal forces. Finally,

we give a brief account of how psychological forces such as intentions are to be understood.

6.3.1 Initial and final situations

We take a situation to be a kind of annotated snapshot of a collection of individuals and their (relevant) properties. A force is a particular input of energy into some such initial situation. This energy is either generated by an animate entity, or comes from the motion or other properties of an individual in the initial situation.[9] The application of this energy can change the initial situation into a different situation.

A force results in a changed situation as long as no stronger force keeps it from doing so. So, for example, if you push on a cup hard enough to overcome the friction between the cup and the table it is sitting on, the cup is set in motion. The initial situation is the one where the cup is at rest and the final situation is one where the cup has velocity. The input of energy causes the change from the initial to the final situation. We take events (as opposed to states) to always involve such an input of energy.

Now suppose that you push on a stationary cup, but that you do not push hard enough to overcome the force of friction on the cup. Nevertheless you are still applying a force by pressing against the cup. This force has essentially no effect because an opposing force, namely, the frictional force of the cup on the table, is stronger.

In the case where the force is strong enough to make the cup move, we observed an initial situation (cup at rest) and a different final situation (cup in motion). On the other hand, in the case where the force is not strong enough to make the cup move, the observed initial situation (cup at rest) has the same properties as the observed final situation (cup still at rest). If we were to grease the bottom of the cup, and thereby reduce the magnitude of the force of friction acting on the cup, we could reduce it sufficiently such that a pushing force with the same magnitude as the

previous force would now allow the cup to move, so again the initial situation would be different from the final situation.

A force's observed final situation is thus contingent on the existence and strength of other forces opposing it. Since this is the case, it is not going to be useful for us to define any given force based on its *observed* final situation; i.e., we don't want to say that intuitively 'the same force' would be defined differently depending on whether the bottom of the cup is greased or not. In fact, much of the work we will want forces to do to account for defeasible causation has to do with counterfactual final situations, those that would ordinarily have been expected to happen if some other force hadn't intervened. So we will base the definition of any particular force on the '*ceteris paribus* ('all else being equal') final situation'—the situation that would obtain in the case that is just like the actual case but in which there is no stronger external opposing force.

6.3.2 Representing forces

In physics, forces are represented as vectors. Vectors are determined by three parameters, namely, an origin, a direction, and a magnitude. We might understand the origin to be the agent or causer, if there is one. The direction is, in an abstract sense, towards the force's *ceteris paribus* final situation. Magnitude is only important in relative terms, to characterize the interaction of opposing forces. We will not have much further to say about the vector representation of forces, although we will exploit intuitions deriving from such representations in illustrating causal chains of forces below.

We propose to represent forces in a Montagovian semantics as functions[10] from situations to situations, type <s,s>, which we will abbreviate for convenience's sake as type f.

(6) *Type of Situations:* s

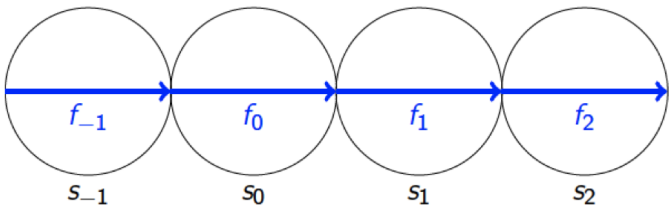
(7) *Definition of Force:*

A force f is a function from an initial situation to the *ceteris paribus* final situation, i.e., it is of type <s,s>.

The idea behind the <s,s> type, as before, is that if you have an initial situation and a force is applied, and no stronger force intervenes (i.e., *ceteris* are *paribus*) the final situation results—not a different *set* of situations; a single situation, according to the laws of naïve physics, which are, we will assume, deterministic.

While it is true that many different forces can combine to result in another force, the idea here is that the causing situation will include all of the individuals and properties that give rise to the *net force* that results in the final situation. (What makes a force 'net' is that it arises from the totality of the individuals and properties in the situation, rather than a subset of them.) Supposing as we do that the laws of naïve physics are deterministic, we may speak of causal chains of situations or forces, with the net force of one situation, when applied to that situation, resulting in a unique successor situation. The bubble diagram below depicts such a causal chain.

(8) Causal chain of situations with net forces



Successive situations will be numbered in series as shown in (8). We will assume that for any given situation s_n, we can always recover its net force f_n (which in some cases may be zero by virtue of our knowledge of the individuals and properties in s_n).

(9) net(s) =: the net force of s

The net force itself is calculated in the cognitive system. This calculation is easiest to understand for cases of forces whose effects are strictly spatiotemporal; it is possible to sum the physical forces that act on a single object to compute the net force acting on that object. However, the notion of force that we are constructing here acts on situations rather than objects. Energy inputs into a situation will not all necessarily be acting on the same object in the situation; indeed the effects may not be purely spatiotemporal. Nonetheless, we assume that this more abstract kind of summation is unproblematic, as humans (and other animals) are very good at looking at a situation and perceiving causality (White 2010, Hubbard 2012) as well as deciding what will happen next if nothing intervenes (Zacks, 2011).[11]

Using the function *net* we can define two other functions that will be useful. Given a net force f, the initial situation of f is simply the situation s of which f is a net force. The final situation is the situation that results when f takes s as its argument.

(10) a. $\text{init}(f) = \text{net}^{-1}(f)$

b. $\text{fin}(f) = f(\text{net}^{-1}(f))$

We define as well a situation's successor and predecessor situation:

(11) a. $suc(s) = fin(net(s))$

b. $pred(s) = suc^{-1}(s)$

6.3.3 Causal chains of situations

This point of view raises a question: if the laws of naïve physics are deterministic, and causal chains are as we have depicted them above, how can there be branching futures? This question is not only of concern to philosophy; it is of concern to semantics as well, since the latter is also concerned with representing what might happen or (if things had turned out a little differently) what might have happened.

In the framework we are proposing, outcomes of fully- understood situations are indeed deterministic. However, real-world states of affairs may be incompletely represented, resulting in several different possible net forces, and therefore in several different potential outcome situations, i.e. in branching futures. There are (at least) three distinct ways that things may turn out differently due to incomplete situations in the mental model, even given the deterministic nature we are assuming for naïve physics. The mental representation of the real-world state of affairs might suffer from any of the following: underspecification of the magnitudes of relevant forces, incomplete knowledge of the identity of the relevant forces, and/or incomplete knowledge of the individuals and/or properties from which forces arise. Any discrepancy in the determination of which forces are included in the calculation of the net force will result in a different net force obtaining in the real world.

First, we may not know the magnitude of the forces that are acting. For example, in the cup-pushing scenario, we may not know that the tabletop has a rubberized surface, resulting in a greater frictional force than expected, counteracting the pushing force acting to move the cup. More generally, Barbey & Wolff (2007) and Wolff (this volume) have argued that a causal chain

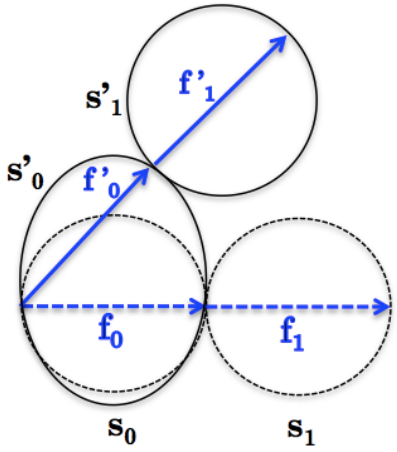
of forces can result in several different outcomes according to the magnitudes of the forces involved. Moreover, they argue, people are bad at assessing anything but the relative magnitudes of two forces, so this indeterminacy arises quite generally and increases with the length of the causal chain, despite the deterministic nature of causation in their model.[12]

The second way that branching can occur is if we do not know which forces are acting. For example, in a coin toss, we don't know exactly what forces are acting on the coin. If we did, we would be able to say confidently whether it would come up heads or tails. One major source of unknown and unknowable forces is the volition of animate entities. We assume that naïve psychology includes a form of free will; animate entities can choose to act on the world in one way or another, according to their preferences. Based on what an animate entity decides to do, there can be different outcomes of what is apparently the same state of affairs. In any situation with an animate entity in it, then, there is the potential for unknown forces to appear, producing variable outcomes.

