Modeling progress: causal models, event types, and the imperfective paradox

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1. Introduction

Durative **telic predicates** (*accomplishments*; Vendler 1957) describe eventualities which comprise a sequence of developmental stages leading to a specific end or **culmination**. Culminations mark categorical transitions between developing *P*-eventualities and their associated *result states*, so that realization of a **culmination condition** (Kratzer 2004) precludes further development as a *P*-eventuality. Culmination conditions take a variety of forms, including the coming into being or destruction of an object (as in *bake/eat a cake*), arrival at the terminus of a path (*run a marathon*), or an instantaneous transition between states (*open a door*). The inherent, defining association between a (durative) telic predicate and its culmination condition is often cashed out in terms of the **culmination assumption:** that an uninflected telic predicate *P* denotes exclusively eventualities which describe complete development arcs, up to and including realization of the appropriate culmination condition.[1]

The culmination assumption is, *prima facie*, in tension with the observation that use of a telic predicate is frequently felicitous in contexts which preclude the appropriate culmination, as in (1).

(1) √Emanuel bake a cake *uninflected accomplishment predicate*

a. Emanuel began to bake a cake (but gave up immediately).
b. Emanuel continued to bake a cake (but never completed it).
c. Emanuel stopped baking a cake (and never returned to it).

Truth in (1a)-(1c) does not depend on the eventual existence of a baked cake; instead, each example relies on an (independent) assessment of the relationship between Emanuel's reference time activities and some notion of an appropriate cake-baking process. Insofar as the truth conditions of (1a)-(1c) differ from one another, their potential felicity suggests that telic predicates invoke a body of rich procedural information which is available for semantic interaction with aspectual verbs (e.g., *begin, continue, stop*) and/or other aspectual operators. Judgements for these data thus set up a puzzle: given that telic predicates appear to specify only their results (culmination conditions) overtly, how is the relevant procedural information introduced and mediated through the specification of a culmination condition?

The puzzle has typically been viewed through the lens of the so-called **imperfective paradox** (Dowty 1979), which centers on the potential felicity of telic progressives in non-culminating contexts:

(2) *Non-culminating telic progressive:* Emanuel was baking a cake (when he died).

The 'paradox' arises in the clash between the culmination assumption and the acceptability of examples like (2). Most work on the imperfective paradox preserves the culmination assumption, placing the

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[1] The telic class properly includes also punctual *achievements*, which pick out only a point of instantaneous change. We focus in this paper on accomplishments, and the term *telic predicate* refers to accomplishments unless otherwise stated. An extension of our proposal to those achievements which are empirically compatible with progressive marking (e.g., Bach's 1986 *culminations*) is left for future work.

explanatory burden for non-culmination on an intensionalized progressive operator (PROG), which shifts the instantiation of a qualifying (culminated) P-eventuality to a set of modal alternatives to the evaluation world (Dowty 1979, Asher 1992, Landman 1992, Bonomi 1997, Zucchi 1999, a.o.). On this approach, a(n actually) non-culminating eventuality e can satisfy the truth conditions of PROG(P) for telic P just in case e develops into a qualifying P-eventuality across the modal alternatives introduced by PROG.

In this paper, we treat the imperfective paradox as a case study for the broader lexical puzzle of telic predicates. While we agree that the non-culmination effects in (1)-(2) necessarily have an intensional element, we propose that the requisite intensionality inheres in the conceptual structure and representation of a telic eventuality predicate, and need not be introduced by an aspectual operator. The basic claim is that telic progressives do not depend for their truth on a (reference time) projection or expectation of culmination, but instead on a truth-conditional assessment of the match between reference time facts and the facts that *would need to hold* in order for a P-eventuality to be in progress.

Concretely, we propose that an accomplishment predicate P corresponds to an accomplishment **event type**, which is structured as a **causal model** (Pearl 2000) in which the culmination condition C_P occurs as a dependent variable. An event type model specifies a set of causal pathways (sets of collectively sufficient causing conditions) which produce and/or preclude C_P, linking lexically-specified information to world knowledge of a fundamentally causal nature (pertaining to the way in which C_P is ordinarily realized or brought about). The structure of an event type model allows us to define an intuitive notion of what it means for a goal-oriented eventuality to be *in progress*—that it is initiated, developing, and as-yet incomplete—in terms of the (sets of) conditions that comprise paths for C_P. We argue that this approach not only makes sense of the 'normality' intuitions which motivate intensional approaches to the progressive, but, by severing the truth of telic progressives from locally-projected culmination, also allows us to explain 'paradoxical' data that persist as a challenge for the received approach.

2. The imperfective paradox: culmination and grammatical aspect

The **culmination assumption** (CA)—that telic predicates denote only culminated eventualities—is motivated not only by telic predicates' specification of a culmination condition, but also by the emergence of **culmination entailments** in a range of aspectual contexts, including the English simple past (analyzed here as a perfective):

(3) Emanuel baked a cake. → *A cake (baked by Emanuel) came into being.*

The CA straightforwardly predicts the entailment in (3) in combination with a standard extensional approach to the perfective aspect: as per (4), PFV existentially closes over the denotation of an eventuality predicate P, providing an 'external' perspective by instantiating a P-eventuality e within the reference time t supplied by tense.

