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Events, their Names, and their Synchronic Structure

Nicola Guarino [a,*], Riccardo Baratella [b] and Giancarlo Guizzardi [b]
[a] *Laboratory for Applied Ontology, ISTC-CNR, Trento, Italy*
E-mail: nicola.guarino@cnr.it
[b] *Dept. of Computer Science, Free University of Bolzano, Bolzano, Italy*
E-mails: riccardo.baratella@unibz.it, giancarlo.guizzardi@unibz.it

Abstract. We present in this paper a novel ontological theory of events whose central tenet is the Aristotelian distinction between the object that changes and the actual subject of change, which is what we call an *individual quality*. While in the Kimian tradition events are individuated by a triple $\langle o, P, t\rangle$, where o is an object, P a property, and t an interval of time, for us the simplest events are *qualitative changes*, individuated by a triple $\langle o, q, t\rangle$, where q is an individual quality inhering in o or in one of its parts. Detaching the individuation of events from the property they exemplify results in a fine-grained theory that keeps metaphysics and semantics clearly separate, and lies between the multiplicative and the unitarian approaches. We discuss then the way language refers to events, observing that, in most cases, event descriptions refer to complex, cognitively relevant clusters of co-occurring qualitative changes, which exhibit a *synchronic structure* depending on the way they are described. Contra Bennett, who famously argued that the semantics of event names ultimately depends on "local context and unprincipled intuitions", we show how the lexicon provides systematic principles for individuating such clusters and classifying them into kinds. Finally, we address some open challenges in the semantics of locative and manner modifiers.

Keywords: events, ontology, qualities, qualitative change, verbal modifiers

1. Introduction

In the vast literature on events, both in philosophy and in liguistics, semantic and metaphysical considerations are tightly intertwined. In particular, the following questions are highly debated:

Q1. What are events?
Q2. What is the referential mechanism that is in play when we describe an event?

While Q1 is surely a metaphysical question, Q2 displays both semantic and metaphysical aspects. More specifically, Q2 asks one to explain whether or not, and why, event names such as *John's falling down the stairs* and *John's fracturing his leg* refer to the same event. Clearly, answers to such a question not only call for an account of the referential mechanism underlying the semantics of event nominals, but they also presuppose one to account for what events are. Famously, Bennett's answer's to Q2 is that

> "there is no general, systematic answer to this question. The truth lies between Kim and the Quinean, but there is no precise point between them such that it lies there [...] The middle territory is the domain of vagueness, or indeterminacy, where what is said can properly reflect differences of context, interest, personal style, and so on." (Bennett, 1988, pp. 126-127)

*Corresponding author. E-mail: nicola.guarino@cnr.it.

Thus, while acknowledging that a proper account of events should lie somewhere between Kim's radical multiplicativism and Quine's unitarianism, Bennett's position leaves us with a no-answer concerning how language refers to events. This explanatory gap affects not only the semantics, but also the metaphysics of events, since it leaves us with no linguistic tools to evaluate the cognitive adequacy and the explanatory power of the metaphysical positions adopted.

A third question that impacts both the semantics and the metaphysics of events is related to the nature of event modifiers. As Davidson showed (1967), one of the reasons for admitting events in our ontology is exactly to account for the fact that the same event may be compositionally described by multiple modifiers. Take for instance his classic example:

(1) a. Jones buttered the toast.
b. Jones buttered the toast slowly.
c. Jones buttered the toast slowly, deliberately.
d. Jones buttered the toast slowly, deliberately, in the bathroom.
e. Jones buttered the toast slowly, deliberately, in the bathroom, with a knife.
f. Jones buttered the toast slowly, deliberately, in the bathroom, with a knife, at midnight.

In some cases however, as Maienborn showed (2003), compositionality of modifiers is challenged:

(2) a. Maradona signed the contract in Argentina.
b. Maradona signed the contract on the last page.

(3) a. The cook prepared the chicken in a Marijuana sauce.
b. The bank robbers escaped on bicycles.
c. Paul is standing on his head.

As we can see, while in (2a) the modifier denotes a holistic property of the signature event that expresses its location, the same is not true in (2b), since in this case 'on the last page' does not specify the location of the main event, but rather the location of something internal to the main event. Similarly, the modifiers in (3) do not refer to the main event, but rather to some internal details concerning the *way* the event occurred. Maienborn calls *event-internal* modifiers those that, in a particular sentence, exhibit this deviant behavior, and *event-external* modifiers those that obey the standard compositional semantics.

The behavior of these 'rebel' modifiers triggers our third question:

Q3. What is the internal structure of events? How are internal modifiers connected to such internal structure?

In this paper we shall address the questions above in the light of two preliminary observations. On the one hand, it seems clear that we must distinguish between simple events, like a temperature increase in an object, and complex events, like a toast buttering or a contract signature. Indeed, most ordinary events appear to have a complex structure: in different words, we shall say that they are *thick* entities. This is because they are amenable to exhibiting multiple aspects or modes of occurrence, and therefore they may be described[1] at multiple levels of detail, as (1) shows[2].

[1]We shall use the expression 'description of an event' as referring to a whole sentence –like one of those in (1)– and not just, e.g., a definite description. While this way of speaking is rather standard in the philosophy of events, it differs from the notions of description typically investigated in philosophy of language (e.g., Ludlow, 2021).

[2]This thickness is perhaps the most relevant difference between events and *facts*, which have a *thin* nature: the fact that Jones buttered the toast does not require any further details to be described: any added detail would create a new fact. As observed by Moltmann (2013, p. 83), this difference is clearly shown in language. For example, we can say *John saw/described Jones's buttering the toast*, but not *John saw/described the fact that Jones buttered the toast*.

On the other hand, the structure of (non-atomic) events appears to have two dimensions: a synchronic one and a diachronic one. In the linguistic literature, when dealing with events people typically refer to their diachronic aspects, such as the way they unfold in time, which determines Vendler's classification (1957), or their decomposition in terms of causal chains (Parsons, 1990), which have often (although not always) a diachronic nature. many works on lexical decomposition of verbs are based. In this paper we shall focus instead on the less explored synchronic dimension, which seems to play a crucial role in explaining the nature of cognitively relevant complex events. In particular, our answer to question Q3 will show that the internal details that are the target of 'rebel' modifiers belong indeed to the synchronic structure.

Let us illustrate the role of the synchronic structure of events more in detail. Assuming that the *synchronic context* of an event is whatever happens while the event occurs[3], in most cases a full description of how the event occurred requires describing a certain *relevant* part of such context. This relevant part of the synchronic context is what we call the *internal context* of an event. The actual boundaries between the internal context and the remaining context (which we call the *external context*) are constrained by the event *kind*, which is typically a cognitive construction associated with the core meaning of a verb. Coming back to Davidson's example, this means that, for an event of the kind associated with the verb 'butter', the boundaries of its internal context are such that 'slowly', and 'with a knife' denote properties that depend on the internal context, while the other adverbials depend on the external context.

The distinction between an event and its external context is not an easy matter, since when we perceive an event we are also exposed to whatever (accessible to our senses[4]) happens meanwhile, so that, in principle, anything that happens meanwhile may be mentioned while adding details to an event description. Consider for instance a car accident: many co-occurring events (the rain falling down, other cars passing by...) may be mentioned while describing what happened, typically using while-clauses. But how to distinguish the description of the totality of what happened from the description of *that* particular car accident? It seems that the presence of *certain* co-occurring events (say, the presence of ice on the road) would be relevant to characterize *how* a certain event occurred, while other co-occurring events (say, the radio program going on) may be *pragmatically* relevant for describing what happened but not *inherently* relevant for describing *how* that particular event occurred. So, in order to fully answer Q3, a further question emerges:

Q4. Given an event of a certain kind, how to articulate and circumscribe its internal context? How to carve it out from the surrounding context, excluding irrelevant elements?

A possible way to address this question is to try to circumscribe an event by looking at its *minimal participants*. This strategy was briefly mentioned by Davidson (1969, p. 228) and discussed in some detail by Lombard (1986, § 5.3), who suggested to consider as 'the subject of an event' the *minimally involved*[5] participant. However, as shown by Varzi (2002) and Borghini and Varzi (2006), isolating the minimally involved participants in an event raises serious problems of vagueness and indeterminacy. For example, considering Titanic's collision with an iceberg, they argue that there are large parts of the ship

[3]We assume here a broad interpretation of the term *synchronic*: two events may be considered as synchronous (or *co-occurring*) even when they do not have the same beginning and ending, i.e., even if they are not perfectly synchronized. We just require that the durations of the two events overlap.

[4]By the way, it seems to us that the role of context in the perception of objects is very different from the perception of events, since when we *perceive* an object we typically ignore its context when requested to describe what we perceived.

[5]As a reviewer noticed, this expression (which is the one Lombard uses) may be misleading, since it may suggest that the subject is less involved than any other participant. Perhaps a better expression would be *minimal involved participant*.

and the iceberg (say, the rear parts) that are loosely involved in the event, while other parts (some suitable parts of the iceberg and of Titanic) are definitely involved, but precisely isolating them as minimal participants is not possible. This means that a strategy based on the notion of minimal participants does not really solve our problem of circumscribing the internal context of ordinary events.

A more fruitful strategy was suggested in one of our previous papers (Guarino and Guizzardi, 2016), where we considered the Titanic example under a different perspective, shifting our attention from the event participants to their *qualities*: while it may be impossible to determine exactly which *part* of Titanic is the core participant in the collision event, nobody would object to the fact that some of Titanic's *qualities* (such as its mass) were *definitely* involved in the event, while others (such as its color) were definitely not. Of course, vagueness and indeterminacy problems cannot be completely eliminated, since, for instance, determining the exact location of the collision would still be a problem. However, for the purpose of isolating an event from its surrounding context, pointing to selected qualities of the participants may be enough to describe *exactly* the event we want to talk about.

Leveraging on the previous considerations, in this paper we shall formulate a fine-grained view of events[6] whose main claims, in a nutshell, are the following:

(1) The simplest events are *qualitative changes*, i.e., changes *in a respect*. This means that there is a fundamental difference, in a change, between the object that changes (the participant in the change) and the actual subject of change.
(2) Most of the events we refer to in our ordinary talk are cognitively relevant *clusters* of qualitative changes, on which we tend to impose a structure depending on how we perceive and we describe them.
(3) Event kinds (typically lexicalized by verbs) provide criteria for isolating such clusters from the surrounding context and determining the structure imposed on them, distinguishing a *focus* which accounts for *what* happens, and an *internal context* which accounts for *how* it happens.

Claim 1 is based on a principle which was already present in Aristotle (trans. 1970), and is at the root of Lombard's work: events are changes in some respects. Our claim is that this principle should be taken seriously, by recognizing the ontological status of such "respects": they are qualitative aspects of objects, such as color or shape, which correspond to what DOLCE (Borgo and Masolo, 2009) and UFO (Guizzardi, 2005) call *individual qualities*, or just qualities for short. According to such notion of quality, the simplest events are not just changes in a quality, but changes of a quality in an object, in which the quality (directly or indirectly) inheres. Under this view, Titanic's crash is a qualitative change involving qualities of physical bodies such as momentum, kinetic energy, and relative position. Note that, differently from Lombard, we also consider a *stasis* as an event, assuming that in this case the quality value changes within a certain minimal threshold.

Claims 2 and 3 reflect the intuition that ordinary events are *cognitively constructed*: while single qualitative changes are of course independent from cognition, we tend to organize them in clusters that have a specific internal structure, accounting for a perception mechanism based on a *figure/ground* scheme (Talmy, 2000a, p. 311).

Summing up, we are going to present in this paper two separate theories, a metaphysical one and a semantic one. Especially in the case of events, the metaphysical and semantic aspects are often highly intertwined. This is certainly true in Kim's account (1976), which has been indeed criticized by Bennett

[6] In the present article we focus on *qualitative events*, ignoring for the time being both *existential events* such as *coming into existence* or *ceasing to exist*, and *mereological events* such as losing/acquiring a part.

(1988), who accepted Kim's metaphysics but rejected his semantics. We believe however that also Kim's metaphysics should be revised, since defining events as property exemplifications unavoidably connects the nature of events to the way they are described. Abandoning such definition helps us to keep the two theories clearly separate, by recognizing first the nature of simple events as qualitative changes, and only then showing how language isolates specific clusters of simple events, and refers to their internal structure. As a result, we have a new fine-grained metaphysics of events that lies between the multiplicative and the unitarian approaches, and a semantic theory that, based on such metaphysics, provides a systematic account of the referential mechanisms of event nominals and event modifiers. The fact that such metaphysics explains these linguistic phenomena is for us a good evidence of its plausibility.

