INTERNAL STRUCTURES OF SOME ACCOMPLISHMENT EVENTS
FROM THE POINT OF VIEW OF SUBEVENT

Hiroshi YOSHIKAWA
Himeji Institute of Technology

Abstract
The aim of this paper is, following Bach (1986), and Krifka (1992,1998), to clarify on the basis of subevents internal semantic relationships that some types of accomplishment events implicitly include. This paper will make clear what kinds of semantic relationships are obtained between subevents of the causing event and subevents of the caused event, when an accomplishment event is semantically divided into the causing activity part and the caused achievement part. Moreover, it will explore the kinds of semantic relationships established between subevents of the caused achievement and the part of the entity that stands in a theme-relation to the main verb. By clarifying these semantic relationships, this work will throw more light on internal structures of some accomplishment events.

Keywords: accomplishment event, semantic relationship, GRADUALITY, INCREMENTALITY, AFFECTEDNESS

1. Introduction

It is generally assumed, according to Dowty (1979), Parsons (1990), Pustejovsky (1991), and Kearns (2000), among others, that accomplishment-type events (accomplishment events) are composed of the activity-type events (activity events) corresponding to the causing parts, and the achievement-type events (achievement events) corresponding to the caused parts. According to Parsons (1990) and Pustejovsky (1991), in particular, an accomplishment event \( \exists e [Q(e)] \) is roughly symbolized in logical form as shown in (1).

\[
(1) \quad \exists e [Q(e)] \Rightarrow \exists e1, e2 [DO(P)(e1) & BECOME(R)(e2) & CAUSE(e1,e2)]
\]

where the notation \( DO(P)(e1) \) means an activity-type predicate having \( P \)'s property and \( BECOME(R)(e2) \) denotes an achievement-type predicate having \( R \)'s property.

However, such an analysis as in (1) does not reveal a deeper internal structure of an accomplishment event. What is needed is a description of the kind of semantic relationship obtained between subevents of the causing activity event and subevents of the caused achievement event within an accomplishment event, and also the kind of relationship held between each subevent of the event and each part of the entity which stands in a theme-relation to the main verb. We hereafter refer to the entity which stands semantically in a theme-relation to the main verb and syntactically in an object-relation to the main verb as an “object theme”.

The standard treatment of this semantic relationship is Krifka’s theory (1992, 1998). This theory clarifies further the internal structure of an accomplishment event. For example, Krifka shows how every subevent of an accomplishment event is semantically associated with a part of the object theme. It is represents by MAPPIND TO OBJCERS, as shown in (2).

\[
(2) \quad \forall e, e', x [\theta(e, x) & e' \subseteq e \Rightarrow \exists x' [x' \subseteq x & \theta(e', x')]]
\]

Shown below in more detail, when an event is analyzed into subevents, the predicate that applies to both the event and its subevent is of the activity type. We can, thus, say that Krifka’s theory clarifies the semantic relationship between subevents of the corresponding active event of an accomplishment.
event and sub-objects of the object theme. The semantic relation would be represented as follows:

\[(3) \forall e, e', x \ [\text{DO (P)} (e) \& \text{Theme} (e, x) \& e' \subseteq e \rightarrow \exists x' [x' \subseteq x \& \text{DO (P)} (e') \& \text{Theme} (e', x')]]\]

Though (3) definitely shows how a part of the object theme is semantically connected with a subevent of the event, it does not explicitly clarify the semantic relationship between the causing subevent and the caused subevent. Moreover, Krifka's theory says that the final state of the object theme is represented by the GOAL argument. If so, we should need to add GOAL arguments to all logical forms of accomplishment sentences. On the other hand, the theory presented in this paper logically infers the final state of the object theme and does not need to introduce the GOAL argument to accomplishment sentences.