(4) $[\![\texttt{PFV}]\!] := \lambda w \lambda t \lambda P.\exists s[\tau(e) \subseteq t \wedge P(e)(w)]$ (cf. Kratzer 1998)

(5) $[\![\texttt{PST}(\texttt{PFV}(\text{Emanuel bake a cake}))]\!]^{w^*} = \exists e.[\tau(e) \subseteq t\{\prec_i t^*\} \wedge \texttt{bake}(\exists x.\texttt{cake}(x))(\texttt{E})(e)(w^*)]$
There is an eventuality e contained in past time t such that e is an evaluation-world eventuality of Emanuel baking a cake.

If, as per the CA, P denotes exclusively culminated eventualities, the instantiated eventuality e necessarily includes the realization of P's culmination condition, C_P. Consequently, the truth conditions in (5) require that C_P is realized within the runtime $\tau(e)$ of e, and thus within the past reference time $t\{\prec_i t^*\}$ (where t^* represents speech time). The culmination entailment in (3) follows immediately.

The CA leads to a contradiction, however, if we attempt to extend (4) to a parallel treatment of the imperfective (progressive) operator. An extensional 'including' semantics for PROG inverts the temporal relationship in (4) to produce an 'ongoing' interpretation:

(6) $[\![\texttt{PROG}]\!] := \lambda w \lambda t \lambda P.\exists e[\tau(e) \supseteq t \wedge P(e)(w)]$

Given the CA, combining (6) with a telic P incorrectly predicts an evaluation world P-culmination. Since culmination condition C_P is necessarily realized with $\tau(e)$, (7) mandates the existence of a temporal interval $t' \supseteq \tau(e)$ at which the corresponding perfective (3) is true.

(7) Emanuel was baking a cake.
$[\![\texttt{PST}(\texttt{PROG}(\text{Emanuel bake a cake}))]\!]^{w^*} = \exists e.[\tau(e) \supseteq t\{\prec_i t^*\} \wedge \texttt{bake}(\exists x.\texttt{cake}(x))(\texttt{E})(e)(w^*)]$
There is an eventuality e containing past time t such that e is an evaluation-world eventuality of Emanuel baking a cake.

This result is incompatible with the acceptable use of *Emanuel bake a cake* in (2), which establishes the impossibility of (3) becoming true. The imperfective 'paradox' thus arises in the clash between two theoretical assumptions—that telic predicates denote culminated eventualities (the CA) and that grammatical aspects simply instantiate such eventualities—and the empirical possibility of non-culminating telic progressives.

The most obvious solution is to let go of one of the two problematic assumptions. 'Extensional' approaches to the paradox (see Bach 1986 on the *partitive puzzle*; Parsons 1989) relax the CA, so that non-culminated portions (stages) of P-eventualities are also treated as belonging to the denotation of a telic predicate P. This approach makes non-culminated P-eventualities available for instantiation by an extensional progressive, predicting the acceptability of data like (2). The success of the 'extensional' approach relies on cashing out a notion of event partitivity which offers a principled account of the properties that qualify a non-culminating cake-baking as a cake-baking; i.e., the properties which unify it with a culminated cake-baking, but differentiate it crucially from superficially-similar activities of baking which lack an associated target state (cf. Szabó 2004: p.46).[2]

In view of the partitivity challenge, most approaches to the imperfective paradox opt instead to preserve the CA, explaining data like (2) in terms of intensionality introduced by the progressive operator. The idea is that, while qualifying P-eventualities are necessarily culminating, PROG requires P instantiations across a set of modal alternatives projected from the evaluation world w^* at reference time t. These alternatives can—but crucially need not—include w^* itself. The central analytical challenge for an intensional-PROG approach is to define the relationship between w^* and its culmination alternatives in such a way that reference-time facts necessarily correspond to some initial stage of a qualifying (culminated) P-eventuality, as it is realized in the culmination alternatives.

Our view is that the two analytical challenges outlined above are fundamentally interrelated, insofar as both extensional and intensional approaches to the imperfective paradox rely on a notion of *partial realization*. This notion is, *ipso facto*, a partitive one, since reference time facts can only constitute a partial realization if there is some (abstract or concrete) object of which they are a well-defined part. Simultaneously, *partial realization* must (at least in the progressive context) be an intensional notion, since an in-progress P-eventuality is, intuitively, one which has developed partway to the (potentially unrealized) culmination condition C_P. The causal approach to telic predicates, to be introduced in Section 4, allows us to combine partitive and intensional perspectives by comparing reference time facts directly to an abstract process for realizing C_P. While intensional approaches to the progressive make the 'partiality' of a reference time eventuality contingent on the locally-projected likelihood of culmination, the causal approach crucially does not: this means that the causal approach avoids the problematic predictions of the received intensional-PROG approach for several key classes of telic progressive data, discussed below.