This article is structured as follows. In Section 2, we first discuss some evidence concerning how language refers to complex events, allowing them to be incrementally described by different kinds of modifiers. In particular, we shall discuss some challenges to Davidsonian compositionality of modifiers, which motivate a distinction between external and internal modifiers, along the lines suggested by Maienborn. Clarifying the semantics of such distinction raises important questions concerning the internal structure of events and their relationship with the surrounding context, which will be discussed in the rest of the paper. In Section 3 we review the main philosophical accounts of events in the light of such questions. We then introduce simple events as qualitative changes in Section 4, and complex events as clusters of qualitative changes in Section 5. Section 6 will be devoted to the nature of event modifiers, and Section 7 to the final discussion.

Finally, the Appendix presents a conceptual model account for the theory we have proposed, in which the theory put forth here is materialized as a concrete modeling artifact. This may be of special interest to readers involved in Conceptual Modeling, Semantic Data Modeling as well as in Knowledge and Ontology Engineering. Such readers may consider reading the Appendix first, and then delve into the details of the theory developed in the rest of the paper. As made evident there, more than just a representation of our theory, this artifact also offers a complementary perspective addressing a number of additional ontological issues (related to application, individuation and identity conditions) regarding the entities put forth by our theory.

2. Events, their context, and their modifiers

The notion of event is intimately connected to that of context. Describing an event means not just saying *what* happened, but also specifying *how* it happened, by specifying details that often involve the context in which the event occurred.

Consider again example (1). We may go on adding modifiers, saying that the event happened silently and in complete darkness (Maienborn, 2011, p. 806), while a band was playing (Sellars, 1973, p. 240), or while Jones was wearing a pyjama. What is the nature of such modifiers? Syntactically, they are all adverbials (adverbs or adverbial clauses), that is, verbal modifiers. Semantically, according to Davidson, what they modify "is not verbs but the events that certain verbs introduce" (1969, p. 298), so that they are simply interpreted as properties of the event introduced by the verb, which can be composed arbitrarily.

Despite its great advantages, however, the (Neo-) Davidsonian approach presents some limitations, concerning in particular the compositional machinery and the ontological nature of the relationship between the modifier and the event it is supposed to modify (Maienborn and Shäfer, 2011, p. 1410ff).

On the one hand, as Maienborn (2003) observed, examples (2) and (3) above show that, in some cases, modifiers do not denote properties that directly apply to the event as a whole, but they rather refer to some

details *internal* to it. She suggests then to distinguish between *external* and *internal* modifiers, proposing for the latter a semantics according to which the property associated with their lexical meaning holds for a certain unspecified *part* of the main event. For her, such a part is a *participant* in the event (Maienborn and Shäfer, 2011, p. 1413).

On the other hand, in a similar spirit, Piñón (2007) argued that manner adverbs actually refer to some conceptual coordinates *internal* to the main event, and not to the event as a whole. For example, in (4) below, he insisted that what was beautiful was not the dancing event, but rather the *manner* Peter danced:

(4) a. Peter danced beautifully.
b. The manner Peter danced was beautiful.
c. I saw how Peter danced.

Piñón proposes therefore to reify manners, assuming them as genuine ontological entities, and systematically paraphrasing manner adverbs as in (4b). One of the reasons he brings to justify this move is that manners can be perceived, as exemplified by (4c). In any case, although their exact ontological nature remains a bit mysterious, manners are for him clearly *internal* to the event.

As Maienborn and Shäfer (2011, p. 1416) noted, there are striking similarities in the behavior of Maienborn's event-internal modifiers and Piñón's manner modifiers. In particular, from our point of view, the interesting thing is that, in both cases, the property denoted by the modifier is grounded in something *internal* to the event. For Maienborn this 'something' is an unspecified *participant*, for Piñon it is an unspecified *manner*. Thus, both these authors agree that ordinary events are internally structured, although they don't do much in order to clarify the nature of such internal structure, and the exact mechanism by which these modifiers target specific elements within it. This is exactly one of the aims of the present work.

As a first step in this direction, we suggest to introduce a distinction between internally- and externally-*grounded* event modifiers (internal/external modifiers for short), which generalizes Maienborn's event-internal/external distinction to a broad class of event modifiers. We shall keep this distinction at the intuitive level for the time being, assuming that a modifier is internally grounded iff the truth conditions of its meaning contribution presuppose the existence of something internal to the event.

Moreover, we also claim that this distinction extends in particular to adjectival modifiers as shown in (5). For example, in (5a) 'easy' is internally-grounded, since it denotes a property whose truth conditions depend on internal details concerning the manner of occurrence of the event, while in (5b) 'short' is externally-grounded, since its truth conditions depend directly on what 'walk' lexicalizes. Note that, differently from the previous cases, the properties denoted by these modifiers *do* directly apply to the verb's event argument: it is the whole walk which is easy, but still to understand what it means for a walk to be easy we need to consider something that is internal to the walk itself[7].

(5) a. Susan had an easy walk in the park.
b. Susan had a short walk in the park.

Coming back to Davidson's example, modifiers such as 'slowly', 'with a knife' and 'deliberately' seem to be classifiable as internal, while all others ('in the bathroom', 'at midnight', 'while a band was playing', 'while wearing a pyjama', 'in complete darkness') seem to be external. However, the exact criteria for these decisions may be not always clear, and ultimately we may wonder what we are really

[7]There is therefore a radical difference between our external/internal distinction and Maienborn's one: while the latter is based on a difference in the *target* of the modifier (i.e., what the modifiers refers to), in our case the distinction is based on the different truth conditions, independently of the target.

describing, when we keep adding modifiers. In particular, two further questions arise, connected with Q3 and Q4 above:

Q5. When we add an external modifier, are we still describing the same event, or are we rather describing the surrounding context?
Q6. What is the manner of an event? How is it related to the internal event structure?

We are convinced that answering these questions will help to clarify not only the nature of event modifiers, but also the nature of events themselves.

3. Thick and thin events in the philosophical literature

Before presenting the details of our approach, let us first consider the main philosophical positions on the ontological nature of events, comparing them in the light of what discussed above. We shall take for granted their metaphysical distinction from objects (Casati and Varzi, 2015, § 1.1), focusing mainly on the various positions concerning their individuation.

According to Pianesi and Varzi (2000), such positions can be classified on a continuum, according to the degree they are *thick* or *thin*. They consider an event as thick "to the extent as it prevents other events from occurring in the same place at the same time"; this is different from the notion of thickness we have used above (the capability of exhibiting multiple aspects or modes of occurrence) so we prefer to label our notion *descriptive thickness*, and to use the term *coarse-grainedness* to mean what Pianesi and Varzi call 'thickness'. We have therefore two comparative dimensions, which appear in Fig. 1.

At one extreme of the coarse-grainedness axis we find Quine (1960, p. 131), according to whom events (like objects) are just "the content, however heterogeneous, of some portion of space-time, however disconnected or gerrymandered". This position was also eventually adopted by Davidson (1985) after he abandoned his account of event identity in terms of causal relations (Davidson, 1969). Under this approach, events are complex spatio-temporal entities whose content may be described in multiple different ways, so that we can consider them as thick entities, in our terminology; however, whatever occurs within a spatio-temporal region is taken as a whole, with no way to distinguish what is happening from the way it is happening, so we ascribe only a moderate descriptive thickness to this approach[8].

At the other extreme of the coarse-grainedness axis we find Kim (1976). For Kim, events are *property exemplifications*, identified by a triple $\langle x, P, t\rangle$, where x is an object, P is a property called *constitutive property*, and t is a time[9]. As clarified by Bennett (1988, 2002) and acknowledged by Kim himself (1991), such exemplifications are actually *instantiations*[10] of a property. In turn, property instantiations

[8] As discussed by Baratella (2020), this position is a consequence of Quine's *austere nominalism*, which is the thesis according to which properties, whether universals or particulars, don't exist. According to such a position, the features or characteristics we detect in reality are primitive facts of objects or space-time regions. For instance, no metaphysical explanation is needed for the fact that something has a mass of 90 kg. This is the reason why Quine cannot distinguish between what is happening and the way it is happening.

[9] As explained by MacDonald (1986; 2008), this does not mean that an event is an abstract entity constituted by three components, but rather that the triple has to be intended as a definite description whose referent is a concrete spatiotemporal particular, namely the exemplification by the object x of the property P at time t.

[10] Note that we should carefully distinguish *instance* from *instantiation*. The car was an instance of the *having crashed* property *because* a certain instantiation of such property (i.e., a certain crash event) occurred. This distinction between instances and instantiations is analogous to Lombard's distinction between *exemplifications* and *exemplifyings*. See also Macdonald and Macdonald (2010, p.150).

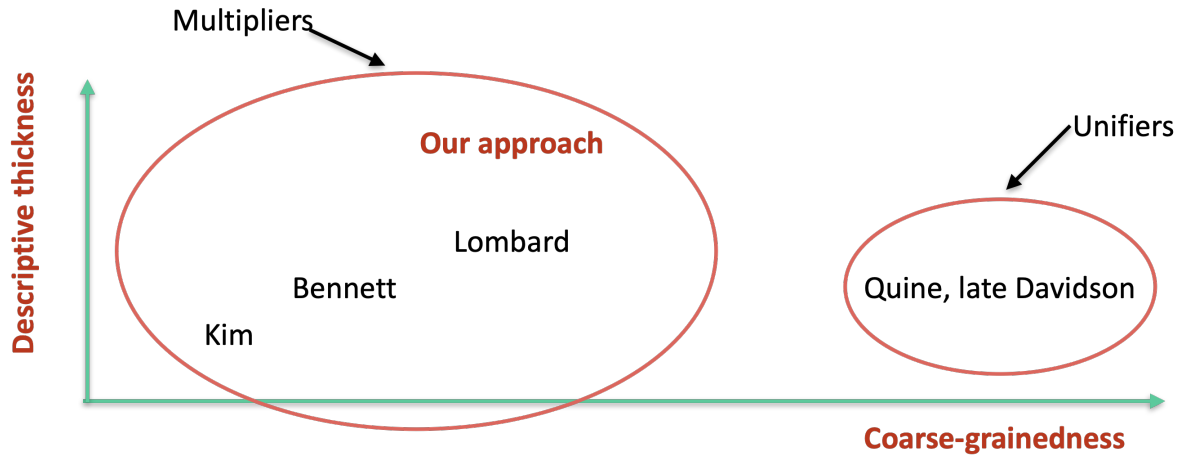

Fig. 1. Our approach compared to the most relevant philosophical positions on events. It is in favor of a moderate multiplicativism and a high descriptive thickness.

are understood by Bennett as *abstract particulars*, i.e., *tropes* (Maurin, 2018)[11]. So, if Kim's events are tropes, they have a minimal descriptive thickness, since, by definition, they abstract from everything except the property they instantiate: an event name just denotes a property instantiation, with no further details to be described. Indeed, as noted by Bennett, Kim's events presuppose a systematic connection between an event and its name, so that for him 'that crash' actually means 'that instantiation of the crashing property'.

Such presupposition is exactly what Bennett criticizes: for him, the property expressed by the name of an event is not necessarily the one that such event exemplifies (i.e., its constitutive property), which may be much more complicated. So, 'that crash' may be just a partial description of a complex event that exemplifies multiple properties, besides that of being a crash. Under this view, 'Brutus stabbed Caesar' may refer to the same event as 'Brutus killed Caesar', just under a different partial description[12]. In summary, Bennett's events are (slightly) more coarse-grained than Kim's events, since he denies that what is ordinarily described as a stabbing is different from a killing, although he does not exclude the existence of thin Kimean events that only instantiate a simple property. The descriptive thickness of Bennett's events is also slightly higher than that of Kim's events, since he clearly admits for an event the possibility of exhibiting multiple aspects, although he has no way to decide what is an aspect of what, i.e., to distinguish what happens from the way it happens[13].

Moreover, on the semantic side, Bennett's view does not account for the reason why different event names are used. Indeed, quite boldly, Bennett suggests that event names ultimately depend on "local context and unprincipled intuitions" (1988, p. 128). On the contrary, we think it is fairly obvious that

[11] As a (standard) example of a trope, Bennett brings the roundness of a pebble. In his own words, "The roundness of this pebble, unlike the property roundness, is a particular, pertaining only to this pebble; and unlike the pebble it is abstract, *involving no property except roundness*" (Bennett, 2002, p. 44, our emphasis)

[12] Bennett himself admits that, in some cases, event names denote constitutive properties, so that different names denote different events. For example, for him a cannon ball journey is different from a cannon ball rotation.

[13] Kim also allows for multiple aspects of events by distinguishing between constitutive properties of events and properties that events themselves exemplify. This distinction is however unexplained and rather problematic, as Bennett (1988, §33) showed.

different event names typically reflect different perceptions or interpretations of what happened, so that they are not arbitrary.