The third way that branching can occur is if the speaker is mistaken about the entities and properties in the initial situation. For example, suppose a car is traveling smoothly along the highway, but runs over a tack, puncturing a tire and resulting in an accident. If you did not initially perceive the tack, the initial situation in your mental representation is not the one that led to the real-world outcome. Alternatively, consider a case in which you look at a vase tipping over and you judge that it is about to fall to the ground and break. But then someone standing next to the vase suddenly catches it. The situation of the person catching the vase is not the successor of the situation that includes only the falling vase; instead, it is the successor of the larger situation which includes both the falling vase and the person making the decision to catch it. (This kind of scenario will become important in our discussion of frustratives below.)

The choice of the initial situation s_0 does considerable work in this framework. When a speaker makes a claim about what forces are in play, they have a specific s_0 in mind and they assume that no forces arising externally to that situation will intervene to prevent the successor of s_0 from happening.[13] In all of the cases discussed below, the unexpected outcome is the result of the speaker's incorrect choice of s_0. The situation that actually determines what comes next is a different (in this case, larger) situation than s_0, call it s'_0. So the successor of s_0 (call it s_1) does not actually occur; what occurs instead is the successor of s'_0 (call it s'_1). This state of affairs is illustrated below (the incorrect choice of s_0, its force f_0, and its non-realized successor s_1 are illustrated with dotted lines to indicate that they were not realized; the realized situations and forces s'_0, f'_0, etc., are illustrated with solid lines):

(12) Larger situation has different successor situation; smaller situation is not efficacious



We will call situations whose successors do occur *efficacious*.

(13) Definition of efficacy (Copley & Harley submitted)

A situation s_n is *efficacious* just in case its normal *ceteris paribus* successor s_{n+1} actually obtains. That is:

for any s_n with a net force f_n, then s_n is efficacious iff fin(f_n) (i.e., $s_{n+1,}$ the successor of s_n) actually obtains.

This definition will undergo a slight revision in section 4.2.1 below, as we discuss statives in the context of Tohono O'odham frustratives. For now we note simply that the effect of branching comes about when the initial situation is not efficacious; the result expected from the net force of s_0 does not occur, while the result expected from the net force of an alternative initial situation does occur.

6.3.4 Gravity, tendencies, and fields

In the spatiotemporal cases such as pushing on the cup, it is evident that there is an application of energy. But in what sense is there an application of energy in the case of the frictional force, which results from the effect of gravity on the cup? Or for that matter, if you hold the cup in the air and then let go of it, and it falls due to the force of gravity, where is the application of energy? There are two answers to this question: the ancient physics answer (represented here by Aristotle) and the modern physics answer.

The Aristotelian explanation (*Physics*, VIII:4) is that heavy things (earth, etc.) have a tendency to descend, while light things (smoke, fire) have a tendency to ascend. '[H]ow can we account for the motion of light things and heavy things to their proper situations? The reason for it is that they have a natural tendency respectively towards a certain position: and this constitutes

the essence of lightness and heaviness, the former being determined by an upward, the latter by a downward, tendency.'

In Talmy's work (1988, 2000, e.g.) on the linguistic reflexes of cognitive representations, he echoes this Aristotelian notion: '…in terms of the cognitive structure of language, an object in a given situation is conceptualized as having an intrinsic force tendency, either toward action or toward rest. This concept appears to correlate with historically earlier scientific theories involving an object's impetus in motion or a tendency to come to rest' (Talmy, 2000 (1): 456).

Newtonian physics has done away with this tendency but has its own tendency, namely *inertia*. Beginning with Newton, rest is understood as zero velocity, and objects tend to move at their current velocity unless acted upon by an outside force (Newton's First Law of Motion).

A more modern understanding of gravity—setting aside general relativity and particle physics—is that of a vector field that interacts with objects in it. Any object in a gravitational field has a gravitational force on it that is calculated by using the value of the vector field at the location where the object is, and the mass of the object. The 'application of energy' comes from the *potential energy* stored up by the energy it took to put the object at that location in the field. It takes energy to raise the cup to the table, against the force of gravity. This energy is converted to acceleration if the cup should fall.

These two perspectives both express the idea that where there is gravity and an object with mass, a force arises; this force results in an event if nothing stronger intervenes. In both perspectives there is an expression of the general (the tendency itself, or the ability of the field to exert a force on any object put into it) and the particular (the specific force that arises from the tendency in any particular situation, or the specific force that arises from the field acting on the particular object). A tendency or field, whatever its provenance, is therefore treated in any particular scenario as producing a specific force whenever an appropriate individual is present.

Many linguistic explanations of meanings make reference to tendencies, natural laws, and so on; we propose to treat these as abstract analogues of the case of gravity. We turn to these next.

6.3.5 Beyond spatiotemporal effects

We are used to thinking of physical forces as contact forces that result in a change in the spatiotemporal properties of an object: where it is, whether it is moving or at rest, etc. In such cases, *init*(f) and *fin*(f) are situations that differ only in these respects. But actually, *any* physical change could be represented as a function from one situation to another.[14] Consider a fruit ripening: *init*(f) includes the unripe fruit and *fin*(f) includes the ripe fruit. Insofar as ripening happens to all fruit unless it is chilled, eaten while it is still green, etc., this case is less like pushing a cup and more like gravity: fruit has a tendency to ripen.

We will collect tendencies such as that of unsupported objects to fall and that of fruit to ripen into something we will call the 'normal field.' Of course, the normal field does not produce a force unless there is an object of the appropriate kind in the field. So the normal field can include the tendency of fruit to ripen, for instance, but unless there is a fruit in the initial situation, such a ripening force is not realized.[15] The forces provided by the normal field should be assumed to combine with other forces in the initial situation to produce the net force that yields the final situation.

We mention the normal field here simply to signal that we are aware of the many forces that arise from dispositions, laws, and the like.[16] For the data we are considering in this paper, the normal field does not have a counterpart in the semantics. Instead, the forces generated by the normal field are considered together with any other forces present in the situation, and the cognitive system is assumed to calculate the net force of the situation—the one that will lead to

the *ceteris paribus* successor situation, if nothing external intervenes.[17]

6.3.6 Physical and psychological forces

Just as we can speak of pushing or putting pressure on an object, we can also speak of pushing or putting pressure on someone, in a psychological sense, to accept an idea or to perform an action. The idea that the conception of the physical world is co-opted for use in the psychological or psychosocial domain is present in Jackendoff (1987 et seq.) and Lakoff & Johnson (1999), among many others (see, e.g., Bloom, Peterson & Garrett 1999 for a representative sample). Talmy (1988, 2000, a.o.) has extensively championed the view that force dynamics is the way to understand this link between the physical and the psychological. For example, while the sentence in (14a) is 'force-dynamically neutral,' the sentence in (14b) conveys that some other force, whether physical or psychosocial, prevents the subject from leaving the house if he wants to.

(14) a. John doesn't go out of the house.

b. John can't go out of the house. (Talmy, 2000 (1): 412)

Wolff (2007) has tested this idea experimentally, showing subjects a scene in which a pedestrian wants to go in a certain direction and a policeman directs her to go in a certain (possibly different) direction, and asking his subjects if the policeman *caused* her to reach, *enabled* her to reach, or *prevented* her from reaching her destination. The results exactly parallel the results he obtains in scenarios where inanimate objects are exerting forces on each other.

Copley (2010) proposes an analysis of desires that treats them analogously to our formal treatment of forces, but assigns them a higher type, to account for the intensional nature of

intentions (Heim 1992, Portner 1997, e.g.). Rather than being functions from situations to situations, desires are functions from situations to properties of situations, or, in some cases (we suspect), to properties of forces: Intention to act is a kind of net desire.[18]

The interaction of intentions with a particular tendency in the normal field will provide our treatment of agency. In brief, we propose that volitional individuals are subject to a normal field tendency which we will call the Law of Rational Action. The Law of Rational Action governs any individual who is subject to a particular psychological force—an individual with an intention or desire. If such an individual is in a situation which does not satisfy the desired property, then that individual is the source of forces which (*ceteris paribus*) will result in a later situation that does satisfy the desired property (or which contains a force which satisfies the desired property).