3. Challenges for projected culmination

Intensional PROG approaches take partial realizations of a telic P to be eventualities which 'naturally' lead to P's culmination condition C_P. Per Dowty (1979), a situation satisfies PROG(P) just in case it continues to C_P in all **inertial** (normal) alternatives. The *inertia worlds* with respect to a world-time pair $\langle w, t\rangle$ are those which share a history with w through t and afterwards develop in the manner "most compatible with the past course of events" (pp.148–149).

(8) **Dowty's (1979) progressive.** PROG(P) is true at $\langle w, t\rangle$ iff, for some interval t' such that t is a nonfinal subinterval of t', and for all worlds $w' \in \texttt{Inr}(w, t)$, P is true at $\langle w', t'\rangle$.

[2] Following Bach (1986), Parsons (1989), we might use nominal partitives to unify (non-)culminating instances of telic predicates with (strictly) incremental themes, such as *Maya eat an apple*, so that an ongoing process counts as an apple-eating just in case its theme is an object which qualifies as *part of an apple*. It is not clear how to extend this approach to predicates whose culmination products lack concrete or measurable extents; see Landman (1992).

As noted by Vlach (1981), the 'global' definition of inertia must be further constrained: the set of facts which matter for the projection of 'normal' continuations necessarily excludes 'interrupting' elements (intersecting but intuitively event-external) such as the trajectory of the truck in a case like (9).

(9) **The collision scenario.** Henrietta stepped into a crosswalk, intending to cross the street. At the same time (but unknown to her), a truck was racing towards the crosswalk on a trajectory which intersected Henrietta's own.

Observer: Henrietta was crossing the street (when the truck hit her).

Allowing all ongoing processes in w^* at t to continue developing inertially would naturally predict Henrietta's collision with the truck, ruling out the possibility of culmination alternatives. A global perspective *à la* Dowty thus predicts the progressive to be false in the context provided, while a more circumscribed set of facts (or *perspective*; Asher 1992), including only facts about Henrietta and her trajectory, but omitting the truck, captures the desired truth and acceptability judgements.[3]

A positive consequence of the (restricted) inertial approach is that progressives of **impossible events** (IEs) such as (10) are immediately ruled out (predicted to be false): the impossibility of the underlying task ensures that no inertial projection from reference time can include culmination alternatives.

(10) **The beach scenario.** Meena has a 5-year old daughter, Maya, who (wrongly) believes that the earth is sand and soil all the way through. Maya is digging a hole at the beach with the intention of tunnelling all the way through the earth to China.

Meena: #/? Maya is digging a hole to China.

The dependence of a telic progressive on even locally-projected culmination runs into trouble, however, when we consider events that are unlikely, rather than impossible. Empirically, telic progressives can be true even where culmination is a remote possibility, while a normality- or inertia-based analysis requires that non-culmination must be abnormal or unexpected (from some relevant perspective). (11), due to Bonomi (1997), belies this prediction: (11) is both acceptable and true in the context provided, even though the majority of attempts to circumnavigate the globe will not culminate successfully.

(11) **The sailing scenario.** An international association organizes a competition to circumnavigate the globe. 100 boats take part, setting sail together. A few days later, a spokesman says:

Spokesman: One hundred boats are circumnavigating the globe. Most of them will fail.

A universal intensional progressive—even one based on a circumscribed perspective—incorrectly predicts the falsity of **unlikely event** (UE) progressives like (11), since an unlikely event is precisely one which does not occur under (most) normal circumstances.

One potential solution to the UE problem—weakening the modal force of intensional PROG from universal to existential—turns out to be a non-starter, in view of data like (12), which involve **out of reach** (OOR) tasks.[4] OOR progressives involve target tasks that are neither impossible nor necessarily unlikely, but are made locally impossible by (potentially mutable) properties of the participants. (12) is based on an example from Varasdi (2014: pp.192–193).

(12) **The un(der)trained runner.** Benny began an ultramarathon for which he (knowingly) undertrained. It was certain before the start of the race that he lacked the stamina to complete the run, but he began with all of the other runners with the intention of going as far as he could. Ultimately, he collapsed from exhaustion near the 16 kilometer mark. Later, he says:

Benny: I was running an ultramarathon (when I collapsed).

[3] Determining which facts to include and exclude is non-trivial (see Asher 1992 on *admissable perspectives*). In the interests of space, we take it for granted here that an appropriate set of constraints can be established, perhaps by using the semantic role structure of a verbal predicate to distinguish between event-internal and -external information.

[4] Dowty (1979) rejects an existential inertial progressive (on which PROG(P) holds at $\langle w^*, t\rangle$ just in case one inertial alternative to w^* realizes C_P after t), citing an example from R. Thomason. Assume a fair coin has been tossed, and is still rising. The coin will come up heads in exactly half of the inertial futures, and tails in the remaining half. Thus, an existential intensional PROG predicts both *The coin is coming up heads* and *The coin is coming up tails* to be true in this context, but neither is empirically acceptable.