Finally, the approach that mostly inspired our position is that of Lombard (1986). He still considers himself as subscribing to Kim's property exemplification account (Lombard, 1998), but rejects Kim's general notion of event including changes and "unchanges", claiming that events are exemplifications of *dynamic* properties (like *heating*, for example), that imply a change from a static property to another belonging to the same *quality space*. A quality space is defined as a maximal class of comparable but mutually incompatible properties, such as the determinates of a common determinable. This means that Lombard's events are more coarse-grained than Bennett's (and Kim's) events, since while 'a walk' and 'a slow walk' would denote two different events for Kim, and for Bennett they *may or may not* happen to be two different descriptions of the same event, for Lombard there is a fundamental reason why the two descriptions refer to the same event, since there is a unique spatial change, which happens to be slow.

Moreover, Lombard's position has a stronger explanatory power than previous ones, since while for Kim and Bennett property exemplification is a primitive notion, and all the properties behave in the same way in this respect, Lombard first distinguishes between dynamic and static properties, and then explains the exemplification of dynamic properties in terms of changes of static properties within a quality space. So, among other things, he can explain in which sense a cooling event is similar to a heating event and why the two cannot co-occur, differently from a heating event and a rotating event. In conclusion, Lombard's events have a higher descriptive thickness than Bennett's events, since they presuppose a distinction between what happens (a change within one or more quality spaces) and the way it happens (the actual variation patterns within each quality space), ignoring however the effect of context on the way an event occurs.

4. Simple events as qualitative changes

According to Lombard, the simplest example of an event is an object changing from a property to another within the same quality space. What is the *subject* of such change? Lombard assumed it is the object undergoing the change, i.e., what we may call the event participant. However, citing Aristotle, Cleland (1991) proposed a different view:

> ...in a process of change we may distinguish three elements — That which changes, that in which it changes, and the *actual subject of change*, e.g., the man, the time and the fair complexion (Aristotle, trans. 1970). Our emphasis.

So, according to Cleland (and Aristotle), there is a fundamental difference between the objects that undergo the change (the *objects* of change) and the proper *subjects* of change. The latter are the entities[14] *in respect to which* the change occurs, such as the fair complexion of a man, or temperature of a physical body. These entities resemble very much what we called *individual qualities* in DOLCE (Borgo and Masolo, 2009) and in UFO (Guizzardi, 2005), and what Moltmann (2007, 2013) called (improperly) *tropes*. Cleland's analysis supports therefore our view of individual qualities as proper subjects of change. In

[14]Unfortunately, Cleland adopts a slightly unintuitive terminology to denote these entities, which in our opinion hinders the appreciation of her contribution. She first introduces *existential conditions*, which are of two kinds: *states* and *phases*. The former are determinate properties, the latter are determinable properties. Then she focuses on *concrete* phases (which are instantiations of phases), which may change by acquiring different states at different times. The latter are the entities in respect to which the change occurs.

the following, we shall first introduce our notion of individual quality, and then discuss the role it plays in our ontology of events.

4.1. Individual qualities

Individual qualities (henceforth qualities for short) are specific aspects of things we use to compare them. They *inhere* in their bearers (also called *hosts*), where inherence is a special kind of *existential dependence* relation, which is asymmetric, anti-transitive, and functional (i.e., it obeys the so-called *non-migration* or *non-transferability* principle. In other words, qualities inhere *uniquely* in their bearers)[15]. Qualities are directly comparable, while objects and events may be compared only in respect to certain aspects. Qualities are distinct from their *values* (a.k.a. *qualia*), which are reified properties corresponding to what exactly resembling qualities have in common[16], and are organized in spaces called *quality spaces*; each quality kind has its own quality space. For instance, weight is a quality kind, whose qualia form a linear quality space. Quality spaces may have a complex structure with multiple dimensions, each corresponding to an *indirect quality*, i.e., a quality that inheres in another quality (e.g., the hue of a particular color). Typical examples of complex qualities are colors and tastes, but we shall also consider mental entities such as attitudes, intentions and beliefs as complex qualities, collapsing, for the sake of simplicity, UFO's distinction between *qualities* and *modes* (Guizzardi, 2005, p. 213).

An important class of qualities are *relational qualities*, which, besides being existentially dependent on the thing they inhere in (i.e., their *bearer*), are also existentially dependent on something else. An example may be *John's love for Mary*, which inheres in John but is also existentially dependent on Mary[17]. Another example, as we shall see, is the relative position of a *figure* object with respect to a *ground* object, which inheres in the former and is existentially dependent on the latter. As we discussed in the past (Guarino and Guizzardi, 2015, 2016, 2018), relational qualities typically come in bundles called *relators*.

4.2. Individual qualities vs. tropes

We have introduced individual qualities as "*specific aspects* of things we use to compare them". What is the ontological nature of such 'aspects'? In the original paper on DOLCE (Masolo et al., 2003), qualities were introduced as primitive dependent entities, inspired by the notion of trope but differing from tropes in the possibility of being 'located' in different regions of their quality space at different times, admitting therefore qualitative change. This was also the approach adopted by Guizzardi (2005) who considered qualities as belonging to the general class of Husserlian *moments*, including other dependent entities such as *modes*. In a subsequent paper, Borgo and Masolo (2009) discussed various options, including the possibility of considering qualities as tropes (of a special kind) that can acquire different properties at different time. More recently, the BFO ontology (Arp et al., 2015; Smith, 2016) adopted a similar approach, considering qualities as instances of *rigid determinable universals*, which can instantiate *non-rigid* determinate universals at different times. So, the color of a particular rose, *color of* $rose_1$ is an individual quality inhering in $rose_1$, which at a given time will instantiate the determinate

[15]For an axiomatization of inherence, one could refer to (Guizzardi, 2005) and (Nicola and Guizzardi, 2021).

[16]The value of an individual quality q at a time corresponds to the property shared by all individual qualities that are exactly resembling q at that time. See (Borgo and Masolo, 2009).

[17]To be more precise, relational qualities inhere in one entity while being specifically dependent on another entity that is mereologically disjoint from their bearer. This is termed *external dependence* in Guizzardi (2005).

universal *red-color* and at another time will instantiate *brown-color*, while always instantiating the rigid kind *color*.

The main difference between individual qualities (so understood) and standard tropes is that the latter are usually considered as super-determinate entities that cannot change, while qualities can change. Indeed, in standard trope-based theory, change is described as trope-replacement. This idea of trope-like entities that are able to change has been also advocated by Moltmann (2013), who brought convincing evidence that natural language does not refer to tropes as standardly conceived, but rather to what she called *variable tropes*[18].

Another intriguing possibility to establish a connection between qualities and tropes was suggested by Cleland (1991), who saw qualities as particularized *determinable* properties, such as *having a temperature*, while tropes are most commonly understood as instantiations of 'natural' *determinate* properties, such as *having a temperature of* $100°C$ (Lewis, 1983b). Being particularized properties, individual qualities would count therefore as tropes, although of a non-standard kind; on the other hand, the fact that a determinable property keeps holding during a change of its determinates would explain the nature of qualities as subjects of change. Under this view, determinate properties would correspond to *states* of their qualities, so that a body would be at a temperature of 100 °C because its temperature quality is in the $100°C$ state.

In any case, it seems clear that no commitment to tropes is necessary in order to admit individual qualities, since there is a good evidence that they deserve their own ontological status, as dependent particulars that contribute to characterizing the nature of the entities they inhere in, playing a role in knowledge representation (Woods, 1975; Guarino, 1991) and conceptual modeling (Guizzardi et al., 2006) that may be more relevant than that of tropes[19].

Let us discuss now the behavior of individual qualities in time. We have seen that they may exhibit different properties at different times, while keeping their identity. They are therefore capable of *genuine change*, in the sense that the whole quality (not one of its temporal parts) remains present at different times, so that we assume that qualities are *endurants*[20]. This choice was explicitly made in UFO, while the authors of DOLCE were more uncommitting, considering qualities as neither endurants nor perdurants, especially because of the uncertain status of qualities of events. Since in the present paper we shall only talk of qualities of endurants, we can safely assume that they are also endurants, without taking a position concerning the qualities of events[21].

Since qualities are capable of genuine change, they can exhibit different temporal behaviors during their life. Consider for instance the (mean) temperature of a sphere. During a particular time interval, it may remain stable for a while, then increase with a certain rate, decrease, remain stable again, and so on, exhibiting a certain *variation pattern*. This term is inspired to Lombard's notion of 'graphs of changes'

[18] UFO originally also countenanced the notion of *moment persistents* (Guizzardi, 2005, p.275), which, like substantials, are continuants or endurants that can be constituted by snapshots that are tropes in the classical sense. This view of moments has not been further developed, however.

[19] In this regard, the following quotation from Prior (1949) (cited by Wilson, 2017) may be illuminating: "(We may think) that only determinate characters could be regarded as genuinely characters of the object, determinable characters (like 'coloured') being only indirect characterisations of objects, and referring primarily to a characterisation of their determinate characters. But [...] *the 'respects in which objects are to be characterised', to which determinable adjectives refer, are related to the objects not less but more intimately than the determinate qualities which 'characterise' them in the strict and proper sense of the term*" (our emphasis).

[20] See however Baratella (forthcoming), for some arguments against the thesis that the possibility of change implies endurantism.

[21] See Guarino (2017) for an approach where events and their qualities are allowed to change.

(1986, Chapter 5), but for us variation patterns include also *stases*, when the quality remains stable within certain thresholds. We may have therefore *static* as well as *dynamic* quality variation patterns. This seems to be an obvious generalization of Lombard's view, which re-enacts Kim's intuitions about the commonalities between changes and stases.

4.3. Qualitative changes

We have seen that qualities are capable of genuine change. Since every quality inheres in an object, a change in a quality results in a change in its bearer. The latter change, which we call a *qualitative change*, is exactly the one described by Aristotle's quote above, which carefully distinguishes the changing quality from the changing object: the former is the proper *subject of change*, the latter is the object that changes, i.e., the *object of change*. Qualitative changes are therefore changes in objects with respect to some quality. They are the simplest examples of events[22]. We distinguish two kinds of them: *direct* and *indirect* qualitative changes. The former are defined as follows:

(D1) A *direct qualitative change* is *the occurrence of a change (or a stasis) in an object with respect to one of its qualities*. It is an event individuated by a triple $\langle o, q, t \rangle$, where o is an endurant called the *changing object*, q is a quality inhering in o called the *changing quality*, and t is a time interval in which q exists.

The change that a sphere undergoes when its temperature increases is an example of direct qualitative change. Should the sphere rotate at the same time, it would undergo a further, different qualitative change, due to a different changing quality. In both cases, the only participant in these events is what undergoes the change, i.e., the sphere itself. Indeed, because of the way qualitative changes are constructed, they abstract away from whatever happens inside the changing object as well as from what happens to anything that contains the changing object as a proper part, focusing only on what the changing object undergoes as a whole. Of course, some proper parts of the sphere will undergo some change, but the sphere is the only thing that undergoes *that* change. In a sense, adopting the terminology used for thematic roles, the object of a direct qualitative change is the only *experiencer* of the change.

(D2) An *indirect qualitative change* is the occurrence of a change (or a stasis) in an object with respect to a quality that inheres *in one of its proper parts*. It is an event individuated by a triple $\langle o, q, t \rangle$, where o is an endurant called the *changing object*, q is a quality (called the *changing quality*) inhering in a proper part of o, and t is a time interval in which q exists.

To understand the difference between direct and indirect qualitative changes, consider a man who is gesticulating (using just one hand for simplicity). This means that his hand is moving, but we don't say that his hand is gesticulating. Indeed, the gesticulation consists of a hand moving, but the hand moving consists of itself moving, so the two events are different: depending on the focus of attention, we can distinguish a *gesticulation* change, where the changing object is the man and the changing quality is the hand position, from a *hand-moving* change, where the changing object is the hand. Admitting that the

[22] In principle, one may argue that an even simpler event is a *quality* change, i.e., the occurrence of a change in a single quality. Since however qualities are existentially dependent on their bearers, whenever there is a change in a quality there is a corresponding *qualitative* change in its bearer. We believe that cognition does not distinguish between the two, and what is cognitively relevant is the latter.

changing object may or may not coincide with the bearer of the changing quality allows us to account for the two cases[23].

Direct and indirect qualitative changes are collectively called *simple events*. Like direct qualitative changes, indirect qualitative changes have just *one* participant, namely the changing object. This means that the only participant in a gesticulation event is the person who gesticulates. What about the hands? They participate in *another* simple event, co-occurring with the former and belonging therefore to its (temporal) context. The connection between the two will be discussed in the next section, where we shall acknowledge that an ordinary event of gesticulation is indeed a complex event, consisting of multiple simple events.