(15) *Law of Rational Action* (cf. also Copley & Harley submitted): If an individual x has a net desire for p in a situation s, x is the source of a force which has a later situation with property p, as long as nothing prevents x from being the source of such a force.

A full implementation of intentionality and agency will take us too far afield here, however; we leave a full discussion of psychological forces and agency for future work.

6.4 Forces in action: non-culminating accomplishments and Tohono O'odham frustratives

In section 2 above, we introduced two cases of defeasible causation. Non-culminating accomplishments do not require any special construction or morphology to indicate the failure of a normal or expected event to occur--that is, the normal consequence is not entailed by the

assertion of a causal event. In other languages, a separate construction is dedicated to such failures: the frustrative. We suggested that to do justice to these data, the causal relationship should be codified quite centrally in the semantics, via the notion of force. In the remainder of this paper we show how this proposal allows us to treat cases of defeasible causation straightforwardly, instead of first generating and subsequently undoing a causative entailment. The non-culminating accomplishments are derived quite immediately. We then present an analysis of the Tohono O'odham frustrative and its interactions with aspect.

To briefly introduce our formal apparatus: We propose that eventive vPs[19] are predicates of forces, type <f,t>; they will be represented by the lowercase Greek letter π. Propositions, as well as statives (including small clauses), are predicates of situations, type <s,t>, and are represented by lowercase Roman letters p, q, etc.[20]

(16) a. ⟦ [$_{vP}$ Juan open the door] ⟧ = λf . source(Juan, f) & ⟦ [$_{SC}$ open the door] ⟧(fin(f))

b. ⟦ [$_{SC}$ open the door] ⟧ = λs . the door is open in s

Situations will be referred to by the variables s, s', and so forth. Recalling the definitions given above in (9) through (11), the net force of a situation s, is *net*(s), and a situation can also be referred to as *init*(f) or *fin*(f), as well as *pred*(s) and *suc*(s). In bubble diagrams, we will continue to refer to situations with respect to other numbered situations in the causal chain; i.e., if s_0 is a situation (typically the topic situation), s_1 is its (*ceteris paribus*) successor, and s_{-1} is its predecessor.

6.4.1 Non-culminating accomplishments

In culminating and non-culminating accomplishments alike, the net force of the topic situation s_0 is described by the vP. In languages or forms where accomplishments culminate, we propose that there is a presupposition that s_0 is *efficacious* (see (13) above). That is, s is presupposed to proceed successfully, via the action of its net force, to its successor without interference from forces generated from outside of s_0. When s_0 is presupposed efficacious, it is entailed that the final situation of the net force of s_0 actually occurs.

Where accomplishments are non-culminating, on the other hand, as in (2)-(3) above, we propose that there is *no* presupposition that s_0 is efficacious. Thus the result situation *fin*(f_0) of the net force of s_0 is not entailed to occur. On the other hand, there is still an implicature that the result situation *fin*(f_0) holds. The reason is ultimately one of Gricean Quantity: *fin*(f_0) is by definition the *ceteris paribus* successor of s_0, the situation that occurs if all else is equal. But if all else is not equal, i.e., if the circumstances are somehow unusual, the speaker would be expected to have said so. So unless something specific is said to indicate that the result situation of the net force of s_0 does not hold, it is implicated to hold. Significantly, there is no need for a modal operator quantifying over possible worlds to account for the non-culmination cases (cf. Matthewson 2004, Copley 2005a, 2007), as the absence of culmination follows from the absence of a presupposition of efficacy, rather than from any additional operator that removes the culmination entailment from the sentence.[21] Thus, the culmination entailment is simply dispensed with—never generated at all—rather than defeated, in our analysis of these forms. It is an *additional* component in languages (like English) that have it, introduced via the extra presupposition of efficacy. In short, the absence of a culmination entailment is the basic case, because by their very nature forces can always be interrupted or overcome, and entailed culmination is the marked case.

The difference between languages with and without culminating accomplishments, then, is a difference in the presuppositions attached to the vP. Such a purely semantic parameter would be unusual in the modern Minimalist generative framework, which generally treats parameters as associated with the properties of particular functional categories in different languages. It is possible that this presupposition is attached to a particular morpholexical item in the relevant languages, rather like the presence vs. absence of definite determiners crosslinguistically.[22] For the moment, we leave the presuppositional treatment as a proposal, noting however that *non*-efficacy shows up as a presupposition in the Tohono O'odham frustrative (see examples (19) and (20) below). For a further indication of the line of argumentation that motivates our view, see, for instance, Copley's (2008, 2009) treatment of the presupposition of ability in futurates and futures. We also believe that there is a strong parallel between this presupposition and that of maximality in definites; see, for example Fillip (2008) on maximality applied to event semantics in the analysis of telic predicates. we leave the investigation of the existence and nature of this parameter for future research.

6.4.2 The Tohono O'odham frustrative

We now turn to the particular empirical analysis that is our central concern in this paper, exploiting the framework developed above. Tohono O'odham, a Uto-Aztecan language spoken in southern Arizona, has a frustrative particle *cem* (Hale 1969, Devens 1972, Copley 2005a). This particle is associated with two[23] meanings: 'non-continuation' and 'unachieved goal,' as shown below, applied to the stative predication 'I (was) ready':[24]

(17) Cem ’añ ñ-na:tokc.

FRUS 1sg 1sg-ready

non-continuation: ‘I was ready but now I'm no longer ready.’

unachieved-goal: ‘I was ready but you weren't there.’

(Copley, 2005a: 1)

Below, we first explicate the treatment of statives and efficacy in the force-theoretic model, and then show how the two readings are derived when *cem* is combined with stative predicates.

6.4.2.1 Statives in the force-theoretic framework

We treat statives, first of all, as properties of situations. The interpretation of the main predicate in (17), then, is given in (18), which is true if ⟦I ready⟧ holds of situation s:

(18) stative : λs . ⟦I ready⟧(s)

In sentences with *cem*, we propose that a presupposition of non-efficacy is introduced. In (17), for instance, it adds the presupposition that the situation s of which ⟦I ready⟧ is predicated is not efficacious. The behavior of negated *cem* sentences (Copley, 2005a: 12) motivates the treatment of non-efficacy as a presupposition, since for them too, s is not efficacious; in (19), for example, the (negative) state fails to continue, and in (20) a goal is unsatisfied—in this case, the goal of the speaker not to go.

(19) Pi ’o cem suam g howij.

NEG aux FRUS yellow DET banana

‘The banana wasn’t yellow.’

speaker: ‘I walked by the banana tree yesterday, it wasn’t yellow, but now it’s yellow.’

non-continuation

(20) Pi an˜ cem n˜-na:tokc.

NEG 1sg.aux.IMPF FRUS 1sg-ready.IMPF

‘I wasn’t ready.’

speaker: ‘Someone came by – I wasn’t planning to go, so I wasn’t ready.’

unachieved-goal

(Copley, 2005a: 12)

Recall our definition of efficacy from (13) above:

(13) Definition of efficacy

A situation s_n is *efficacious* just in case its normal *ceteris paribus* successor s_{n+1} actually obtains. That is:

for any s_n with a net force f_n, then s_n is efficacious iff fin(f_n) (i.e., $s_{n+1,}$ the successor of s_n) actually obtains.

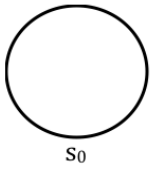
A presupposition of non-efficacy, then, as things currently stand, says that the successor situation s_{n+1} does not occur. However, it is not clear that this will suffice to capture the readings associated with *cem* when applied to a stative predicate. The reason is that this definition of

efficacy does not address the status of the successor to a situation described by a stative predicate. The question is whether the model must represent such situations as having no net force at all; if such situations are to be represented, the further question that arises is how to define the notion of efficacy in such cases.