Even an existential intensional progressive predicts (12) to be false: since the context establishes that Benny lacks the appropriate stamina (endurance) to complete an ultramarathon, there are no normal (inertial) futures in which he completes the race. Nevertheless, a majority of our informants judge the target sentence to be both acceptable and true in the context provided.

Based on the data from acceptable UE and OOR progressives, we argue that the core tenet of the intensional progressive approach to telic progressives—that their truth relies on locally-projected culmination alternatives—cannot provide a complete account of non-culmination. The acceptability of (12) is, instead, based entirely on the intuitive notion that, while Benny in fact cannot complete the race, he is, at the reference time, doing exactly what he would be doing if he were an appropriately trained ultramarathoner with a realistic chance of success. The same is true of the boats in the sailing competition in (11): independently of the likelihood of success in each individual case, the reference time actions of each boat correspond to a procedure or set of actions that any given boat would need to be taking at reference time in order to get to (and thus to make progress towards) culmination.

The notion of a culmination procedure—to be cashed out in the next section—not only explains the acceptability of UE and OOR progressives, but moreover serves to distinguish them from the unacceptable IE progressive in (10). Impossible events are, by definition, events for which no plausible culmination procedure exists (at the world historical or conceptual level). Thus, while participants in UE and OOR events can make progress towards a culmination condition C_P regardless of their (locally-assessed) chances of success, no such possibility exists for participants in the IE cases.

Before formalizing the key notions, we offer the following descriptive generalization. A telic progressive can be true as long as two conditions are met. First, there must be a plausible *culmination procedure* (at least one strategy or process for realizing the appropriate culmination condition); information about such a procedure or procedures is supplied by world knowledge and experience. Secondly, the progressive of a telic predicate P is true just in case events and activities at (or leading up to) reference time correspond to the events and activities included in some procedure for culmination condition C_P. Consequently, the truth of $\texttt{PROG}(P)$ does not depend on inertial or normal expectations for development after reference time, but instead on the relationship between what is already true (and/or taking place at reference time) and the structure and development of an abstract (uninstantiated) P eventuality.

4. Causal models for accomplishment event types

Our central claim is that judgements about telic predicates rely on world knowledge of a specific type. The relevant knowledge is procedural (or processual), encapsulating information—gained through observation, experience, and/or interaction with others—about how a particular culmination condition is occasioned (typically realized or *brought about*) in the world. This information is causal in nature: it is only natural, therefore, to propose that the use of a telic predicate P with culmination condition C_P relies on a structured representation of the causal conditions under which a process for C_P can be initiated, sustained through development, and ultimately completed (as well as, by extension, the conditions under which C_P is precluded). Within a model-theoretic approach to meaning, such a representation constitutes a formal **causal model**, which we take to correspond to an abstract **event type**. An event type model for telic P thus provides a set of generalized causal relations between conditions (point events, properties, states, and so on) which collectively comprise reliable or plausible causal pathways for realizing C_P.

4.1. Background on causal models

In reasoning about causation, it is intuitively clear that any caused event occurs as the consequence of a number of conditions (causing factors) acting or occurring together. Striking a match can cause it to light, but only if a number of 'normal' background conditions obtain (i.e., if the match is dry, oxygen is present, and so on). Causation, in other words, is a relation that exists—pre-linguistically—between effects and sets of causing conditions. A **causal model** is simply a formal representation of these complex causal interrelations.

Structural equation models (Pearl 2000) represent causal information by means of a directed acyclic graph $D = \langle V, A \rangle$ in which the set of vertices V is provided by a (finite) set of salient propositional variables, and the set of directed edges A by a relation which corresponds to an atomic notion of *causal*

relevance: $\langle p, q\rangle \in A$ for $p, q \in V$ indicates that p is an immediate causal ancestor of q. Given D, a causal model M_D is a tuple $\langle D, F_D\rangle$ which assigns to each $X \in \{q \mid \exists p \in V : \langle p, q\rangle \in A\}$ (all causally dependent variables in V) a pair $\langle Z_X, f_X\rangle$ where $Z \in Z_X$ just in case $\langle Z, X\rangle \in A$, and $f_X : \{0,1\}^{|Z_X|} \rightarrow \{0,1\}$ is a function specifying how the the truth value of proposition X is determined by truth value assignments to its immediate ancestors.

The structure of a causal model allows us to distinguish certain binary causal relations within an existing situation. **Causal necessity** (13b) relates a singular causing fact $C = 1$ to an effect $E = 1$ within situation s just in case changing the value of C in s requires changing the value of E in order to maintain causal consistency. **Causal sufficiency** (13c) relates a situation (set of facts) s to an effect $E = 1$ just in case s comprises only the effect and necessary causes thereof (cf. Baglini & Bar-Asher Siegal 2020).