Finally, each qualitative change has a *variation pattern*, which is the variation pattern of its changing quality. More formally,

(D3) The *variation pattern* of a qualitative change individuated by the triple $\langle o, q, t\rangle$ is a function that returns the actual value of q for each time instant (or atomic sub-interval) belonging to t.

In general, language refers to simple events by isolating those that exhibit *cognitively relevant* variation patterns (we call such events *ordinary simple events*). Consider for instance the body temperature evolution of a person throughout her life. We rarely have the need to refer to such long event, but we rather tend to isolate those temporal parts whose variation patterns belong to certain relevant classes, such as *rising, falling, reaching* or *staying above/below a certain threshold*, and so on.

4.4. Qualitative changes vs. property exemplifications

Before considering the case of ordinary events, which typically involve multiple qualitative changes, let us discuss the implications of the perspective shift we are proposing, comparing qualitative changes to property exemplifications.

A first difference between a Kimean event e individuated by the triple $\langle o, P, t\rangle$ and a qualitative change m individuated by the triple $\langle o, q, t\rangle$ is that the latter makes it explicit that, as Lombard underlined (1986, Chapter 5, section 1), any change is a change in a respect; the individual quality q is the *reification* of such respect. Moreover, the substitution of P with q allows us to distinguish between *what* happens (a change in o in respect to q during the time interval t) and *how* it happens (q's temporal behavior during t, i.e., m's variation pattern).

A second difference concerns the explanatory power of considering events as qualitative changes. Under this view, events may still be *described* as exemplifications of properties, but they are not *defined* as such, since these properties are not those that characterize their nature. So, to decide whether a given object is involved in one or two events at a given time we do not have to look at the properties it exemplifies, but at what happens to its individual qualities. For example, this means that the same event, consisting of a a certain qualitative change with respect to the *temperature* quality, may be an exemplification of the two properties of *warming up* and *warming up slowly*.

A further difference concerns the notion of *participation* in an event. As mentioned in Section 1, Borghini and Varzi (2006, p. 317) consider this as a vague notion, yet acknowledging that "a full-blown metaphysical theory of events [...] would provide some means for answering the question of what it is for an object to qualify as an event participant". As they explain, a first reason for this vagueness is

[23] As a further evidence of the importance of distinguishing between the two cases, observe that, in the case of the person gesticulating, we can ask whether it was intentional; in the case of the hand moving this question does not arise since hands don't have intentions (thanks to Antony Galton for this observation).

the fact that, if Brutus is assumed as a participant in Caesar's stabbing, any mereological sum including Brutus would also qualify as a participant. This fact is a consequence of a principle widely adopted by exemplification-based approaches, labelled by Lombard (1986, Ch. 5) 'the Principle of Event Expansion':

(PEE) Any event which is a change in an object is (identical with) a change in any other object of which the first is part.

This principle was already anticipated by Davidson (1967) with a simple statement: "if one object is part of another, a change in the first *is* a change in the second" (our emphasis). We think there is a problem here, which lies in the word 'is'. Indeed, as Lombard observed, PEE is the result of two separate assumptions:

(PEE-a) If e is an event that is a change in an object, x, and e occurs at t, then for any object y, such that x is a part of y at t, there is an event, e', that is a change in y and occurs at t.

(PEE-b) In the case above, $e = e'$.

We believe that PEE-a is unquestionable, but PEE-b is not true. Of course a change in a part *implies* a change in the whole, but the latter is not *the same* change as the former. For example, when a single tree leaf withers, of course there is a change in the tree, but this is not identical with the change in the leaf: the latter is a dramatic one, while the former may be not dramatic at all. Another example we have already seen is a person who gesticulates: she moves her hands in a certain way, but the change in her hands is different from the change in her body[24]. Indeed, what the person's body undergoes when the hands move is different from what the hands undergo when they move, and this seems to be enough to conclude that these are different events: their changing quality is the same, but they are different because they have a different changing object.

In conclusion, a crucial aspect of our approach is the distinction between the changing object and the changing quality of a simple event, and the explicit reference to them in order to refer to a simple event. This dissolves the two vagueness problems raised by Varzi and Borghini, since the Principle of Event Expansion does not hold (so that the vagueness due multiple participation disappears) and a simple event has exactly one participant (so that the problem of isolating a minimal participant disappears).

5. Complex events as clusters of qualitative changes

In the previous section we have seen that qualitative changes are the simplest case of events. As we have seen in the introduction, however, those things we perceive as events do typically have a thick, more complex structure. What happens is that we tend to cluster together multiple *cognitively relevant* qualitative changes, so that ordinary event descriptions typically refer to a plurality of them.

[24]The gesticulation example is subtler than the withering example, since one may argue that gesticulating is *defined* in terms of moving the hands in a certain way, so the two events must be identical. This is indeed the position maintained by Lombard (1981, p. 140) and MacDonald (1986; 2008) who commit to a version of Kim's approach according to which multiple non-canonical descriptions of the same event are possible. For them, y's gesticulating is a non-canonical description of x's moving. So, in our example, if y is a person and x denotes her hands, they claim that y's gesticulating is identical to x's moving. We observe however that, since gesticulating actually means *having a part* (the hands) that moves, this would mean that having a part that moves is identical to the moving of such part, which is clearly false.

As a linguistic evidence[25] for this clustering mechanism, consider verbs expressing manners of movement. In general, as well-known in cognitive semantics (Talmy, 2000a,b), movement verbs denote a change in the relative position of a *figure* object with respect to some *ground* object. Such change can be understood as a qualitative change whose changing quality is the figure *distance from the ground*. Some verbs expressing *manner* of movement, however, presuppose a *further* qualitative change, which is of static nature: *skiing* presupposes a contact with a snowy surface, while *swimming* presupposes an immersion in a liquid. In these cases, there are two different qualitative changes that contribute to the nature of the event denoted by the verb: a primary one (of dynamic nature) corresponding to the figure movement with respect to the ground, and a secondary one (of static nature) that expresses the permanence of a certain contact relationship between the figure and the ground. Slightly more complicated examples are verbs such as *walk*, *roll*, or *bike*. In these cases there is a primary movement that is associated with a more complicated secondary movement, so that the cluster includes two dynamic qualitative changes: the body moves forward while the legs alternate, the ball goes in a certain direction while rotating, the biker proceeds while sitting on a bike whose wheels rotate, and so on.

From these examples we conclude that, besides simple events, we need to admit at least some kinds of *complex* events in our ontology. In particular, we shall focus here on *synchronically complex* events, which are mereological sums of heterogeneous, co-occurring simple events, involving different changing objects and/or qualities. In the present paper we shall not discuss *diachronically complex* events (sometimes called *processes*), consisting of sequences of simple events of different kinds. So, when talking of complex events, we shall implicitly refer to synchronically complex events, unless otherwise specified. We shall also remain neutral concerning the ontological status of *arbitrary* sums of events, which we shall not discuss.

5.1. Scenes and cognitively relevant complex events

Within (synchronically) complex events, we distinguish *scenes*, which are mereological sums of qualitative changes located within the same spatiotemporal region, and *cognitively relevant* complex events typically emerging from a scene. As an example of a scene, consider a busy street market in a working day. Several events are going on: a person is buying some food, a vendor is yelling, a kid is passing by, and so on. Describing these events seems to imply first a focusing mechanism that isolates certain aspects of the scenes that mark the occurrence of a certain event kind[26], and then a description of whatever relevant occurs meanwhile[27].

As we anticipated in a previous paper (Guarino and Guizzardi, 2016), cognitively relevant complex events are therefore carved out from scenes, i.e., from whatever occurs in a certain region of spacetime. Note that for us a scene is just a (synchronically) complex event of a particular kind, whose individuation criteria are specified in a spatio-temporal way[28]. Cognitively relevant complex events, on the contrary,

[25] The importance of recognizing this clustering mechanism is not only motivated by linguistic considerations. On one hand, authors like Molnar (2007) would take events to be "polygenic manifestations", i.e., the resultant of the interaction of several qualities (dispositions, powers, in their case). On the other hand, such a clustering mechanism seems relevant also for a clarification of our causal explanations, since both causes and effects are often described as clusters of multiple phenomena.

[26] Interestingly, Casati and Varzi (2015) acknowledge that "the content of adult perception, especially in the auditory realm, endorses the discrimination and recognition *as events* of some aspects of the perceived scene". They do not clarify however the nature of such aspects.

[27] An interesting depiction of this phenomenon in the arts is the videoclip for the song *Imitation of Life* (www.youtube.com/watch?v=fJrgbCv6kcE) of the American band REM. The video directed by Garth Jennings has one single scene and unfolds by exploring different events in that same scene.

[28] Our scenes correspond therefore to Quinian events.

typically have a finer granularity, and the criteria for isolating them from the surrounding scene are stored in the lexicon (mainly in verbs).

This means that we assume a systematic connection between events and their linguistic descriptions, but such connection is a matter of semantics, not of ontology: while a complex event, as we shall see, may be described under different perspectives and at different levels of detail, its identity is just given by its proper parts, i.e, the *sub-events* it is composed of. In other words, we assume the following *extensionality principle*: if x and y are complex events, they are the same iff they are composed of the same sub-events.

5.2. The structure of complex events

Let us examine now more in detail the nature of the connection between complex events and their descriptions. In the general case, an event description encodes an *event sortal*, which determines specific *individuation criteria* and *application conditions* for its instances.

More specifically, as Bennett (1988, p. 3) clarifies, event sortals can be picked out by noun phrases that are grammatically derived from whole sentences, so that, for example, from the sentences in (1) we can derive increasingly more specific sortals, such as *John's buttering of a toast*, *John's slowly buttering of a toast*, and so on. All such sortals are specializations of the simple verbal nominalization *buttering*, which encodes the core meaning of the various event descriptions which are using that verb. The sortal encoded by the verbal nominalization is the most general one that provides specific individuation criteria and application conditions for its instances, and is therefore classified as a *kind* in UFO (Guizzardi, 2005)[29]. The other more specific sortals are classified as *subkinds*, since they inherit the individuation criteria and the application conditions from their kind, possibly adding further criteria and conditions.

Consider for instance the event kind associated with the verb *walk*. Limiting ourselves to human walks, each instance of such kind is for us a cluster of qualitative changes that necessarily includes (as a first approximation):

(1) A translational movement of a human body b along a certain line, expressed by a change of its relative position p with respect to some ground object, corresponding to a (suitably constrained) qualitative change $\langle b, p, t\rangle$.
(2) Two alternate movements of b's legs (l_1 and l_2), each expressed by a (suitably constrained) change of their relative positions with respect to the body, p_{l_1} and p_{l_2}, corresponding to the direct qualitative changes $\langle l_1, p_{l_1}, t\rangle$, and $\langle l_2, p_{l_2}, t\rangle$.
(3) A static event involving the distance h between the (mereological sum of the) body's feet (f_1 and f_2) and the surface of the ground object, expressed by a (suitably constrained) qualitative change $\langle f_1 + f_2, h, t\rangle$. Such distance must be 0 during the period t (we have a running event otherwise).

Note that each of the three statements above describes a qualitative change whose presence in a cluster represents a *necessary condition* that such cluster must satisfy in order to be classified as a walk event; a further condition is that the three qualitative changes must occur together in the same interval t, and they must be *suitably constrained* in their variation patterns. Note also that the various spatial changes in this example occur with respect to the same ground object: horizontal changes of the body are actually changes in the feet location on the surface of the ground object, while vertical changes are actually changes in the distance between the body and the surface of the ground object.

[29] Although in most cases a verbal nominalization encodes an event sortal, this is not true for all verbs. See the discussion on the verb *to kill* at the end of Section 5.5.

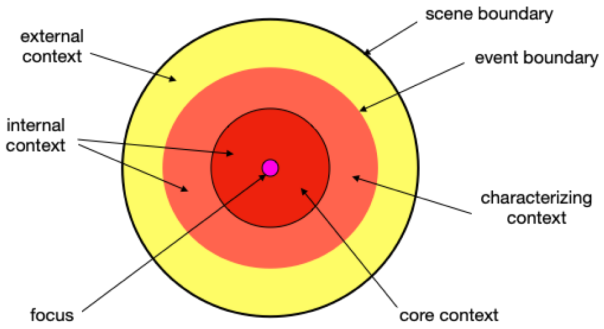

Fig. 2. The structure imposed by an event description on a cognitively relevant complex event. Points in the diagram correspond to qualitative changes.

In addition to determining the necessary components of the events they describe, kinds of cognitively relevant complex events impose a certain *synchronic structure* on their instances, which reflects the focusing mechanism mentioned above, and distinguishes *what happens* from the *way* it happens. The basic structure we have in mind is illustrated in Fig. 2, which shows how a cognitively relevant complex event is carved out from the scene where it occurs. An event description refers to a complex event by viewing it as composed of a *focus*, a *core context*, and a *characterizing context*.