We take it to be reasonable to represent such situations. A speaker can easily have in mind a 'still life' snapshot--a situation where no energy is being added, and hence no net force exists (making *net* and *suc* partial functions). It is crucial to distinguish still life situations from situations in which energy is being input but counteracted, which have a zero-magnitude net force because the forces involved in the calculation of the net force are exactly balanced. The latter kind of situation can be described by a verb of maintaining, such as *keep* or *stay* (see Copley & Harley submitted, for an analysis). In such cases, there is a successor situation, and it is identical to the first situation: a zero-magnitude net force creates a successor situation to s just as any other net force does. In the case of the still life situations, however, we claim that no successor situation is defined; in order for a situation to have a successor, force (i.e. energy) must exist in the situation.[25]

A still life situation, having no causal relation to a subsequent situation, is depicted in the bubble diagram notation as follows:

(21)



Such a situation is a good candidate for the situation argument of stative predicates. The failure of stative assertions to advance the temporal anchor of the narrative in discourse suggests that asserted statives indeed do describe such a situation: a stative assertion has a 'scene-setting' effect, adding information about the situation under discussion, but not providing any information about what happens next. In other words, stative assertions do not entail (or even imply) the existence of a successor situation. We conclude that statives can only be asserted of still life situations.

(22) Assertability of statives:

A stative predicate of p is asserted to hold of a situation s only if there are no forces represented in s.

We can now ask what it would mean for a still life situation to be efficacious. A speaker with a still life situation in mind does not expect anything to happen; if no energy is input into the situation, it will not lead to a successor situation. For such a situation to be efficacious, then, nothing should happen.

A situation therefore can be efficacious regardless of whether it has a net force. If an efficacious situation has a net force, the result of that force applied to the situation actually happens. If an efficacious situation does not have a net force (because no energy is being applied to the situation), then it is efficacious to the extent that (or just as long as) that situation persists. When something else happens, as it inevitably will, necessarily the energy that causes that something else will come from outside of the situation. The intuition is that without an input of energy, nothing happens.

Let us then add a clause to our definition of efficacy to capture this intuition:

(23) Definition of efficacy (extended to include statives)

A situation s_n is *efficacious* just in case its normal *ceteris paribus* result actually obtains. That is:

for any s_n with a net force f_n, then s_n is efficacious iff *fin*(f_n) (i.e., $s_{n+1,}$ the successor of s_n) actually obtains.

for any s_n that has no net force, then no successor is defined, and so s_n is efficacious iff it has no successor.

4.2.2 Stative cem sentences

Now we are ready to consider what happens when a speaker uses *cem* with a stative predicate as in (15). We have said, following Copley (2005a), that *cem* contributes a presupposition of non-efficacy.

(24) [[*cem*]] λs λp . p(s)

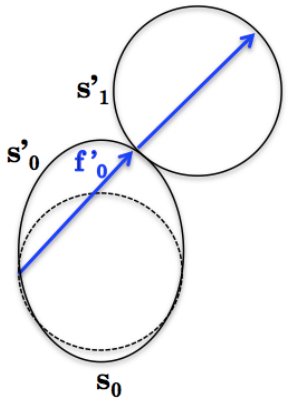
presupposed: s is not efficacious

This denotation is appropriate because when *cem* is added, in both the non-continuation reading and the unachieved-goal reading alike, the property actually does hold at the past topic situation; the speaker was ready, but the state didn't continue or some goal was not achieved.

Now, we elucidate how the combination of *cem* with a stative predicate derives the two readings. First, the non-continuation reading: the *cem* presupposition is that s_0 is not efficacious. Since s_0 is described by a stative predicate, s_0 is a still-life situation—it has no net force. That

means that nothing happens next; s_0 has no successor s_1. However, if s_0 is non-efficacious, as presupposed by the use of *cem*, we know that something happens next instead of nothing happening next. In fact, there is an efficacious situation s_0' that includes s_0, and what happens next is exactly the successor of s_0'. This state of affairs is illustrated below:

(25)



That means that s_0 was not a good representation of the relevant state of affairs in the actual world: something external to s0, but in s'_0, produced a force f'_0 that intervened to produce s'_1.

Because s_0 is a still-life situation, it does not have any forces represented in it. Let's assume for now as well that s_0 is minimal; we will look at the non-minimal case shortly. If situations are annotated snapshots, then a minimal s_0 in this case is one that contains only the speaker with the annotation that corresponds to readiness (and no other individuals, nor any other annotations representing properties of the speaker).

For the non-continuation reading, what we want to derive is that the speaker is not ready in s'_1. *Cem* tells us that there was a perturbing force, i.e. energy was put in that produces s'_1. Given that s_0 was minimal, the force that was put in must have produced an alteration in the

characteristics included in s_0; for if nothing had happened to these characteristics as a result of the input of energy, nothing would have resulted, contra the presupposition contributed by *cem*.[26] So, as desired, the only possible net force in s'_0 results in a successor s'_1 in which the speaker isn't ready.

Now let us suppose instead that s_0 was *not* minimal. What else could be represented in s_0 while still respecting the assertability condition on statives above? The assertability condition tells us there can't be any energy in s_0, so if s_0 is not minimal, the only other annotations it contains must also be stative in character. Aside from p, [[*I ready*]], suppose some other arbitrary stative proposition q also holds of s_0. In this case, given what we have said up to this point, the addition of *cem* would not be expected to guarantee the non-continuation of p, because q could also be affected by the (unexpected) net force of s'_0, so we would predict a 'non-continuation of arbitrary q' reading. That is, there could be an s'_0 such that its net force results in s'_1 where p holds of s'_1 but q does not—i.e. it could be that the net force of s'_0 makes it be that not q. Then we would expect to be able to get a reading in which p holds in both s_0 and s'_1, that would be neither the non-continuation (of p) reading, nor the unachieved-goal reading (on which see below). However, no such 'non-continuation of arbitrary q' reading is available. We assume that such a scenario is out for reasons of relevance: if q is what changes, the speaker would be expected to say so. So there is no such reading because the speaker is talking about p, not about another arbitrary stative property q; p must be what fails to continue to the successor situation s'_1.

Now we move to the unachieved goal reading. In this reading, p does hold in the successor situation s'_1, namely, in which what goes wrong is not the continuation of p but rather a goal or plan that depends on p holding for its realization.[27] To make sense of the unachieved goal reading, we must therefore first consider how to characterize the relevant notion of a plan within the force-theoretic framework.

We hypothesize that the notion of plan evoked in the unachieved goal reading is the same as that in futurate sentences, in which only plannable events are allowed (as in (26a); (26b) is possible if it can be felicitously planned that the Red Sox defeat the Yankees tomorrow).

(26) a The Red Sox play the Yankees tomorrow.

b #The Red Sox defeat the Yankees tomorrow.

Futurates occur in many but not all languages; Tohono O'odham, for instance, lacks them. A plan in futurates is held by an entity (the 'director') who has a desire for p and the ability to control whether an instantiation of p happens (Copley 2008, 2009a).[28] We distinguish between the existence of the plan (or goal) itself, the content of the plan, and the realization of (the content of) the plan. For example, in (26a) above, there exists a present plan for the Red Sox to play the Yankees tomorrow; the content of the plan is the proposition that the Red Sox play the Yankees tomorrow, and the plan is realized just in case the Red Sox actually do end up playing the Yankees tomorrow as a causal consequence of the director's desire and ability.

A more explicit characterization of plans and planning will take us too far afield. In the context of the force-theoretic model, we will note merely that the existence of the plan behaves like a present stative predication, as might be expected for an existence predicate. For instance, similar to the stative in (26a), the futurate in (27b) is compatible with 'it's true that' in the antecedent of a conditional (cf. Copley, 2009b); we know it's a futurate in (27b) rather than any other kind of future reference because the unplannable eventuality in (27c) is unacceptable.

(27) a. If it's true that Mary is here ...

b. If it's true now that Mary leaves tomorrow …

c. If (#it's true that) Mary gets sick tomorrow ...