(13) Let $M_D = \langle D, F_D\rangle$ be a causal model over a set V of propositional variables, and let s be a situation, or a set of pairs $\langle X, x\rangle$, where $X \in V$ and $x \in \{u, 0, 1\}$.

a. **Ancillary definitions.** (cf. Schulz 2011, Nadathur & Lauer 2020)

i. **Causal ancestors.** The set A_X of causal ancestors of $X \in V$ is given by $A_X = \{Y \in V \mid R^T_{F_D}(X, Y)\}$ where the relation $R^T_{F_D}$ is the transitive closure of A

ii. **Domain.** The domain $\texttt{Dom}(s)$ of situation s is the set of propositional variables from V to which s assigns a non-u value: $\texttt{Dom}(s) := \{X \in V \mid \langle X, 1\rangle \in s \vee \langle X, 0\rangle \in s\}$

iii. **Fact.** A *fact* is a pair $\langle X, x\rangle$ where $X \in V$ and $x \in \{0, 1\}$.

b. **Causal necessity.** Fact $\langle X, x\rangle \in s$ is *causally necessary* for fact $\langle Y, y\rangle \in s$ iff $X \in A_Y$ and for any situation s' such that $\texttt{Dom}(s) = \texttt{Dom}(s') \wedge s(X) \neq s'(X)$, we have $s - s' \supseteq \{\langle X, x\rangle, \langle Y, y\rangle\}$

c. **Causal sufficiency.** A situation s is *causally sufficient* for a fact $\langle Y, y\rangle \in s$ ($\texttt{Suff}_{M_D}(s, \langle Y, y\rangle)$ iff $\forall X \in \{Z \mid Z \in A_Y \wedge Z \in \texttt{Dom}(s)\}, \langle X, s(X)\rangle$ is causally necessary for $\langle Y, y\rangle$.

Taken in the abstract, a causal model provides a set of generalizations about causal relations between variables. As such, a model can be translated into a set of *nomological* claims; that is, a set of statements of causal law or regularity (between certain conditions or properties). Such statements are *de facto* **type-level causal claims**, insofar as they express generalizations over the observation and/or experience of token (singular) instances of causation in the world (Woodward 2003, Hausman 2005).

Type-level claims differ crucially from **statements of singular** (*token*) **causation**, which describe actual cause-and-effect relations as they occur in the world. Linguistically speaking, singular causation is the domain of *causative expressions* such as lexical or periphrastic causative verbs. These verbs are used to make claims about specific causal instances (e.g., *Flipping the switch {turned off the light/made the light turn off}*); causative claims are licensed by models of locally-relevant properties, but depend for their truth on particular conditions obtaining at specific times and places (see Baglini & Bar-Asher Siegal 2020, Nadathur & Lauer 2020). Our claim is that type-level relations are also relevant for linguistic judgements: crucially, however, a type-level causal relation (e.g., that $C = 1$ is causally necessary for $E = 1$ in situation s) is not falsified by a single instance of failure (a single observation that changing C in an s-context did not alter E). The robustness of type-level causation is, ultimately, what allows for 'paradoxical' uses of telic progressives in non-culminating contexts.

We propose that an accomplishment event type is simply a type-level causal model, reflecting generalizations about the relationships between a culmination condition C_P and the (sets of) properties and conditions in view of which C_P typically comes about. Concretely, then, a telic predicate P invokes a model M_P in which C_P occurs as a dependent variable, (nomologically) linked to a range of point events (process steps), background conditions (properties, dispositions) and/or participants (semantic roles) which are causally implicated in its realization. In other words, an accomplishment event type reflects a language user's normative world knowledge about how events of type C_P are realized or brought about.

The structure of a causal model allows us to set out clear conditions under which a situation qualifies as *making progress* (or developing) towards C_P. Within M_P, a process (causal pathway) for C_P corresponds to a set of jointly sufficient conditions for C_P—i.e., a situation Σ such that $\texttt{Suff}_{M_P}(\Sigma, \langle C_P, 1\rangle)$ holds. Depending on the base predicate P, an appropriate model might specify a single set Σ or a range of distinct sufficient sets for C_P, reflecting the potential for there to be more than one way to do a particular task. In accordance with the structural equations, the model also establishes information about (sets of)

conditions which preclude C_P's realization. Our contention is that the information which is relevant for truth value judgements of telic progressives is provided by considering the set of sufficient sets for $C_P = 1$ alongside the set of sufficient sets for $C_P = 0$.

4.2. Analytic truth conditions for telic progressives

A P-event is *in progress* if three things are true. First, an appropriate process must have been initiated at reference time: appropriate processes are defined as causal pathways for culmination condition C_P within model M_P. Secondly, no process for C_P should yet have been completed; formally, no sufficient set of conditions for C_P within M_P should be fully realized. Finally, it should be possible for progress towards the realization of C_P to continue (see also Landman 1992); thus, no sufficient set (within M_P) for the negation of C_P should yet be realized. These requirements are formalized below: in (14), the variables Q, Q', Q'' should be understood to stand in for facts, as defined in (13a).