The focus (the thick central dot, also called *focal event*) is the main sub-event the description refers to, corresponding to *what* the main event is about. It consists of a sum of one or more qualitative changes, the sum of whose changing objects is called the *focal object* of the event, and is typically the subject of the sentence.

The core context (the most internal ring) is formed by the further sub-events (if any) whose co-occurrence with the focal event is necessary in order to satisfy the application conditions presupposed by the event kind encoded by the description. In addition to the constraints on the focal event itself, such sub-events contribute to express *how* the focal event has to occur in order to fit the description.

The characterizing context (the intermediate ring) is formed by those co-occurring sub-events that are considered as relevant for describing how an event of such kind occurred, but are not necessary for classifying it as belonging to that kind. All the remaining co-occurring events belong to the external context (the external ring).

For example, in the *walk* event described above, the focus is the translational movement, while the alternate movement of the legs and the persistence of body contact with the floor belong to the core context. Since these sub-events are parts of the main walk event, this is in line with the intuition that proceeding in a certain direction, moving the legs in a certain way, and keeping at least one foot in touch with the ground are all *parts* of walking.

5.3. The characterizing context

Very often, describing an event goes beyond the focal event and its core context, which together form what we call the *event core*. Indeed, in many cases, although the most important properties useful to describe a complex event are grounded inside the core, there may be other properties that are relevant for describing how the event occurred, but are grounded outside the core. Consider for instance:

(6) a. Susan had a short walk in the park.
b. Susan had a fast walk in the park.

c. Susan had an easy walk in the park.

d. Susan had a nice walk in the park.

e. Susan had an illegal walk in the park.

In these examples, it seems clear that both *short* and *fast* are grounded in the event core: *short* is grounded in the focus, since it refers to the duration (or possibly the length) of the translational movement, while *fast* is grounded in the core context, since it refers to the pace of the legs movement.

However, neither *easy* nor *nice* are grounded in the core, since they do not refer to changing qualities that, if suitably constrained, would contribute to specify the core meaning of a walk event: *easy* refers to the body effort, while *nice* refers to the subjective value of the walk experience, which in turn may depend by the weather, or perhaps the company. In both cases, these qualities do not play any role in specifying *what* a walk is, although they contribute to describe *how* the event occurred. We say therefore that *easy* and *nice* are grounded in the *characterizing context*, which, together with the core context, constitutes what we call the *internal context* of the walk event.

On the contrary, *illegal* does not seem to express any information about *how* the event occurred[30], but it is rather grounded in a co-occurring legal prescription (a static social event), which happened to be violated by that walk event. This means that whether or not a walk is illegal does not impact on the nature of the walk event[31], as it is grounded in the external context, i.e., in a qualitative change that is outside the boundary of the walk event (see Fig. 2).

5.4. The boundary between a complex event and its external context

Of course, a question that immediately arises is how to determine the boundary between an event and its external context, i.e., to decide whether or not an arbitrary co-occurring qualitative change is indeed relevant for describing how the event occurred. This relevance information depends on the specific event kind, so it is implicitly stored in the lexicon, typically associated with the verb which encodes that kind.

In our example, we assume that the quality of the agent's experience is relevant for describing a walk but not relevant for describing a mere body movement. In our view, this is because enjoying the walk experience (i.e., enjoying the scenary, the weather or the company) is part of the meaning of *walking*, while enjoying the movement experience it is not part of the meaning of *moving*. This explains the difference in meaning between a *nice walk* and a *nice move*: in the former case *nice* is grounded in the characterizing context (the walk was intrinsically nice), while in the latter it is grounded in the external context (the move was extrinsically nice, due to an external judgement).

As this relevance information is not usually stored in current lexical resources, the question is still open: are there any practical ways to decide, given an event e of kind K and a qualitative change e_1 co-occurring with e, whether or not e_1 belongs to e's internal context? In other words, is there a way to explain *why* (or why not) is e_1 relevant to e?

[30] Of course, this depends on the kind of event we consider: being or not illegal may be definitely relevant for describing how a *protest march* occurred.

[31] So the puzzle discussed by Bennett (1988, p. 126) concerning the vagueness of an event described as an illegal fight disappears, since whatever determines whether a fight is illegal depends on something external to the fight itself.

A first observation we can make is that *synchronic* causality plays a role here[32], as it seems plausible to assume that whatever directly causes e or is directly caused by e is relevant for describing how e occurred, provided that it co-occurs with e. Consider for instance a stone that breaks a window: both the hitting event and the crashing sound appear to be relevant for describing how the break occurred. This causal relationship is however only sufficient to determine the relevance of a certain sub-event, since there are cases of relevant sub-events with no causal connection with the main event: consider for instance verbal and non-verbal human interaction events such as utterances, looks, smiles: bodily gestures and facial expressions are definitely relevant for describing how these events occur, but they do not play any causal role. The same holds for the agent's experience in our walk example: the fact that it is relevant for describing how the walk was is just the result of a cognitive phenomenon.

We conclude therefore that there is no general answer to our question: relevance information is encoded in the event kind, that's it. There is however a way to check at least the plausibility of a relevance hypothesis, by means of a mental experiment which relies on the notion of *exact similarity* between events. Simply put, we shall assume that two events are exactly similar if the only difference between them is the interval of time on which they occur. Two exactly similar events are called *duplicates* of each other. Then we can ask ourselves whether a duplicate of e_1 would co-occur with *all* possible duplicates of e, i.e., it would belong to the *global* context of all of them. Suppose for instance that the weather was nice when Susan did her walk. Would 'the same walk' (i.e., an exactly similar walk) have occurred with different weather? If not, the weather is relevant for describing how the walk occurred, so it somehow contributes to characterize what a walk is. On the contrary, suppose that Susan's mother was at home while she did her walk. Would 'the same walk' have occurred while Susan's mother was not at home? If we say yes, as seems plausible, it means that what somebody else does at home while somebody walks is not relevant for describing how the walk occurred.

The rationale behind this mental experiment is that the qualitative changes that belong to the internal context of an event are those that ground its *intrinsic properties*. Intuitively, being short, fast, easy or nice are all intrinsic properties of a walk[33], while being illegal is not. According to Lewis (1983a), the intrinsic properties of a certain entity are those shared by all its duplicates. So, determining whether a certain sub-event would be shared by all duplicates of the main event is equivalent to checking whether the properties grounded on it are intrinsic properties of the main event. Exploiting this equivalence may be useful to check the plausibility of a relevance hypothesis.

5.5. Event descriptions and event kinds

We have explained so far the way language describes complex events by isolating a focus, a core context and a characterizing context, which are determined by the event sortal associated to the particular description. Of course, as we have underlined, the same complex event may be described in different

[32] We take causality as a primitive here, without entering into discussions concerning its nature, and simply assuming that, from the cognitive point of view (i.e., at the macroscopic level), it can be either synchronic or diachronic. In particular, we tend to talk of synchronic causality when a certain event is realized in a particular way. For instance, when we screw a bolt into wood we may say that the penetration of the bolt into the wood (which is synchronous with the rotation) is "caused" by its rotation. Similarly, we may say that, when a person is walking, her linear movement is "caused" by the movement of the legs.

[33] One may argue that these modifiers have a relative nature, since they express judgements that typically depend on the agent who formulates them. However, according to our *descriptive ontology* stance, we can consider them as intrinsic within an ontology that describes the conceptualization of reality in the mind of a single agent, or a shared conceptualization reflecting agreed rules of interpretation. Within such conceptualization, whether a certain entity is long, fast or nice only depends on the way that entity is. This means that the conceptualization provides specific rules that allow one to decide, for every event kind, whether an instance is slow, easy, or fast independently of anything else *within that conceptualization*.

ways, being classified as belonging to multiple event sortals. Consider for example a collision between two bodies, *A* and *B*. There are several ways to describe it:

(7) a. *A* and *B* hit each other.
b. *A* hit *B*.
c. *B* hit *A*.

In our view, in (7a) there are two changing objects in the focus, namely *A* and *B*, whose changing qualities are, respectively, *A*'s distance from *B* and *B*'s distance from *A*, both with a variation pattern of type *become zero*. In the core context there are two other changing qualities, namely *A*'s momentum and *B*'s momentum, whose variation patterns reflect the momentum conservation principle. In the characterizing context we may find what happens to the specific body parts involved in the collision, which are relevant for describing how the two bodies hit each other. For instance, if *A* and *B* are cars, we may say:

(8) *A* and *B* hit each other on the front.

In (7b), the focus is on *A* as the changing object, with its distance from *B* as the changing quality. *B*'s distance from *A* is in the core context. In (7c) (which only makes sense if *B*'s momentum is not zero), the structure is similar, but the focus is on *B*. We see therefore how the same complex event can be described in different ways, each imposing its own cognitive structure. Note that in (7b-c), the event is described by, respectively, the verbal phrases *hit B* and *hit A*, which denote *subkinds* of the kind *hit*. In this case, the kind supplies the individuation criteria, determining which qualitative changes are involved in the event, while the subkind supplies further application conditions that reflect a specific focus choice.

We must observe however that not all event descriptions are associated with kinds. Consider the classic example of Brutus stabbing Caesar, thereby killing him. While *stabbing* clearly denotes an event kind, since it supplies specific individuation criteria, this is not the case for *killing*, since from the fact that a killing event occurred we get no information on the nature of such event. *Killing* denotes therefore a property that merely classifies those events that satisfy a specific application condition, namely having caused a death. Our position in the stabbing/killing debate is therefore very clear: only one event occurred[34].

5.6. The participants of complex events

To conclude our analysis of complex events, let us now discuss the issues concerning participation. What does it mean to participate in a complex event? In Section 3.3, we have already defined the participant in a qualitative change as its changing object. We then generalize this definition as follows:

(D4) An object *x* participates in an event *e just in case*: i) if *e* is a simple event, *x* is the changing object of *e*; or ii) if *e* is a complex event, *x* is a changing object of one of the qualitative changes that are parts of *e*.

To better understand the implications of this definition, consider again the gesticulation example we have discussed in Section 4.3. Intuitively, the moving hand seems to be a cognitively relevant participant in the gesticulation event, while, if we see the latter as a simple event, the only participant is the person who gesticulates. The solution is that a gesticulating event is a complex event, whose focus is the change

[34] In terms of UFO's classification of properties, we believe that *killing* may be classified as a *role mixin* (Guizzardi et al., 2004), modulo some adaptations to the definition of such notion. The discussion on event roles is however beyond the scope of this paper.

the person undergoes when her hands move, and whose core context includes the change the hands undergo. The hands are therefore a participant in the complex event because they are the participant of a sub-event.

Indeed, whenever the focus of an ordinary event includes an indirect qualitative change, definitely there is a change occurring in a proper part of the changing object whose occurrence is necessary for describing the whole event, so that it belongs to the core context. Therefore, according to the definition above, the changing part is a participant in the whole event.

On the other hand, the heart of the gesticulating person is not a participant in the gesticulating event, despite the fact that a proper heart beating necessarily must occur when such event occurs. This is because the heart beat is not cognitively relevant for describing how the gesticulation event occurred, so, since the internal context only includes the cognitively relevant events, it belongs to the external context. An evidence for this lack of relevance is the fact that no adverbial modifier (besides while constructions) of a gesticulating event would directly refer to the heart beating.

6. The nature of event modifiers

6.1. The interaction mechanism between modifiers and events

We are now in the position to analyze the nature of the interaction between modifiers and events, accounting for the way their meaning contribution is interlinked with the synchronic structure described in the previous section.

Let us first go back to the external/internal distinction. While in section 1 we informally introduced internal modifiers as those whose meaning contribution depends on some property holding for *something* internal to the event, now we refine our definition by clarifying that this 'something' is actually a sub-event that belongs to the internal context of the main event:

(D5) A modifier is *internal* if it is grounded[35] in some sub-event that belongs to the internal context, and *external* otherwise.

A few observations are due. First, notice that the grounding event (on which the truth conditions of the modifier depend) may be different from the target event (which is what the modifier refers to). Indeed as we have seen in the walk example, the target of *fast* and *easy* is the walk as a whole, but they are grounded in its internal context, while *short* has also the whole walk as a target but it is grounded in its focus. Moreover, the above definition allows that the same modifier can have an external nature when applied to events of a certain kind, and an internal nature when applied to events of a different kind. Finally, consider the 'thing' internal to the event to which an internal modifier refers: while for Maienborn this is a *participant* and for Piñon is an unspecified *manner*, for us it is a sub-event belonging to the internal context. This allows us to deal with locative adverbials homogeneously with manner adverbials, since both modify events.