In the force-theoretic framework, this means that plans can be treated essentially as states, albeit rather special states; they are states that somehow entail a successor. Copley (2011) argues that when a futurate is asserted of s_0, it is presupposed (due to a presupposition of the ability of the director) that the plan is realized in the successor of s_0. This successor, s_1, is the causally immediate successor of s_0 but is not necessarily the temporally immediate successor of s_0; it can happen after a temporal gap. This ability to provoke causally immediate but temporally distant effects is a hallmark of volitionality. For most physical forces, on the other hand, the causally immediate result is necessarily temporally immediate; the causal successor of s_0 is either cotemporaneous to s_0 or is immediately temporally subsequent to s_0. It is in part for this difference between plans and physical forces that the planning contrast in futurates arises, as it is only plannable eventualities that can leap into a distant future time with one causal step via a plan.[29]

A plan is evoked in unachieved-goal readings of *cem* sentences such that p is apparently related to the successful carrying out of the plan. We have just suggested that the existence of a plan, asserted in futurates, is presupposed in unachieved goal readings of *cem* sentences. A question thus arises: why the existence of a plan is necessarily presupposed in the reading where p continues (recall from the discussion above of the non-continuation reading that an arbitary stative predicate q is not possible).

To address the first question, recall that we argued for a constraint we called the 'assertability of statives', which requires there to be no energy input into the situation of which a

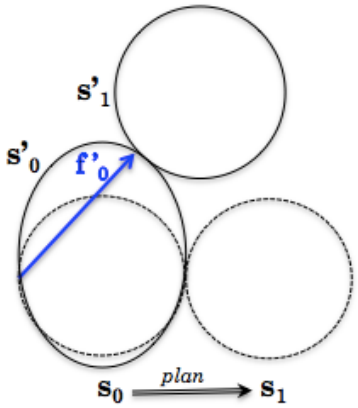
stative is asserted. So, as we argued, no force, and thus no eventive predicate, can figure presuppositionally in the calculation of the failed result entailed by *cem*. The only thing that can be presupposed to hold of s_0 is another stative predicate. As we argued above, the existence of a plan is a stative predicate holding of a situation, so it is a possible candidate presupposition.

However, we also argued above, appealing to relevance, that *arbitrary* stative q can *not* be presupposed of s if p holds of s'_1. Does this erroneously rule out the case when q is the existence of a plan? We suggest that it does not, because p can be relevant to the plan in a certain way, so the argument about arbitrary q does not apply to plans. The state p is relevant to the plan in the sense that it contributes to the ability of the director to bring about the realization of the plan. That is, if the speaker thinks that p is causally necessary to their ability to be the source of forces to realize their plan (i.e., to make the successor come about), then relevance is satisfied.[30]

Thus, since plans are statives that nonetheless entail the existence of a successor situation, and since a stative p can be relevant to a plan, the accommodation of a plan licenses stative *cem* sentences in which p is true of s_0 and s'_1, guaranteeing that such sentences have an unachieved goal reading. What is unachieved is the realization of the plan.

We are at a disadvantage when it comes to representing such a state of affairs in bubble diagrams, as we have not given a full analysis of what it is to be a plan (cf. Copley 2008, 2011 for earlier efforts). In the absence of such an analysis, we will indicate that a plan in s_0 yields a successor s_1 with a double arrow, as illustrated below:

(28)



Having addressed the interaction of *cem* with lexical statives, we next consider the derivation of the readings that occur when *cem* is added to sentences containing eventive predicates—predicates denoting properties of forces.

6.4.2.3 Tohono O'odham aspect in the force-theoretic framework

In combination with an eventive predicate, the meaning contributed by *cem* depends on the viewpoint aspect (Smith, 1991) of the sentence, as shown in (29a-c) (Copley, 2005a: 9). [31] The unachieved goal meaning is always possible. However, only the perfective can license the non-continuation meaning.

(29) a. Huan ’at o cem kukpi’ok g pualt.

Juan aux.PF FUT FRUS open DET door

unachieved goal: ‘Juan tried to/was going to open the door.’

(he tripped before he got there)

b. Huan 'o cem kukpi’ok g pualt.

Juan aux.IMPF cem open DET door

unachieved goal: ‘Juan tried to open the door.’

(he pulled but couldn't get it open)

c. Huan ’at cem ku:pi’o g pualt.

Juan aux.PF FRUS open DET door

‘Juan opened the door in vain.’

non-continuation: Juan got the door open but it didn't stay open

unachieved goal: The door's being open didn't have the desired effect

Thus only the perfective *cem* sentence, i.e. (29c), has both the non-continuation reading (where it is the result state that fails to continue) and the unachieved goal reading. In addition, the unachieved goal reading, common to all three of (29a-c), is realized differently in each. Note that (29c) is different from (29a) and (29b) in that in (29c), the force applied to open the door is actually successful, instead it's the staying open, or being open for some reason, that fails.[32] We will argue below that these differences between aspects follow straightforwardly from the composition of aspect and *cem.*

It is clear that in order to fully understand the patterns illustrated above, we must understand how O'odham aspect interacts with the denotation of the vP in the force-theoretic framework. We therefore will take a brief detour to accomplish this.

Aspect, we assume, maps from predicates of forces to predicates of situations, so it is type <<f,t>, <s,t>> (this assumption is analogous to the common idea that aspect maps from event predicates to temporal predicates; e.g., Klein 1994, Kratzer 1998).

The prospective aspect[33] is shown in (30):

(30) Huan 'at o kukpi'ok g pualt.
Juan aux.PF FUT open DET door
'Juan will open the door.'

In the force-theoretic framework, we propose that the prospective takes a predicate of forces π, the denotation of the *v*P, and a situation s_0, the topic situation provided by tense, and says that π holds of the net force of some situation in the causal chain proceeding from s_0, that is, in one of s_0's successor situations.[34] We inductively define a successor function 'suc^n' below:

(31) a. $suc^1(s) =: fin(net(s))$

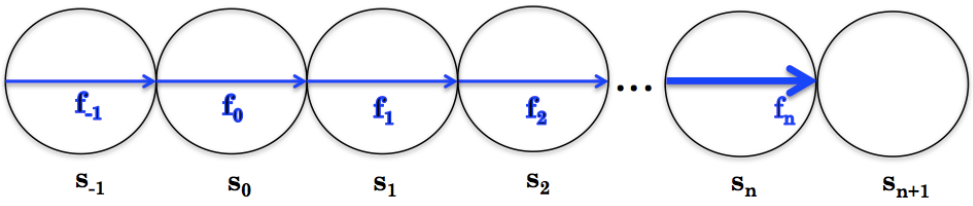
b. $suc^{n+1}(s) =: fin(net(suc^n(s)))$

The denotation of the prospective is given in (16):

(32) $[\![\text{prospective}]\!] = \lambda\pi\, \lambda s\, .\, \exists n\text{: } \pi(\text{net}((\text{suc}^n(s)))$

The diagram below shows that some future net force is referred to in the denotation of the prospective; (32) is true in s_0 because there is a later situation s_n in the *ceteris paribus* chain of situations proceeding from s_0 such that [[Juan open the door]] holds of the net force of s_n. The thickened arrow represents the net force of which the vP is predicated.

(33)



The imperfective is realized as an auxiliary in Tohono O'odham, as shown in (34):

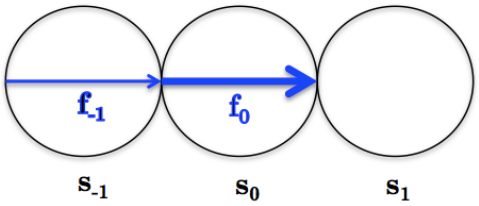
(34) Huan 'o kukpi'ok g pualt.
Juan aux.IMPF open DET door
'Juan is opening the door.'

For the progressive reading of the Tohono O'odham imperfective[35] we propose, following our discussion of the English progressive in Copley & Harley (submitted), a denotation that takes a predicate of forces (π, the denotation of the vP), and a situation s (which will be identified with s_0, the topic situation provided by tense), and says that the property π holds of the net force of s.

(35) $[\![\text{imperfective}]\!] = \lambda\pi\,\lambda s\,.\,\pi(\text{net}(s))$

So, for example, if Juan is baking a cake, the net force of the current situation is one which leads to a situation in which a cake[36] has been baked by Juan (i.e., the normal result obtains), if all else is equal.

(36)



That is, a force with the property π is the net force in the topic situation, and if all else is equal and nothing external interferes, s_1 results. For example, $[\![\text{imperfective}]\!]([\![\text{Juan open the door}]\!])(s_0)$ will say that the net force of s_0 is the force of Juan opening the door; if nothing intervenes, the door will subsequently be open in the situation immediately following the topic situation.