(14) **Truth conditions for telic progressives.** Let M_P be a model for telic P with culmination condition C_P. Given reference time t and world w, $\texttt{PROG}(P)$ holds at $\langle w, t\rangle$ just in case:

$$\exists s \subseteq w[\tau(s) \circ t \wedge [\exists Q \exists S : Q \in S \wedge \texttt{Suff}_{M_P}(S, \langle C_P, 1\rangle) \wedge Q(s) = 1] \wedge [(\forall S' : \texttt{Suff}_{M_P}(S', \langle C_P, 1\rangle))[\exists Q' \in S' : Q'(s) = 1 \rightarrow \exists Q'' \in S' : Q''(s) = 0]] \wedge [\forall S : \texttt{Suff}_{M_P}(S, \langle C_P, 0\rangle))[\exists Q \in S : Q(s) = 0]]]$$

The causal approach thus allows us to formally capture common-sense intuitions about what it means for a telic eventuality to be in progress. The inherent intensionality of a predicate's association with culmination is captured at the level of the causal model, insofar as an accomplishment event type provides (normative, world knowledge-based) generalizations about appropriate and/or plausible processes for culmination. Within the local (reference time) context for a telic progressive claim, truth-conditional evaluation involves straightforward (extensional) subset comparisons: the idea that an ongoing P-eventuality is necessarily one which has developed partway towards C_P is achieved by evaluating whether or not the relevant reference time situation is a possible cross-section of an incomplete but plausible causal pathway for C_P. This approach allows us to capture the correct empirical judgements for the IE, UE, and OOR progressives in Section 3, and crucially to distinguish unacceptable IE progressives from (potentially) acceptable UE and OOR cases.

On the causal approach, IE progressives like (10) are not false (as per a Dowty- or Asher-style intensional PROG approach), but instead infelicitous. This follows from the infelicitous invocation of an impossible predicate P. Reasonable use of an event type predicate such as *dig a hole to China* is precluded because there is (objectively) no causal model for the specified culmination condition: there is (as far as we know) no plausible way to effect the existence of a hole dug through the earth to China.[5]

UE and OOR progressives, on the other hand, both involve predicates with event type models. As a result, these progressives can be true or false of ongoing events—truth simply depends on the validity of all three conditions in (14). For instance, (12) can be true as long as Benny has started the race (e.g., by taking at least one step along the designated race path), has not reached the end of the race, and is able at reference time to continue in the appropriate course. In particular, it can be true that *Benny is running an ultramarathon* even if he is walking rather than running at reference time, or indeed has paused for refreshment. Crucially, however, the truth of the progressive does not, per (14),s take into account the inevitability of Benny's pre-finish collapse: what matters is that *at reference time* it remains possible for him to make progress towards the finish line. As soon as he collapses (unable to take another step), this possibility is closed: in the terms established above, Benny's collapse completes a sufficient

[5] Landman (1992) makes the curious observation that, in the unlikely event that an event hitherto deemed impossible is actually realized, the past progressive becomes felicitous. Although we cannot elaborate on this here, it seems to us that this effect is explained, on the causal approach, by the fact that actual observed occurrences in the world are necessarily classified as causally-realizable. A single culminated witness for a particular predicate is thus expected to license past progressives which reference the successful instance, but it may reasonably remain difficult to assess progressives of the same predicate in other contexts, since a single witness need not provide sufficiently rich procedural information for the truth-conditional judgements required by (14).

set of conditions for non-culmination ($\neg C_P$) falsifying the progressive. The case of unlikely but possible circumnavigation in (11) is evaluated in much the same way.

5. Intentions and other globally necessary conditions

Certain conditions play a special role in event type models for telic predicates: these are conditions which (like the reserve of energy which permits Benny's continued progress along the race course) must be true or sustained throughout the entire developmental arc of a process for C_P. Within the established framework, we can define such **globally necessary conditions** (GNCs) as facts which constitute singleton sufficient sets for non-culmination.

(15) **Globally necessary conditions.** Fact Q is *globally necessary* for C_P with respect to model M_P iff $\texttt{Suff}_{M_P}(\neg Q, \langle C_P, 0\rangle)$.

Given an agentive accomplishment predicate P, an agent's intention to realize C_P is a straightforward example of a GNC. Taken together with the truth conditions in (14), definition (15) predicts that the truth of an in-progress accomplishment can be toggled on and off in case of variation in an agent's intentions. This prediction appears to be supported, as the following example shows.

(16) **The (re)commitment scenario.** Benny began running in a marathon at 9:00am on an extremely hot day. At 11:35 he felt overheated and sat down in a aid tent, intending to quit the race then and there. After a short rest and some refreshment, however, he started to feel better, and so at 11:48 he decided to continue his run. He started running again at 11:50.

a. *At 11:30, 11:55:* Benny is running a marathon.

b. *At 11:45:* #Benny is running a marathon.

The judgements in (16) are captured by the third condition (conjunct) for telic progressives set out in (14), as long as Benny's intention to run the full marathon is modeled as a GNC.

GNCs also play a deeper role in the evaluation of telic progressives, insofar as their underdetermination appears to preclude truth-value judgements. In the context provided, neither (17a) nor (17b) is judged to be acceptable.