Besides the internal/external distinction, which simply tells whether a modifier depends or not on the internal structure of the event, let us introduce now a further distinction useful to understand the nature of the interaction mechanism. We shall distinguish *nonrelational* modifiers, which are grounded in the

[35] We adopt here the notion of grounding as a primitive. Informally, a modifier is grounded in a certain event if its truth conditions depend on the occurrence of that event. For some formal clarifications, see Correia and Schnieder (2012); Fine (2012) and Bliss and Trogdon (2016).

focus, from *relational modifiers*, which are grounded in an event that is different from the focus, and yet co-occurs with it. Clearly, nonrelational modifiers are all external, while relational modifiers may be either internal or external. In the case of a walk, *short* is nonrelational (and therefore external), *fast* and *easy* are internal and relational, while *illegal* is external and relational.

The way nonrelational and relational modifiers interact with the main event is very different. While the former simply express a property of the focal event, the latter express a temporal relationship (typically co-occurrence) between the focal event and another event.

Limiting ourselves to the cases where the focal event is a simple one, consisting of a single qualitative change, some common examples of non-relational modifiers may be isolated, depending on which component of the grounding triple $\langle o, q, t \rangle$ is concerned:

(1) Duration modifiers concerning the length of the temporal interval: *a long-lasting walk*.
(2) Modifiers concerning the value of the changing quality or in general its variation pattern: *a fast trip; a loud talk; a circular walk; a spiralling descent* (Bennett, 1988, p. 127). Note that complex variation patterns (e.g., those concerning sound) may be described by multiple modifiers, each referring to single aspects of the variation pattern (e.g., those concerning amplitude or frequency for the case of sound).
(3) Modifiers that constrain and orient the quality space of the changing quality with respect to some reference object. Typical examples are modifiers expressing some properties of a spatial movement, which is always relative to some reference object (*to the station, along the river, across the road...*).
(4) Modifiers expressing the nature of the changing object: *a car accident*.

Considering now relational modifiers, the following cases may be isolated:

(5) Temporal location modifiers, expressing the temporal position of the focal event with respect to the grounding event (*at 3 o'clock/after lunch*);
(6) Spatial location modifiers, expressing a co-occurrence relationship with an event that concerns the spatial position of certain object which may or may not coincide with the focal object: *in Argentina*, *on the last page*.
(7) Modifiers expressing co-occurrence relationships with other (non-locative) events whose changing object coincides with the focal object. Mental attitude modifiers such as *deliberately* or *reluctantly* seem to belong to this category. They can be reduced to while-clauses describing, for instance, the event of having that particular attitude towards the main event.
(8) Modifiers expressing arbitrary co-occurrence relationship with other events which do not involve the focal object. These have the form of arbitrary while-clauses (*while a band was playing*).

To better understand the nature of the distinctions discussed so far, let us see now how they can be used to explain the semantics of two important classes of modifiers: locative and manner modifiers.

6.2. The case of locative modifiers

Concerning locative modifiers, let us first observe that being located somewhere in a certain time interval is clearly a simple event: for example, a sentence like *John was on the boat* describes a *locative event* (which is actually a *stasis*) whose (un)changing object is John and whose (un)changing quality is John's relative position with respect to a certain reference object, namely the boat.

So, since being located somewhere is an event, we can see a spatial modifier of a certain event as relational modifier, expressing a co-occurrence relationship between the focus of that event and a certain locative event. Indeed, in many cases, locative modifiers such as *on the boat* can be paraphrased by while-clauses (*while he was on the boat*). This means that the same event may be described using a spatial modifier or the corresponding while-clause, which is actually a temporal modifier. However, this semantic equivalence does not always work. Consider the following examples:

(9) a. John kissed Mary on the boat.
b. John kissed Mary while he/she/they was/were on the boat.
c. John kissed Mary on the cheek.
d. ?John kissed Mary while his lips were on Mary's cheek.

These are all examples of case 6 above. In (9a), the modifier is grounded in a locative event whose participant is ambiguous: it may be John, Mary, or both. (9b) shows that a while-paraphrase may be appropriately used to disambiguate. In any case, the modifier is external, since, according with the ordinary lexical meaning of *kiss*, the kissing event may have a duplicate that does not occur on the boat.

In (9c) the modifier is grounded in a sub-event (John's lips being located on Mary's cheek). According to the ordinary sense of a kiss, the body place where it occurs matters, so we should not admit duplicates that occur on different body places. The sub-event belongs therefore to the internal context (in particular, it belongs to the *characterizing* context, since although it is essential for a kiss that the lips are in touch with the body, the particular location on the body surface is not essential).

Example (9d) shows that the while-paraphrase seems not appropriate in this case. To better understand this issue, consider some further examples inspired by those discussed by Maienborn (2003).

(10) a. Maradona signed the contract in Argentina.
b. Maradona signed the contract while he was in Argentina.
c. Maradona signed the contract on the last page.
d. Maradona strolled in downtown Buenos Aires.
e. Maradona strolled while he was in downtown Buenos Aires.
f. Maradona strolled in downtown Buenos Aires while he was in Argentina.

Example (10a) (repeated from 2a) is again an instance of case 6 above. Example (10b) shows that the while-paraphrase works. Again, like in (9a), the modifier is an external one, since the lexical meaning of *sign* does not imply any cognitive relevance of the place where the signature event occurs.

In (10c), on the contrary, the modifier has an internal interpretation, since it is grounded in a location event that does not concern Maradona, but rather a certain ink pattern resulting from his signing action. Such location event is a sub-event of the global signature event. Note that in this case the paraphrase in terms a while-clause is not possible.

Let us now consider (10d). Its syntactic form is very similar to that of (10a), the only difference is that now we are talking of a different kind of event. In this case, it seems plausible to assume, on the basis of the core lexical meaning of *stroll*, that being in a specific place while strolling (and hence enjoying the scenery, and so on) is a relevant part of a stroll (in the sense that it affects how the stroll occurs), so a stroll downtown Buenos Aires, differently from a contract signature in Buenos Aires, can't have a duplicate occurring in another city. *Maradona's being downtown Buenos Aires* is therefore an event that belongs to the internal context of the strolling event, so that the locative modifier *in downtown Buenos Aires* is in this case internal, and acquires a manner reading.

Note that a while-paraphrase is still possible in this case, as shown in (10e), but this seems to reflect an external interpretation, which would be ambiguous in (10d), although its most natural interpretation seems to be internal. This preferred internal interpretation seems indeed confirmed by (10f). Moreover, we believe there is some evidence for a manner reading of *in downtown Buenos Aires* in (10d) and in (10f), which may be confirmed also from a pragmatic point of view. For instance, from the utterance *I had a stroll downtown Buenos Aires* we may expect a reaction such as *Was it nice?*, while we wouldn't expect the same reaction to the utterance *I signed the contract in Buenos Aires*.

These examples motivate therefore a conjecture: the semantic equivalence between a locative modifier expressed by a prepositional phrase and the corresponding while-clause only works if the modifier has an external reading. If the modifier expressed by the prepositional phrase is internal, it is either the case that its while-paraphrase is impossible, or that the modifier has an ambiguous reading, and the while-paraphrase forces the external interpretation.

In conclusion, although our analysis of these examples should be surely supported by more systematic investigations, for instance considering a wide range of examples extracted from Levin's verb classes (1993), we believe it shows that the internal/external distinction we have introduced is a useful tool for understanding how the different behavior of modifiers captures subtle distinctions in verb semantics. In particular, our refinement of Maienborn's distinction allows us to analyze (10a) differently from (10d). This would not be possible using the original distinction, which relies on the idea that, when a locative modifier has an internal reading, it expresses the location of something which is *part* of the main event. This does not work for (10d), so Maienborn would be forced to take an external reading for it, with no difference from (10a).

6.3. The case of manner modifiers

Like locative modifiers, manner modifiers, too, may have an external or an internal interpretation. As Maienborn and Shäfer (2011, p. 1415) noted, although all such modifiers can be questioned by *How ...?*, their meaning contributions may be very different. In particular, not all of them can be easily paraphrased in terms of *manners* or *ways*, as shown in (11) below.

(11) a. Marie sings loudly.
?Marie sings in a loud manner/way
∗The manner Marie sings is loud
b. Kim dances beautifully.
Kim dances in a beautiful manner/way.
The manner/way Kim dances is beautiful.
c. Peter runs fast.
Peter runs in a fast manner/way.
?The manner/way Peter runs is fast.
d. The crowd moved noisily.
The crowd moved in a noisy manner/way.
The manner/way the crowd moved was noisy.

Maienborn and Schäfer pointed out that in (11a) "*to sing loudly* means that the sound-volume of the singing is loud, not the manner." On the other hand, in (11b) the modifier clearly concerns the manner the event occurs. How to account for this difference?

Following Piñón (2007, 2008), Maienborn and Schäfer suggest that in these cases the modifier refers to a certain *conceptual coordinate* of the event, which has a simple scalar nature in (11a) and a more

complex nature in (11b). Their conclusion is that the manner (or way) an event occurs refers to a complex coordinate. However, this explanation does not seem to work in (11c). Such sentence is a bit ambiguous, since *running fast* may be interpreted either as running at a fast *speed* (measured in, say, meters per second) or running at a fast *pace* (measured in footfalls per second). Presumably, Maienborn and Schäfer had the first interpretation in mind while arguing that "*to run fast* means that the speed of the running is fast, not the manner". But under the second interpretation it seems plausible to say that the manner Peter runs is fast. If so, since *running speed* and *running pace* have both a scalar nature, we cannot conclude that the manner Peter runs refers to a complex coordinate. A further example is (11d), where *noisy* appears to have a scalar nature, and still it may make sense to see it as a property of the manner the crowd moved.

In our approach, the reason of the difference between (11a) and (11b) is simply that *loudly* is an external modifier, while *beautifully* is an internal modifier. Indeed, *loudly* is grounded in the focus of the singing event, consisting in a certain vibration of the vocal cords. According to the classification discussed in Section 6.1, it is therefore an external modifier of kind 2, since it depends on the *variation pattern* of the vibration event, namely on its *amplitude*. So, we agree with Maienborn and Schäfer in that it is not the manner of singing that is loud, but rather its sound volume.

On the other hand, in (11b) *beautifully* is an internal modifier, since it is not grounded in the focus of the dancing event, but in a number of relevant co-occurring sub-events (such as those involving Kim's facial expression or the position of his fingers) that belong to the internal context. Note also that *fast* (under the *pace* interpretation) and *noisily* are internal modifiers in (11c-d), since they are grounded in something relevant that happened while the focal event occurred. The difference between (11b) and (11c-d) lies in the fact that in the former case the modifier is grounded in the *global* manner in which the dance occurs, while in the latter case, while still targeting the global manner, it is grounded in a *part* of it, i.e., the legs motion or the noise production sub-events.

In conclusion, Kim dances in a beautiful manner exactly because the sub-events belonging to the internal context of the dance are *jointly* beautiful, so that saying that the manner Kim dances is beautiful is the same as saying that the internal context of such dance event is beautiful. This suggests a simple answer to question Q6, which shades some light on the ontological nature of manner:

(D6) The *manner* (or *way*) an event occurs is just its internal context.

This definition clarifies that each event has just *one* manner, which is the sum of all co-occurring sub-events that are relevant to describe how the event occurred. To make a musical example, the timbre of a note (the *way* it sounds) is exactly defined as the sum of all its co-occurring harmonics.

Admitting that an event has just one manner allows us to avoid a further problem of Maienborn and Schäfer's approach. For them, each event may have *many* individual manners, each of which is a conceptual coordinate associated to a specific manner modifier[36]. So, it is not clear what *the* manner of an event is. As a consequence, it is difficult to formulate the semantics of statements such as (12a-c). On the other hand, this example is not a problem if we assume that there is *one* manner of talking that is *both* fast and calm.

[36] A possibility to capture Piñon's intuition of conceptual coordinates, endorsed by Maienborn and Schäfer (2011, 2019) and further elaborated by Schäfer (2013, p. 188-201), is to consider them as *qualities* of events. They would be second-order qualities, grounded in qualitative changes concerning ordinary qualities. In this way, we could simply distinguish between external qualities, which inhere in the event focus, and internal qualities, which inhere in its internal context. The latter would coincide to what Maienborn and Schäfer call individual manners, which we would rather call *manner qualities*. The difference would be that, instead of having multiple manners, we would have just one manner with multiple manner qualities. In any case, the notion of event quality should definitely deserve a dedicated discussion, which we postpone to future work.

(12) a. Peter talks fast and calmly.
b. Peter talks in a fast and calm manner/way.
c. The manner/way Peter talks is fast and calm.