Finally, we will treat perfective aspect as a kind of resultative, signaling that the result of some force holds of the topic situation; this entails that π holds of the net force of the situation in the causal chain immediately preceding s_0. We define a function 'pred' that picks out the[37] immediate predecessor of a situation.

(37) pred(s) =: the s' such that fin(net(s')) = s

Like imperfective aspect, perfective aspect in Tohono O'odham is also realized by means of an auxiliary:

(38)

Huan	'at	cem ku:pi'o	g pualt.
Juan	aux.PF	FRUS open	DET door

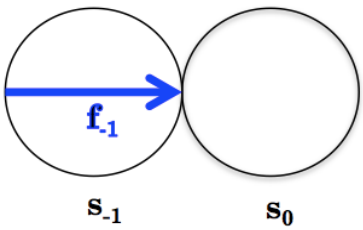
'Juan opened the door.'

The proposed denotation for perfective aspect takes a predicate of forces (π, the denotation of the *v*P), and a situation s (to be identified with s_0, the topic situation) and says that the predicate of forces π is the net force of the predecessor of s— that is to say, π is true of the net force of s_{-1}, the situation preceding the topic situation.

(39) ⟦perfective⟧ = λπ λs . π(net(pred(s)))

In the diagram below, the net force that has the property π is again in bold:

(40)



That is, a force with the property π is the net force in the causal predecessor to the topic situation, and s_0 results. (Because of historical necessity, we already know that s_{-1} is efficacious and results in s_0; or rather, the speaker knows how to choose s_{-1} so that it is efficacious.) ⟦perfective⟧(⟦Juan open the door⟧)(s_0) says that the net force of s_{-1} is a Juan-opening-the-door force; in the topic situation s_0, the door is open.

6.4.2.4 Eventive cem sentences

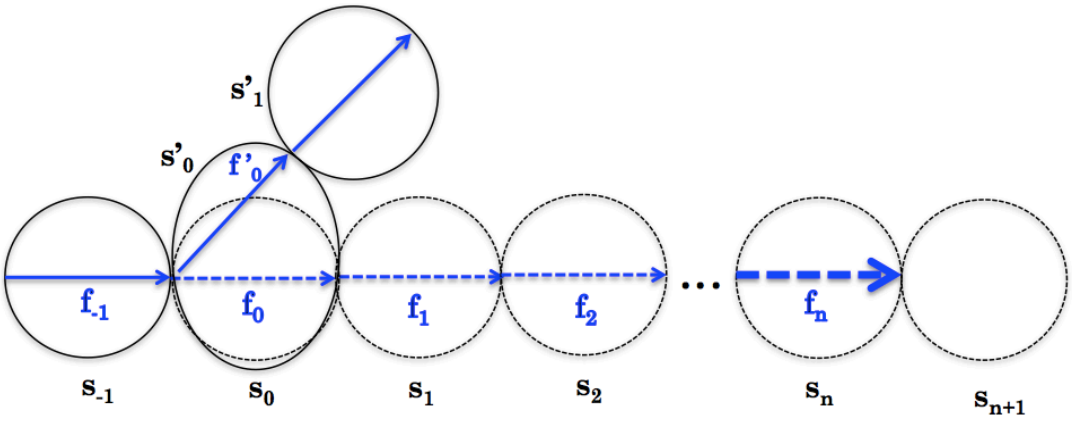
Now we will show how the interaction of *cem* with aspect results in the correct denotations for the eventive *cem* data. We will take each aspect in turn, first repeating the denotation of the sentence without *cem* and then showing how the correct denotation arises from the addition of the presupposition supplied by *cem* (namely that s_0, the topic situation, is not efficacious).

The prospective aspect *cem* sentence, as in (29a), conveys that Juan tripped on his way to open the door (for instance) and so never began the event of opening the door. We analyze (29a) as follows. The assertion is the same as if *cem* were not there: there is a situation s_n in which the net force is described by the *v*P; s_n is in the causal chain proceeding from the topic situation s_0.

(41) ⟦ (29a) ⟧ = ∃n: ⟦Juan open the door⟧(net($suc^n(s_0)$))

We propose that *cem* adds the presupposition that s_0 is not efficacious; that is, that s_0 did not proceed without interference. Thus the immediate successor of s_0 (namely, s_1) doesn't happen.[38] Therefore s_n doesn't happen either—no Juan-open-the-door net force ever occurs, so Juan doesn't even start opening the door. This is indeed the correct meaning for (29a). The addition of forces external to s_0 originating in s'_0 is illustrated below:

(42)

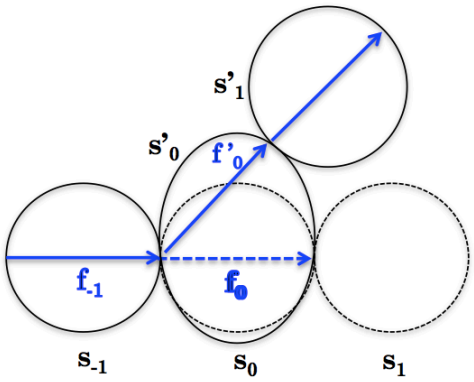


In the case of the imperfective, a sentence with *cem* as in (29b) conveys that Juan does something to open the door, but the door does not open. As before, the assertion is the same as without *cem.* In this case that means that the net force in s_0, the topic situation, is described by the *v*P. In (29b), for instance, the net force in s_0 is a Juan-open-the-door force, which results, *ceteris paribus,* in a situation where the door is open.

(43) $[\![(29b)]\!] = [\![\text{Juan open the door}]\!](\text{net}(s_0))$

With *cem* we add the presupposition that s_0 is not efficacious, therefore s_1 didn't happen, because something from outside s_0 (but, we assume, inside s'_0) originates a force that intervenes. Instead, s'_1, the successor of s'_0, happens. This correctly entails that the force was applied in s_0 without successfully causing s_1, as illustrated below:

(44)



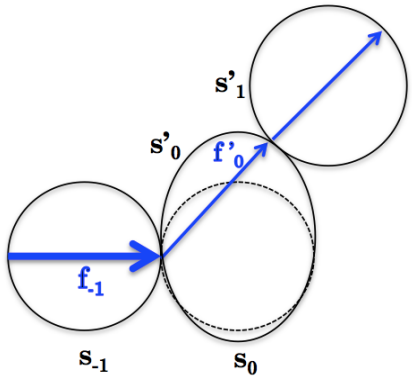
Unlike the prospective and imperfective *cem* sentences, perfective *cem* sentences have both of the meanings attested for statives: non-continuation as well as unachieved goal. Again, the assertion of the perfective *cem* sentence is the same as that of a perfective sentence that lacks *cem*. That is, the *cem* sentence in (29c) asserts that the vP characterizes the net force of s_{-1}, the immediate predecessor situation of s_0. The final or resulting situation of the net force of s_{-1} thus holds in s_0, the topic situation.

(45) ⟦ (29c) ⟧ = ⟦Juan open the door⟧ (net(pred(s_0)))

So in the perfective case, the result state holds of the topic situation s_0. But then, as in the stative case, a stative predicate holds of s_0, so by exactly the same arguments as for the stative case, the unachieved goal and non-continuation readings arise.

The perfective *cem* sentence is true at s_0 in a state of affairs such as (46):

(46)



Given that these two readings occur with both perfective and stative *cem* sentences, the question arises of whether the theory correctly predicts that imperfective and prospective *cem* sentences do not get their own analogues of the non-continuation reading. It turns out that the theory does correctly make this prediction. The non-continuation reading is derived when compliance with the non-efficacy presupposition means interrupting a state—that is, something happening instead of nothing. In the prospective and imperfective cases, there is no state to interrupt.[39]

6.5 Conclusions and consequences

Above, we have proposed to reify *forces* in the semantic ontology, as functions from situations to situations. We argue that this provides a natural approach to phenomena in which one event would normally be expected to cause another in a causal chain, but exceptionally the second event fails to occur. We have suggested that this defeasibility of causation should be modelled by understanding Davidsonian arguments as forces rather than events, where the first argument is the force and the second argument is the situation that results from the force only if

nothing external to the initial situation intervenes to perturb that force. We have illustrated the application of these ideas in the analysis of the O'odham frustrative particle *cem*.