(17) **The variable distance scenario.** Benny began running in a marathon, which he did not intend to complete. Uncertain about his precise level of fitness, he planned to decide at 15km whether to stop altogether or continue to run a half marathon (21km). He unexpectedly collapsed at 10km, before he had made a decision.

a. *Benny:* ?I was running a 15K when I collapsed.

b. *Benny:* ?I was running a half marathon when I collapsed.

The judgements in (17) are captured by constraining our treatment of telic progressives with the following presupposition about GNCs:

(18) **Determination of GNCs.** $\texttt{PROG}(P)$ is defined at $\langle w, t\rangle$ iff no GNCs for C_P are undetermined in context: $[\![\texttt{PROG}(P)]\!]^{w,t} \in \{0, 1\} \leftrightarrow \forall Q : \texttt{Suff}_{M_P}(\{\neg Q\}, \langle C_P, 0\rangle), Q(w, t) \neq u$

An interesting predicted consequence of (18), and one which appears to be empirically supported, is that a process for C_P can (retrospectively) begin prior to the time at which the (present) progressive could first be truthfully stated. For instance, if we modify the scenario in (17) so that Benny in fact reaches the 15km mark and decides to stop there, the past-tense claim that *Benny was running a 15K* becomes true for any reference time between the time at which he started the race and the time at which he reached 15km; at the same time, however, it remains clear that the present-tense claim *Benny is running a 15K* was not true at any of these times. GNCs, in other words, represent necessary conditions for the conceptual initialization of a process for C_P, but their determination need not correspond to the temporal initiation of such a process; the causal approach thus allows us to capture an observed temporal asymmetry in judgements of telic progressives which has resisted explanation on the received intensional-PROG accounts (but see also Bonomi 1997, Varasdi 2014).

The temporal asymmetry is closely related to the puzzle of disjunctive outcomes discussed in detail by Bonomi (1997). In a context like (17), Bonomi notes that the progressive disjunction—*Benny is running a 15K or a half marathon*—is true (up to the moment of collapse), without affecting the judgements of the disjoint progressives in (17a) and (17b).[6] This result also falls out, in a fairly straightforward fashion, on the causal approach: while Benny's (potential) intention to run 15km is undetermined prior to his collapse, as is his intention to run a half marathon, his intention to run one of the two relevant distances is established from the time he begins the race, allowing truth-conditional evaluation of the progressive disjunction to follow as per (14).

Non-agentive accomplishments presumably also have GNCs, which are expected to play the same role as intentions with respect to the truth-conditional evaluation of telic progressives. Appropriate conditions in the non-agentive cases might be akin to Benny's stamina in (12), for instance involving conserved quantities such as momentum or (potential or kinetic) energy. Knowledge of such quantities—unlike knowledge of intentions—is a matter of fine-grained physical measurement and observation. This leads to an interesting predicted contrast between agentive and non-agentive progressives. On our proposal, Benny's underdetermined intention in (17) is sacrosanct: there is simply no truth of the matter with respect to (17a) or (17b) until and unless he makes up his mind. In a parallel non-agentive case, such as (19), the progressive of one of the disjuncts is ostensibly true, but its determination is out of reach of the standard (unaided) human observer.

(19) A fair coin is tossed, and is still rising.
   a. ?The coin is coming up heads.
   b. ?The coin is coming up tails.

(20) a. *In context (17):* Benny is running a 15K or a half marathon, ??but I don't know which.
   b. *In context (19):* The coin is coming up heads or tails, but I don't know which.

This prediction—and thus the causal approach to telic progressives—gains some preliminary support from the contrasting judgements in (20), but a detailed investigation is left as a topic for future research.

6. Conclusions and outlook

In addressing the semantics of telic progressives, the main theoretical challenge lies in establishing what constitutes the relevant notion of *partial realization*—that is, in capturing what precisely allows us to assess whether or not a particular (actual) situation qualifies as *making progress* towards the culmination condition associated with the telic predicate in question. The received intensional-PROG approach, on which partial realization is cashed out in terms of correspondence between actual events and locally-projected culminations, encounters empirical problems with the acceptability of UE and OOR progressives such as (11) and (12) (respectively). We proposed, in lieu of intensionalizing the progressive operator, that intensionality enters into the assessment of telic progressives via the need to compare actual reference-time facts to some idealized (hence, modally-supplied) notion of a *culmination process* or *procedure*. The structure induced by realizing an accomplishment predicate in terms of an (event type) causal model allows us to straightforwardly evaluate a set of facts (a reference time situation) or eventuality as a potential partial realization of a P-eventuality, by virtue of a truth-conditional match between the set of facts comprising the token and a cross-section of a normative process for C_P, as established by model M_P (that is, a type-level representation of how C_P comes about under ideal conditions).

We emphasize that, while our proposal links telic predicates to causal information, it is crucially distinct from claiming that accomplishments are causative predicates (see, e.g., Dowty 1979), in which a specified action involving the external argument is linked in a binary causal relationship to the realization of C_P. The use of a telic predicate conveys a speaker's knowledge of a causal model for C_P, but use of the predicate, at least in the progressive context, only predicates (reports on) an observed match between actual events and what is provided by the model.