7. Final discussion

In this paper we have presented both an ontological theory and a semantic theory. Indeed, especially in the case of events, the two are highly intertwined, so that the principles governing the semantic bridge between a linguistic expression and an event are not a simple matter. Famously, Bennett (1988, p. 128) claimed that such principles cannot but rest on "local context and unprincipled intuitions".

As already said, we disagree with Bennett. Indeed, the two theories we developed show that a *systematic* connection between events and their names is possible, if not always immediate. Concerning the metaphysical part, our initial idea was to distinguish between the objects that undergo a change and the actual subjects of that change. According to our view, the latter are aspects in respect to which a change occurs. We reified such aspects and realized they were what we used to call *individual qualities*. We came then to the conclusion that (qualitative) events are either (direct or indirect) qualitative changes or sums of qualitative changes. This is our answer to question Q1 mentioned in Section 1, which is about the ontological nature of events.

Concerning question Q2, which is about the referential mechanism used to describe events, we showed that all ordinary events (i.e., those we talk of in language) are cognitively constructed, in the sense that they consist of qualitative changes isolated on the basis of cognitive relevance criteria. Indeed, we may define *simple ordinary events* as simple events that have a cognitively relevant variation pattern, and *(synchronically) complex ordinary events* as complex events that have a cognitively relevant (synchronic) mereological structure. We brought some evidence showing that the criteria for cognitive relevance are stored in the lexicon, so that the way language refers to events does not depend on unprincipled intuitions, but comes from the cognitive structure *systematically* imposed on qualitative changes by the kind according to which they are described.

Going back to the ontological part of our theory, we believe it has several advantages over its competitors. First of all, with respect to Kimean extreme multiplicativism we have a more moderate position, being able to explain why *warming up* and *warming up slowly* do not describe different events, while *warming up* and *rotating* do. In addition, we can explain why *killing* is not a constitutive property of an event, so that Brutus' stabbing was a killing.

More generally, our strategy to detach events from the properties they exemplify allows us to avoid all the problems related to the very notion of property exemplification: what does it mean that events are exemplifications of properties? Is such an exemplification just the nexus connecting a universal to an object? Is it just the possession of a property by an object? Or, is it a state of affairs of the type advocated by Armstrong (1980)? In any case, such a notion seems not to be apt to fully capture our intuitive idea of what events are. On the contrary, our notion of qualitative change seems to be better tailored for such a task, since it captures Aristotle's idea that events are changes in a respect.

Let us now consider questions Q3-Q6. The first part of Q3 (on the internal structure of events) is answered by Fig. 2, while our definition of internal modifiers (D6) provides a direct answer to the second part (on the way internal modifiers are connected with the internal structure of events): internal modifiers are *grounded* in a sub-event that belongs to the internal context. Question Q4 (on the boundary between an event and its surrounding context) is answered by our account of the characterizing context, whose

boundary with the surrounding context depends on the relevance criteria provided by the event's kind (Sections 5.3 and 5.4). Question Q5 (on the nature of external modifiers) is answered by the discussion in Section 6.1, where we clarify that an external modifier describes an event if it is grounded in the focus of that event, while it describes its surrounding context if it is grounded in the external context of such event. Finally, definition (D6), saying that the manner of an event is just its characterizing context, is our answer to question Q6, on the nature of event manners.

In conclusion, despite its strong explanatory power, the theory we have presented is of course subject to some limitations. A first one is that we only focused on *qualitative events*, ignoring both existential events and mereological events (see footnote 6). We believe that an ad-hoc approach may be adopted in these cases[37], with no implications on the theory we have presented here. As a second limitation, we only concentrated on the *synchronic* structure of events, with not much attention to their *diachronic* structure, that is, to the way they extend in time. We see the two aspects as complementary, so that, for example, the distinctions among events based on telicity or homeomericity still work in our approach. As a further limitation, we did not take into account *qualities of events* (such as the speed of a movement or the beauty of a dance). We are convinced it makes sense to account for them (see note 36), but we still have to investigate their nature. Finally, a possible limitation could be the fact that we did not discuss instantaneous events, since qualitative changes are defined with respect to a time interval, not a time instant. We do not think this is really a limitation, since, especially under a cognitive perspective, we think it makes sense to deny the existence of instantaneous events.

Let us finally discuss our future research directions. A first direction is to explore the connections with the view, shared by many philosophers (Molnar, 2007), that events are manifestations of dispositions. For instance, the shattering of a glass due to a fall is the manifestation of its fragility and its altitude together with the gravity force. A second line of research concerns the application of our theory to the lexical semantics of verbs, trying to account in a systematic way for Levin's (1993) verb classes and alternations, as well as to the ontological nature of thematic roles (Parsons, 1990). Lastly, a natural and necessary line of development is to revisit our previous work –especially (Guarino and Guizzardi, 2016; Almeida et al., 2019a, 2018)– to provide a formalization of the concepts here discussed that is compatible with some well-worked out foundational ontologies, notably UFO and DOLCE.

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[37] Perhaps these events are also cognitively constructed, in the sense that they ultimately depend on qualitative changes: if a stone wall ceases to exist it is because of some qualitative changes concerning the stones. Similarly, if a tree loses a leaf it is because of a qualitative change involving the leaf. This is just a conjecture, however.

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Appendix A. OntoUML diagrams

Figures 3 and 4 depict a conceptual model comprising the various notions discussed in this article. These models focus respectively on the *ontological* and *semantic* theories of events proposed here. The former focuses on the fundamental categories of events countenanced here and their relations to endurants; the latter focuses on the connection between cognitively salient event types and the semantics of verbs and verb phrases. Figure 5 unifies these two perspectives in one single model, providing a global view of the approach.[38].

We advocate that these models not only summarize the discussion developed hitherto, but they also offer a complementary perspective addressing a additional ontological issues regarding the nature of these entities and their relations. In addition, they capture the notions put forth by our theory in terms of concrete formal artifacts that, despite the necessarily limited expressivity, can be reused, reasoned with, verified and validated (Guerson et al., 2015; Almeida et al., 2019b), and which therefore amount to a first step towards a full logical axiomatization.

The models are represented using the OntoUML conceptual modeling language (Guizzardi, 2005). This language has been systematically designed to reflect the ontological distinctions put forth by the foundational ontology UFO (Guizzardi et al., 2015). However, UFO includes notions that intersect with other approaches from which it took its original inspiration, namely, the ontology of types underlying OntoClean (Guarino and Welty, 2000) (e.g., type distinctions based on formal meta-properties), as well as the foundational ontologies DOLCE (Masolo et al., 2003) (e.g., the notion of quality) and GFO (Herre, 2010) (e.g., the original notion of relator). For this reason, the primitives represented therein can also be used to a certain extent to connect to these other approaches.

OntoUML is also a technical extension (what is termed a *modeling profile*) to the UML (Unified Modeling Language) *de facto* standard[39]. As such, OntoUML introduces a series of stereotypes to classes and relations (syntactically marked by «») to reflect the ontological nature of their instances according to UFO.

Before we proceed, a very short introduction to notation. UML class diagrams, such as the one presented here, represent types (called classes in UML) and their ties. Classes are represented as named rectangles. A fundamental relation connecting classes is *subtyping*. A class *B* is a subtype of class *A* iff all instances of *B* are instances of *A*, necessarily. Subtyping is represented by a continuous hollow-headed arrow moving from a subtype to a subsuming type (e.g., in Figure 3, every *Object* is an *Endurant*).

Simple lines connecting classes in UML are meant to denote relations between individuals instantiating those classes. These relations (termed *associations* in UML) can be endowed with *cardinality constraints* (e.g., in Figure 3, every instance of *Complex Event* is associated with at least 2 instances of *Qualitative Change*). The notation 'min..max' refers to the so-called minimum and maximal cardinality constraints. So, for example, a cardinality constraint pair '0..1' represents an optional but functional relationship (the latter example connecting *Complex Event Sortal* and *Core Context Type* in Figure 4). When

[38]The OntoUML models in this section use a conventional color coding adopted by the community: types whose instances are objects are depicted in light red, those whose instances are qualities in light blue, those whose instances are events in yellow, and those whose instances are themselves types in purple. Finally, grey is used for types collecting instances in more than one ontological basic category.

[39]https://www.uml.org/

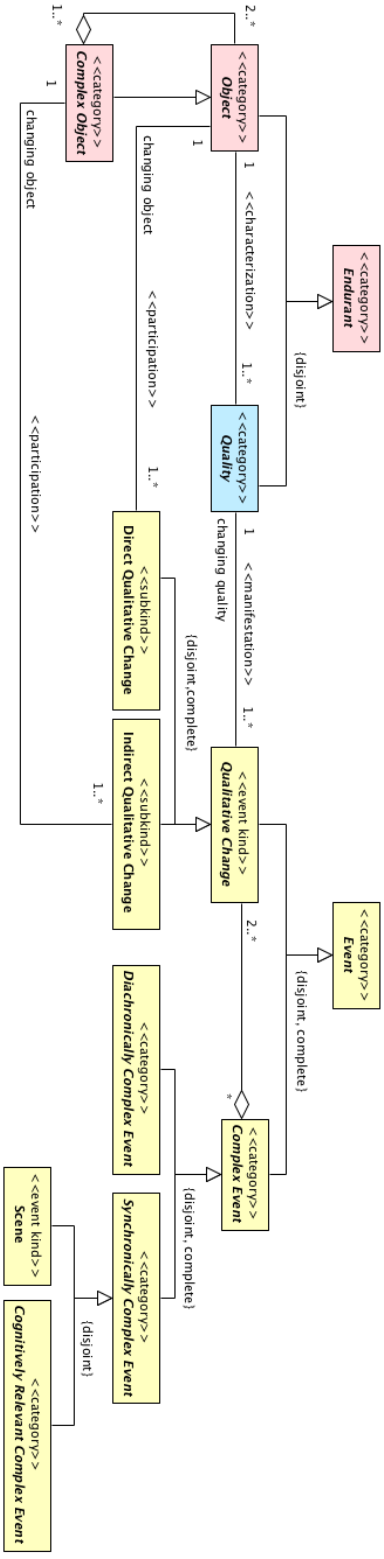

Fig. 3. Partial OntoUML diagram describing basic event types and their relations to endurants.

appearing in a constraint pair, '$*$' represents the absence of a maximum cardinality constraint (e.g., every *Complex Event* is associated with a minimum of 2 but possibly many *Qualitative Changes*), while when appearing alone it is a shorthand for '0..*'. Moreover, '1' is a shorthand for '1..1' (e.g., every *Quality* is connected to exactly one *Object*). A black triangle is used as a notational element to simply suggest a reading direction for the verbalization of an association and, as such, it carries no special semantics.

A special type of association in UML is the so-called *aggregation*, which is meant to represent a mereological relation. A diamond on one of the ends of that relation indicates the class representing the whole (e.g., a *Complex Event* is composed of 2 or more *Qualitative Changes*).

UML allows for the specification of logical constraints connecting associations. For example, in Figure 4, the *OR* constraint connecting the two aggregation relations between *Cognitively Relevant Complex Event* and, respectively, *Core Context* and *Characterizing Context* says that a cognitively relevant complex event, in addition to the *Focal Event*, must have as parts a core context, a characterizing context or both (the sum of latter two constituting what we call an *internal context*, not shown in the diagram for the sake of simplicity).

Finally, UML allows for describing constraints across a set of subtyping relations. For example, the terms *disjoint* and *complete* in Figure 3 refer, respectively, to the fact that no *Qualitative Change* is both *Direct-* and an *Indirect Qualitative Change*, and that every *Qualitative Change* is either one of the two.

Considering now OntoUML, a class is stereotyped as a «category» if it denotes a type that *rigidly* (i.e., necessarily, in the modal sense) classifies its instances but does not carry uniform *principles of identity and individuation* for its instances (Guizzardi et al., 2004). In contrast, the so-called *sortal types* do carry these uniform principles, either because they inherit them from their supertypes or because they *supply* their own principles. The most general sortal that supplies these principles is termed a substance sortal or a *kind*. Rigid specializations of kinds are termed *subkinds*(Guizzardi et al., 2018). In other words, sortals are either kinds or specializations of kinds. All sortals specializing a kind inherit these principles supplied by that kind. They can, however, include additional principles to those supplied by that kind. In particular, they may include additional *application conditions* (also called *principles of application*), which are provided by all types, and determine conditions that must be satisfied for something to be an instance of that type. In the model of Figure 3, principles of identity and individuation may be supplied by kinds specializing the category *Object* (such as the object kinds *Car* or *Person*) or the category *Quality* (such as the *quality kinds Color* or *Weight*).