In so doing, we have come to various conclusions about the behaviors of different types of predicates in the framework. In particular, the discussion leads to a concrete proposal about how stative predicates function. Statives are asserted only of 'still life' situations— those with no net force. Without a net force, no successor situation is defined. The interaction of the absence of forces with the notion of 'efficacy' imposes restrictions on the interpretation of stative sentences modified by *cem*. In analyzing how these restrictions play out, we have been motivated to incorporate the notion of 'plan' into the linguistic semantics as a natural component of the treatment of unachieved goal readings of stative and perfective sentences. We note that the alternative, in a standard Kratzerian model, would be to posit an unpronounced plan modal (cf. Copley 2008, 2009) that quantifies over possible worlds, just for the unachieved-goal readings but not for the non-continuation readings. We consider such an alternative to be a non-starter for these data. Even if the plan is accommodated in such a model rather than represented directly in the semantics, it would not be clear why. In the force-theoretic framework, we have proposed that the reason why is that it is the only way to satisfy two constraints imposed by the model on the representation: namely, that only statives are predicated of the still life situation s_0, and that s_0 nonetheless has a successor.

The viewpoint aspect denotations represent a departure from many analyses of aspectual operators in that there is no explicit reference at all to temporal relationships between times, situations, or events. Rather, the way that we put the 'view' in 'viewpoint aspect' is by appealing to discrete situations, net forces, and the causal relationships between them in a deterministic causal chain. Causally precedent and subsequent situations and forces can be referred to, using the functions *pred* and *suc,* which are themselves derived in large part from the definition of net

force. In our framework, for instance, the denotation of the (resultative) perfective is nearly immediate; the other aspects are also simplified greatly by the notion of net force. We expect that a force-theoretic approach to aspect will prove similarly fruitful in treating aspectual distinctions in other languages; we plan to revisit this topic in future work.

The overall result of the force-theoretic framework is a simpler semantics, compared to the possible world approach, which must rely on additional semantic machinery to account for non-occurring results, to defeat the causative entailment. The denotations that then result are markedly simpler than in the possible world approaches. We do not deny that *some* notion of inertia is necessary for many different types of meanings; in our model, however, this complexity is managed in the cognitive system that calculates net forces, rather than in the semantics.

Our feeling is that the force-situation framework could clarify the interface with the cognitive system, since its ontology—situations as spatiotemporal arrangements of individuals with the forces on them—may be preferable to that of the event-based framework with its concatenated events that somehow cause one another.[40] It may also be preferable to treatments of situations as partial worlds within the framework of situation semantics (Barwise & Perry 1981, Kratzer 1989, 1990/2009, Portner 1997), since it is not at all clear how to make cognitively plausible sense out of possible worlds thus constructed.[41] On the other hand, we see no reason why many of the advantages of situation semantics (such as, for example, the use of situations as arguments of quantification in modals, Kratzer 2009) could not be retained with our situations.

Notes

[*] We gratefully acknowledge helpful comments and discussion from Berit Gehrke and two anonymous reviewers.

[1] Talmy, as well as Sweetser (1982, 1984), further proposed that the physical-force model maps straightforwardly to the psychological realm, since these same predicates are used to characterize psychosocial as well as physical causal relations. This proposal develops a central theme of cognitive linguistics according to which abstract conceptual content is derived from representations of physical reality (see, e.g., Bloom, Peterson & Garrett (1999) for an overview). Wolff (2007, this volume) has demonstrated the psychological validity of Talmy's proposals, showing experimentally that the magnitudes and interaction of physical forces in an animated environment can be very precisely predictive of speakers' choice of lexical items for such predicates, and that these effects transfer unproblematically to psychosocial contexts.

[2] We address the English progressive and the imperfective paradox at length in Copley & Harley (2012).

[3] We use the term 'accomplishment' following common usage, although this category includes some achievement predicates as well.

[4] Note that although the underlying form of the infix is listed as *-an-*, it is subject to morphophonological changes that can affect its surface realization.

[5] In Dell's 1987 paper, 'N' stands for the 'neutral' form of the verb, 'A' for the 'abilitative' form of the verb.

[6]It is worth emphasizing that these neutral sentences, while not entailing completion, are not imperfectives or progressives; they do not, for instance, behave in discourse as though they were derived statives, and cannot be an answer to the question 'What is/was happening?' (Matthewson,

2004). In fact, in Bar-El (et al. 2005), the authors assert that the neutral form is perfective, lacking an overt marking for imperfectivity. We follow these authors in considering that it is inappropriate to treat such sentences as containing, e.g., a null imperfective operator.

[7]Abbreviations: ACT = actuality aspect, COMPL = completed, DS = different subject, NONSQ = non=sequence, SQ = sequence, TH = theme, TR = transitive, DECL = declarative.

[8] See also Vecchiato (2003, 2004) for a use of 'force' that is very much in the spirit of the proposal here, but without a specific formal implementation.

[9] For a more detailed discussion of how the terms *force* and *situation* are to be understood in the force-theoretic framework, see Copley & Harley (2012).

[10]Davidson (1966) expresses skepticism that events can be represented by transitions from one state to another, remarking that there are any number of ways to go from San Francisco to Pittsburgh (by foot, by air, by mule, …) and all these are different kinds of events although the initial and final state are the same. This objection does not, however, pertain to the idea of events as functions from one state (situation) to another. There are any number of ways to get from the integer 2 to the integer 4 ($x+2$, $x*2$, x^2, …) by way of distinct functions; likewise, there are in general different ways to get from one situation to another by way of distinct functions.

[11]In a sense, we are proposing that the cognitive system treats the initial situation as the 'object' on which all forces act; a force on a cup in fact is a force that applies to the situation to result in another situation where the cup is located somewhere else. If this perspective is correct, it may provide some insight into the way our cognitive system represents such apparent 'forces on objects'; no object can be represented in isolation; it always forms part of a situation, even if that situation is quite minimal. A force diagram containing just an object, with no external spatiotemporal frame of reference, makes no intuitive sense.

[12]This implies that the nature of the indeterminacy of the future may be epistemic, i.e., that there is a fact of the matter but we just don't know what it is (cf. McTaggart's (1908) B-theory of time). We do believe that there is a metaphysical difference between the past and the future in that the future hasn't happened yet (making us A-theorists, in McTaggart's terms), in part because of overwhelming grammatical evidence that there are temporal differences between metaphysical and epistemic modality (Condoravdi 2001, Werner 2006, among many others). It is true that the nature of the indeterminacy is in general epistemic in the model, with the (important) exceptions of animate entities' whimsical choices and, presumably, quantum events. However, it is significant that in our model, what is not known is not the future, but the present; this principle is also endorsed by Kissine (2008) with respect to *will*.

[13] This is the 'closed-world' assumption; see Weld (1994) and van Lambalgen & Hamm (2005).

[14]This abstraction is already present in Aristotle's *Physics*, though Aristotle doesn't extend this analysis to verbs of creation and destruction (V:1); we assume that it applies to all predicates.

[15] Our normal field bears some similarity to Mackie's (1974) background or causal field.

[16]Many of the intervening situations in a causal chain involve forces which are crucial to the outcome, but not usually licit as causer subjects in sentences about that causal chain, as illustrated by the example in (i):

(i) Booth/The gunshot/The bullet/#Gravity/#Friction/#The density of his clothes and flesh killed Lincoln.

Languages may vary in which causers in the causal chain can be subjects (see, e.g. Folli 2002 on Italian vs. English), but one feature of the illegitimate subjects in (i) above is that the entities which they name are associated with forces in the normal field. We do not propose to try to provide an account of which causes in the chain are licensed as appropriate subjects in a given

language or in general, that being properly within the purview of psychologists or philosophers studying causation (see Thomason, this volume, for instance). We note, however, that one relevant factor may be whether the speaker mentally represents a given force as derived from the normal field.

[17]In generic sentences, however, we suspect that the normal field may make an appearance in the semantics; the idea would be that generics assert that a particular force is in the normal field of the topic situation.

[18] See Condoravdi & Lauer (2009), as well as the notion of 'commitment' in Copley (2009).