[6] Non-distributivity of disjunction is not *a priori* a problem for a universal-force intensional PROG (e.g. Asher 1992), but is difficult to reconcile with a successful treatment of UE progressives like (11). Bonomi points out, for instance, that Landman's (1992) 'continuation branch' proposal (which we do not discuss here for reasons of space) necessarily makes the truth of a progressive disjunction contingent on the truth of the progressive of one of the disjuncts.

This paper takes the first steps towards a complete causal analysis of imperfective paradox (and other non-culmination) effects, insofar as we have provided only analytic (non-decompositional) truth conditions for telic progressives. A clear compositional breakdown must await future work. We want to suggest, however, that event type models induce a causal mereological structure for telic predicates, in which (non-)culminating eventualities can be defined and compared to one another in terms of structured subsets of causal pathways for a specified culmination condition. When subsets of sufficient sets are taken together with their crucial (temporal and/or ordering) interrelationships, they provide the types of partial *P*-eventuality that are picked out by other forms of aspectual modification, such as the aspectual verbs in (1); a causal mereological structure also promises to lend itself to a treatment of empirically-observed non-culminating perfectives (Singh 1998, Koenig & Muansuwan 2000, among others) in terms of the (relative) maximality of an instantiated eventuality (see also Altshuler 2014, Nadathur & Filip 2021). The causal approach ought also to extend to judgements of aspectually-marked atelic predicates; while we believe that causal models offer a natural framework in which distinct aspectual classes can be analyzed (and related to one another; Moens & Steedman 1988) we leave an exploration of the structure and features of non-accomplishment event types as a topic for future research.

References

Altshuler, Daniel. 2014. A typology of partitive aspectual operators. *Natural Language & Linguistic Theory* 32. 735–775.

Asher, Nicholas. 1992. A default, truth conditional semantics for the progresive. *Linguistics & Philosophy* 15. 463–508.

Bach, Emmon. 1986. The algebra of events. *Linguistics & Philosophy* 9. 5–16.

Baglini, Rebekah & Elitzur Bar-Asher Siegal. 2020. Direct causation: a new approach to an old question. In *43rd Penn Linguistics Conference*, 19–28.

Bonomi, Andrea. 1997. The progressive and the structure of events. *Journal of Semantics* 14. 173–205.

Dowty, David. 1979. *Word meaning and Montague Grammar*. Dordrecht: Reidel.

Hausman, Daniel. 2005. Causal relata: tokens, types, or variables? *Erkenntnis* 63. 33–54.

Koenig, Jean-Pierre & Nuttanart Muansuwan. 2000. How to end without ever finishing: Thai semi-perfectivity. *Journal of Semantics* 17. 147–182.

Kratzer, Angelika. 1998. More structural analogies between pronouns and tense. In Devon Strolovich & Aaron Lawson (eds.), *Proceedings of Semantics and Linguistic Theory 8*, 92–110. Ithaca, NY: CLC Publications, Cornell University.

Kratzer, Angelika. 2004. Telicity and the meaning of objective case. In Jacqueline Guéron & Jacqueline Lecarme (eds.), *The syntax of time*, 389–423. Cambridge, MA: MIT Press.

Landman, Fred. 1992. The progressive. *Natural Language Semantics* 1. 1–32.

Moens, Mark & Mark Steedman. 1988. Temporal ontology and temporal reference. *Computational Linguistics* 14. 15–28.

Nadathur, Prerna & Hana Filip. 2021. Telicity, teleological modality, and (non-)culmination. In *39th West Coast Conference on Formal Linguistics*, to appear.

Nadathur, Prerna & Sven Lauer. 2020. Causal necessity, causal sufficiency, and the implications of causative verbs. *Glossa,* 5. 49.1–37.

Parsons, Terence. 1989. The progressive in English: events, states, and processes. *Linguistics & Philosophy* 12. 213–241.

Pearl, Judea. 2000. *Causality*. Cambridge: Cambridge University Press.

Schulz, Katrin. 2011. If you'd wiggled A, then B would've changed. *Synthese* 179. 239–251.

Singh, Mona. 1998. On the semantics of the perfective aspect. *Natural Language Semantics* 6(171–199).

Szabó, Zoltan. 2004. On the progressive and the perfective. *Noûs* 38. 29–59.

Varasdi, Karoly. 2014. Making progressives: necessary conditions are sufficient. *Journal of Semantics* 31. 179–207.

Vendler, Zeno. 1957. Verbs and times. *The Philosophical Review* 66. 143–160.

Vlach, Frank. 1981. The semantics of the progressive. In Philip Tedeschi & Annie Zaenen (eds.), *Syntax & Semantics 14: Tense and aspect*, 271–294. New York: Academic Press.

Woodward, James. 2003. *Making things happen: a theory of causal explanation*. Oxford: Oxford University Press.

Zucchi, Sandro. 1999. Incomplete events, intensionality, and imperfective aspect. *Natural Language Semantics* 7. 179–215.