With this brief introduction, we can then start discussing the model of Figure 3, which describes the ontological core of our theory. We make a fundamental distinction between *Endurants* and *Events* (a.k.a. *perdurants*). *Endurants* are further specialized in *Objects* and *Qualities*, the latter being existentially dependent aspects of the former. In OntoUML, the stereotyped relation «characterization» represents the relation of *inherence* connecting *Qualities* to their bearers (Guizzardi, 2005).

In our ontology, we countenance two fundamental types of events, namely, *Qualitative Changes* and *Complex Events*. A qualitative change, as discussed throughout this paper, is individuated by a triple $\langle o, q, t \rangle$. Since this individuation principle applies uniformly to all instances of *Qualitative Change*, the latter is assumed to be a fundamental event kind.

Complex Events, as explained in the main text, are mereological sums of heterogeneous qualitative changes, differing either in the changing quality or in the changing object[40]. Note that the type *Complex Event* does not provide a homogeneous principle of individuation for its instances, since just knowing

[40]Although this heterogeneity constraint, like others in this ontology, cannot be expressed diagrammatically, (Onto)UML models can be extended with formal constraints in a first-order logical language named OCL (Object Constraint Language).

that something is a sum of *Qualitative Changes* does not impose any constraints on what its parts actually are. These principles of individuation would be supplied by the event kinds that would specialize *Complex Event* (such as *Walking*, *Kissing*, *Hitting*, etc.). So, *Complex Event* represents a general type whose instances are mereological sums of *Qualitative Changes*, each of which may be individuated by a particular event kind.

As discussed in the main text, within complex events we distinguish two disjoint subclasses, *Synchronically Complex Event* and *Diachronically Complex Event*. The latter is not further discussed here, while we distinguish two further subclasses of the former, namely *Scene* and *Cognitively Relevant Complex Event*. A *Scene* is the sum of all qualitative changes occurring in a given spatiotemporal region, hence, the scenes *x* and *y* are the same iff they occupy the same region. Since the *Scene* class provides an identity criterion for its instances, it is therefore stereotyped as a *kind*. *Cognitively Relevant Complex Events* are those synchronically complex events that are referred to by ordinary event names. The details of such referential mechanism are described in Figure 4, discussed below.

Finally, Figure 3 connects events with endurants involved in them. As discussed in the main article, we have two types of *Qualitative Changes*: *Direct Qualitative Changes* and *Indirect Qualitative Changes*. In the former, the *changing object* of that *Qualitative Change* is exactly the bearer of its *changing quality*; in the latter, the changing object has as a proper part the bearer of the changing quality of that event.

Now, let us move to Figure 4, which shows the way event sortals pick up cognitively relevant events, and impose a structure on them. As discussed in the main paper, event sortals are cognitively constructed, and are typically associated with verbs and verb phrases. They can pick up simple events (i.e., single *Qualitative Changes*) or sums of *Qualitative Changes* that are considered as cognitively relevant. In the latter case, they provide specific individuation criteria and application conditions that impose a structure on the complex event, determining the nature and the boundaries of its cognitively relevant parts (i.e., its *Focal Event*, and its *Core* and *Characterizing Contexts*). Every *Cognitively Relevant Complex Event* is composed of a *Focal Event* and either a *Core Context*, a *Characterizing Context*, or both[41].

To capture the fact that complex event kinds and subkinds impose a structure on their instances, as we discussed in the paper, we employ the support for multi-level modeling proposed in (Carvalho et al., 2016). Here, the relation stereotyped as «instantiation» connects a type with a higher-order one, and has the following semantics: if a type T_1 is connected by «instantiation» to a type T_2 then every instance of T_1 is an instance of an instance of T_2. The instances of T_2 are themselves types and, given the semantics of subtyping, they are necessarily specializations (subtypes of) T_1. Higher-order types (i.e., types whose instances are types) are represented by the stereotype «type». A particular type of higher-order type is a «powertype»: the type T_P is the powertype of another type T iff the instances of T_P are all the possible subtypes of T (improperly, i.e., including T ifself).

In this model, the type *Event Type* is a powertype of the type *Event*. *Event Type* is specialized in *Event Sortal*, which is further specialized into *Event Kind* and *Event Subkind*[42].

A *Complex Event Sortal* (here a complex event kind or subkind) determines a *Focal Event Type* and either a *Core Context Type* or a *Characterizing Context Type* (or both). Each of these types provides the individuation principles and the application conditions for isolating the corresponding part of a *Cognitively Relevant Complex Event*. To constrain the intended semantics we need to complement the model

[41] *Focal Events*, *Core Contexts*, and *Characterizing Contexts* can be mereologically simple events (i.e., *Qualitative Changes*). However, in case they are *Complex Events*, then they are taken here to be *Synchronically Complex Events*. This constraint is easily expressed in OCL.

[42] As discussed in the main paper, we leave open the possibility for countenancing a category of *Event Roles*. However, this is a topic that shall be investigated in a future paper.

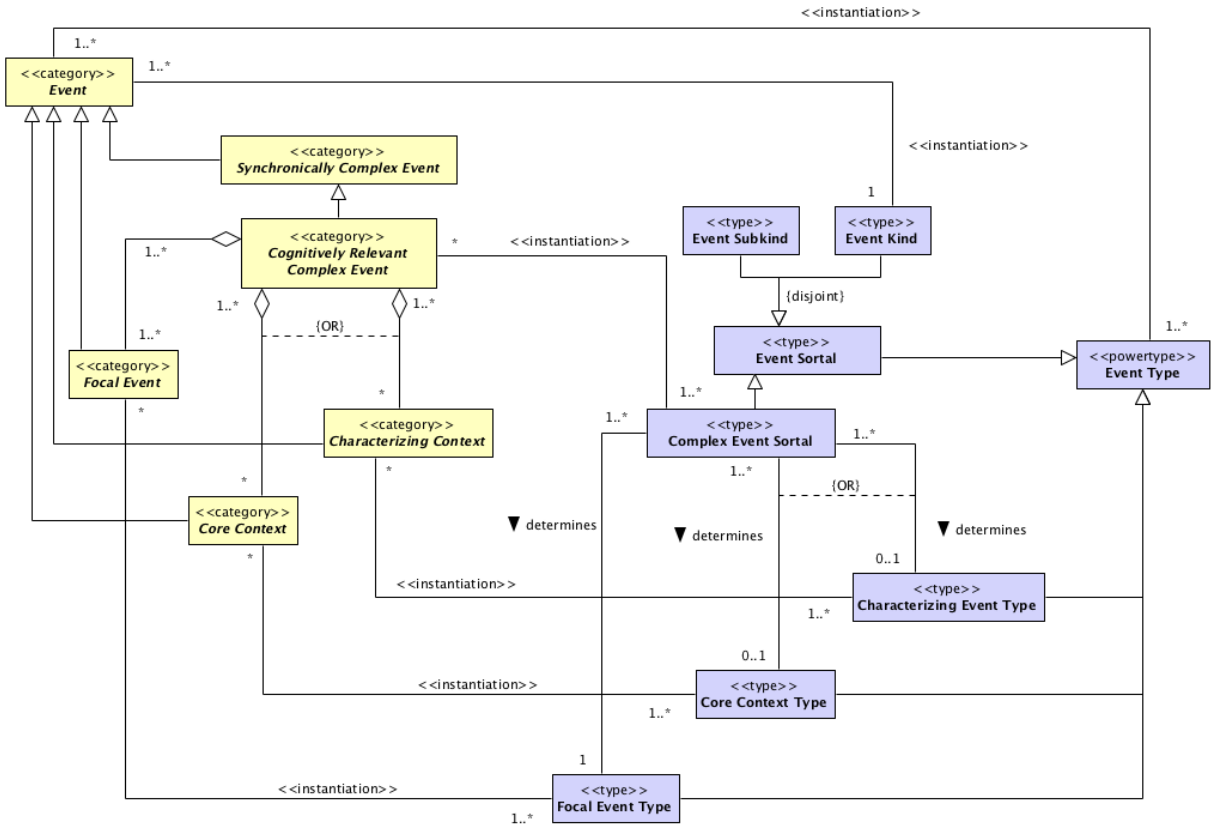

Fig. 4. Partial OntoUML diagram describing cognitively relevant complex events.

with the following integrity constraint (easily expressible in OCL): if a *Cognitively Relevant Complex Event* instantiates a *Complex Event Sortal* then its *Focal Event*, as well as its *Core* and *Characterizing Context*, instantiate the corresponding types determined by that sortal.

In summary, in the ontology proposed here, events are either *Qualitative Changes* or sums thereof. In the second case, these are either the "totality of everything that happens" in regions of space-time, or they are sums individuated by proper *Event Kinds*. In the latter case, either these *Event Kinds* or their subtypes (*Event Subkinds*) supply also a cognitively-salient focusing mechanism, namely, a set of types that provide application and individuation conditions for carving cognitively relevant parts out of the original sum. These parts are a *Focal Event* and its contexts.

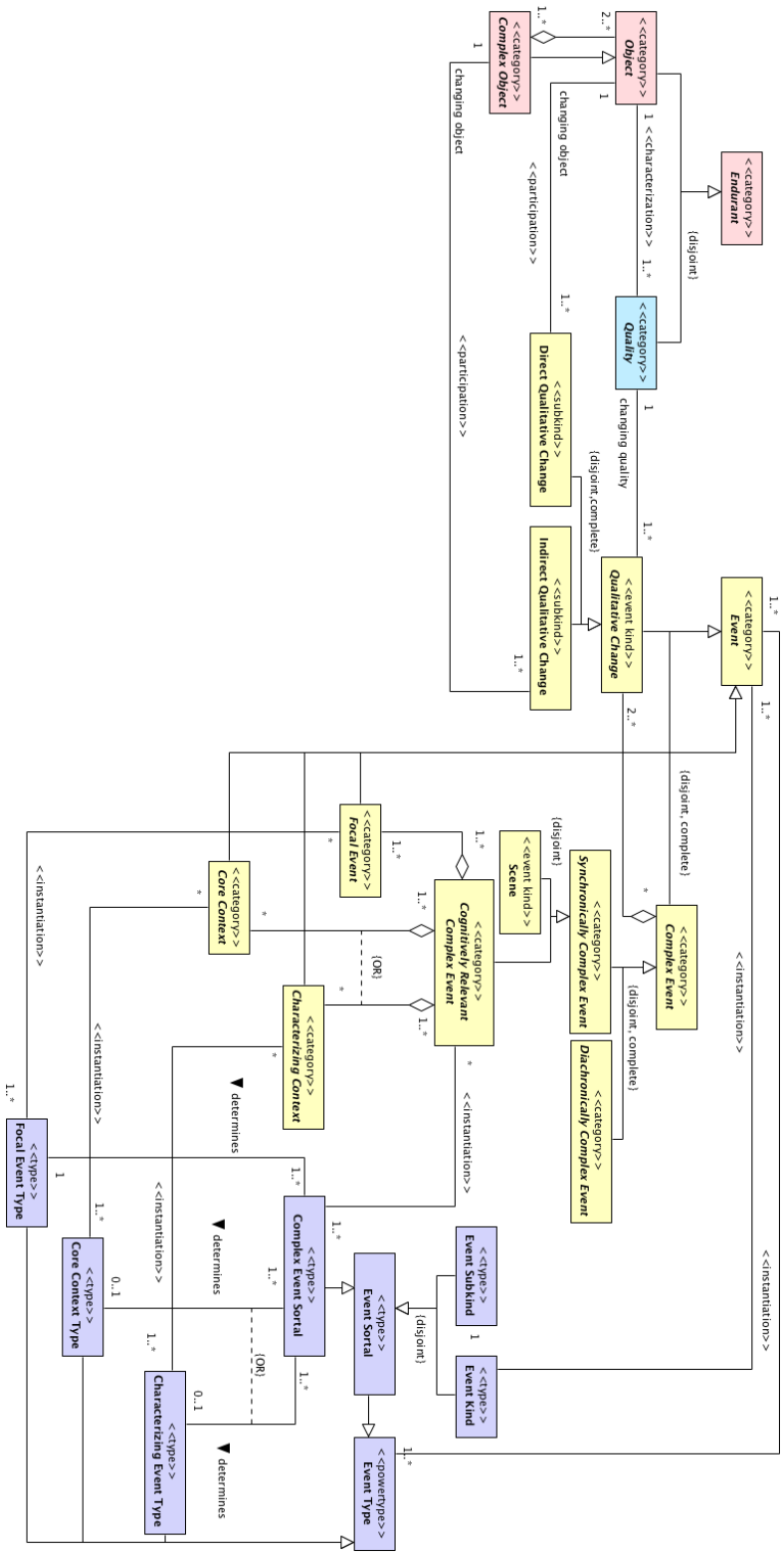

Fig. 5. The integrated OntoUML diagram describing events, their structure and their relations to endurants

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