[19] The vP corresponds to the constituent which in Government-Binding theory and other syntactic theories is typically labeled VP, 'verb phrase'; it is the highest projection within the verb phrase and responsible for introducing the Agent argument. See Harley (2010) for a fuller exposition.

[20] The force-theoretic framework thus provides a type distinction between eventive and stative predicates; some consequences of this distinction are noted in Copley & Harley (2012).

[21] We note also that partial event accounts such as that of Singh (1998) and Koenig & Chief (2008) have the same problem as pointed out in Portner's (1998) critique of Landman (1992) and Parsons (1990); namely, that the question of how a partial event is related to a completed event is left unaddressed.

[22]It is striking to note that in languages with non-culminating accomplishments, there are frequently overt morphosyntactic indicators of completion. This may support the notion that the efficacy presupposition is attached to a particular lexical item.

[23] There are also other readings of *cem;* it occurs in counterfactuals (Hale, 1969) and also with a 'bad example' reading, as shown in (i) Devens (1972: 351, in the very closely related language

Akimel O'odham, orthography updated) and (ii) Copley (2005a: 3) below; for the latter, reading (iia) is the unachieved goal reading, while reading (iib) is the bad example reading.

(i) m-a-n-t cem hikc heg heñ mo'o c 'ab**s** heg heñ novi 'ep hikc
INTR-AUX-1s-PERF FRUS cut.PERF ART my-hair and but ART my finger also cut.PERF
'I cut my hair but I cut my finger at the same time.'

(ii) Huan 'at cem pi cikp tako.
Juan aux-PERF FRUS NEG work-PERF yesterday
a. speaker: "Juan did work, but he didn't want to."
b. speaker: "Juan worked, but he did it badly."

We do not follow Copley's (2005a) assumption that bad example cases like (iib) are straightfoward instances of the unachieved goal reading. We suggest that the bad example reading might an epistemic variant of the unachieved goal reading: instead of p being a plan that fails to be realized, p is an expectation that fails to materialize. This story is in line with the idea that metaphysical/circumstantial modality progresses into the future but epistemic modality doesn't (Werner, 2003, a.o.); see also the discussion in Copley & Harley (2012) about analogies between metaphysical and epistemic modality in the force-theoretic framework.

[24] Note that past tense is not overtly marked in Tohono O'odham.

[25] It is, incidentally, perfectly possible to conceive of a still life situation s without entailing the end of the universe: since the transition to a successor situation is causally, not temporally,

defined, time may go on during s although nothing happens. That scenario at first blush sounds like a recipe for 'heat death'—the point at which the universe reaches a state of highest entropy and nothing else can happen—but recall that s is not the entire universe, but only a representation of a small bit of it. Forces generated externally to s can, as usual, intervene to change the individuals and properties in s.

[26] Recall that we have differentiated here between a still life (with no net force) and a keeping/staying situation, with a zero net force. The difference is that there is a non-zero input of energy in the latter situation, counterbalanced by a force in an opposite direction. That is, in the keep/stay situation, there's a subsituation with a net force that would take you to a different situation that the keeping energy input counteracts. Here on the other hand, there is no subsituation with a force. Still life situations have no force (and indeed probably no subsituations, as they are minimal). Consequently, if energy is put into a minimal situation, a zero net force could not arise from that input of energy. So things have to change: The speaker has to become unready.

[27] Note that the plan is not analogous to q in the 'non-continuation of arbitrary q' reading, as we will see shortly; the existence of a plan in s_0 entails that there is a successor s_1 of s_0, which is not the case with the stative predicate q. Furthermore, the plan is not arbitrary.

[28] The director can be but need not be the subject. For example, in (26a) above, it can be someone else, not the Red Sox themselves, who holds a plan for them to play the Yankees tomorrow and has the ability to ensure that that plan is realized.

[29] Plans thus require us to talk about the length of causal chains, which is possible in the current framework but has not been addressed in possible worlds approaches.

[30] This point might be due to a more general requirement that when p is asserted with the purpose of conveying something about q, p needs to be causally relevant to q.

[31]The future is always expressed by means of the perfective auxiliary plus a future marker. Tohono O'odham has no overt past tense marking, so that non-future-marked sentences are interpreted as either past or present tense. *Cem* sentences, however, are always interpreted as past tense; whether this fact follows from something in the meaning of *cem* or whether it is a pragmatic effect is not known.

[32]The frustrative morpheme *cem* is in a different place in the word order in (17) and (29), which raises the question of whether *cem* has the same scope when it occurs with statives as it does when it occurs in eventives. Since Tohono O'odham has quite (albeit not entirely) free word-order (See M. Smith 2004 and references therein for discussion of syntax in the closely related language Akimel O'odham (Pima)), there is a limit to the syntactic information that can be drawn from the word order facts, but it seems to occur just before (above) the state in the unmarked examples. The semantics reflects this as well: the existence of two similar readings for each of (17) and (29c) seems to indicate that *cem* bears the same relationship to the result state in (29c) as it does to the state in (17). We can also see that *cem* scopes over aspect, because aspect seems to apply directly to the verb phrase; the failure happens at a different point in the action in (29a-c) depending on the aspect.

[33]This periphrastic form is normally called a future (e.g. by Zepeda,1983); we call it an 'aspect' here to emphasize the similarity in meaning to the imperfective and perfective. We call it 'prospective' because it seems appropriate, not because it means *about to.* We suspect that *about to* may make a claim about s_1: $[\![\text{about to}]\!] = \lambda\pi\, \lambda s.\, \pi(\text{net}(\text{suc}(s)))$.

[34] The idea that futures should refer to longer causal chains than imperfectives is first raised in Copley (2004, 2005b).

[35] The O'odham imperfective does not occur with statives (Zepeda, 1983) and also has a generic reading, which we will ignore for the purposes of this chapter.

[36] As Landman (1992) notes, the progressive creates an intensional context: if Mary is baking a cake, the cake does not (yet) exist and may never exist. The status of such 'temporally opaque objects' (von Stechow, 2000) in the present framework is that they are objects referred to in the *ceteris paribus* result situation of the Mary-bake-a-cake force—a situation that may never come to pass. This status is similar to that of objects that exist only in inertia worlds. The status of the force itself is a different question, but it too has an existence; the Mary-bake-a-cake force exists, as it is the net force of a current situation. Thus we avoid positing partial events such as those proposed by Parsons (1989, 1990), and yet one key empirical benefit of inertia worlds is retained.

[37] We know that there is a unique such situation because of historical necessity; cf. Thomason (1970, this volume).

[38]Recall that the topic situation s_0 has a net force which, *ceteris paribus,* will result in s_1. But when s_0 is not efficacious, *ceteris* is not *paribus*.

[39] Another question that arises is whether the single reading available to prospective and imperfective *cem* sentences, which we have labeled 'unachieved goal' following Hale (1969) and Copley (2005), is indeed the same reading as the 'unachieved goal' reading for stative and prospective *cem* sentences. On our analysis, they are not exactly the same, because no accommodation of a plan is required in prospective and imperfective sentences with *cem* (though they are intuitively quite similar). Thus, if nothing more is said, we expect that a speaker should be able to say *Maria cem [prospective] get sick* (meaning something like 'Maria was going to get

sick (but she didn't)') and *Maria cem [imperfective] get sick* (with a meaning like 'Maria was getting sick (but she didn't)'), with an unplannable event that is not relevant to anybody's plan; i.e., Maria's getting sick does not make any relevant director able to carry out their plans. We hope to verify or falsify this prediction in future work.

[40] The force-theoretic framework should have ramifications for the interaction of lexical syntax with the semantics as well, as it represents a significant departure from now-standard accounts according to which each subevent in a causal chain is described by a separate predicate in its own phrasal projection within the lexical syntax (cf., e.g. Folli (this volume), Ramchand (this volume), Tatevesov & Lyutikova (this volume) for analyses within this general tradition). See Copley and Harley (ms) for extensive discussion.

[41] The difference between constructing possible worlds in a Lewis/Kratzer-style model and constructing them as we have suggested boils down to difference between the dependency and production views of causation; see the contributions of Copley & Wolff, Kistler, and Wolff, this volume.