In addition, Krifka (1998) has another problem. His work says that the state of goal at which the object theme finally arrives is represented by a path argument. The using of the path argument seems to raise a problem.

\[(4) a. \text{Mary wrote something (in ten minutes).} \]
\[b. \text{Mary hiked (for 10 minutes).} \]

These sentences are taken from Krifka (1998). Though sentence (4a) is distinct from sentence (4b) in aspect, once they are symbolized in logical form along the lines of Krifka (1998), the aspeсtual distinction between them gets lost. The sentences are transformed in logical form along the lines of Krifka as follows:

\[(5) a. \Rightarrow \exists z \exists e [\text{WRITE (M, z, e)}] \]
\[b. \Rightarrow \exists x \exists e [\text{HIKE (M, x, e)}] \]

where \(x\) denotes a path of movement, and tense is disregarded. (See Krifka (1998, p224) for details.)

The problem raised here is how to distinguish both logical forms from each other in aspect since it seems impossible to distinguish (5a) from (5b) in aspect. This is because the \(z\) in (5a) is considered to have a certain kind of structure similar to a path structure like the \(x\) in (5b).

The present paper proposes that there are internal semantic relationships semantically correlating logical forms as in (1) with semantic relationships as in (3), which Krifka (1992, 1998), Dowty (1979), Parsons (1990) and Pustejovsky (1991) do not cover. They will be referred to here as GRADUALITY, INCREMENTALITY, and AFFECTEDNESS. It will be shown below that these internal semantic relationships play the crucial roles of semantically connecting (1) with (3), and they apparently display a certain kind of semantic relationship between the causing event and the object theme which is shown by Krifka’s MAPPING TO OBJECTS. As the aim of this paper is to clarify on the basis of subevents the deeper semantic relationships that an accomplishment event implicitly includes, mainly follow along the lines of Krifka (1992, 1998) and Bach (1986), focusing, in particular, on the following questions:

\[(6) a. \text{What kind of semantic relationship is established between subevents of the causing event and subevents of the caused event when an accomplishment event is analyzed into two events?} \]
\[b. \text{What kinds of semantic relationships exist between subevents of the two divided events and the object theme?} \]
\[c. \text{What kind of entity is semantically associated with each subevent of the caused achievement event?} \]

In this paper, I will treat only sentences of the accomplishment type with object themes. Thus, sentences like \textit{John ran to the store}, (i.e., sentences without object themes) are not treated.

2. Internal Structures of Accomplishments

In this section, before going into the issue of analyzing accomplishments on the basis of subevents, we will look at the kinds of internal structures that make up accomplishments. In exploring them, this paper assumes, following Dowty (1979), Parsons (1990), Pustejovsky (1991), Kearns (2000), among others, that an accomplishment is made up of the causing part associated with an activity event (hereafter, the causing activity) and the caused part associated with an achievement event (hereafter, the caused achievement). This premise is roughly represented as follows:

\[(7) \text{DO (P) - CAUSE - BECOME (R)} \]
where DO (P) denotes a causing activity predicate and BECOME (R) denotes a caused achievement predicate, both of which an accomplishment implies.

In order to explore the structures of accomplishments, this paper will set up three test questions which will help sort accomplishments into semantic categories.

(8) a. Question I : Is the existence of the whole of the object theme presupposed in the corresponding predication or not?
b. Question II : Is the object theme produced / consumed at the final culmination or not?
   When it appears, it will be tentatively represented as BECOME (N). When it disappears, it will be represented as BECOME (∼N).
c. Question III : Does the main verb specify the causing activity or the caused achievement?

We will examine the following sentences in terms of these three questions.

(9) a. John painted a door.
b. John read a paper.
c. John drew a circle.
d. John ate an apple.
e. John pushed a cart to the store.
f. John washed his clothes white.
g. John leveled the ground.
h. John sank the boat.

These sentences have the following implications, respectively.

(9a) \[ \text{John painted.} \] (9b) \[ \text{John read.} \]
(9c) \[ \text{John drew.} \] (9d) \[ \text{John ate.} \]
(9e) \[ \text{John pushed a cart.} \] (9f) \[ \text{John washed.} \]
(9g) \[ \text{John leveled.} / \text{The ground leveled.} \]
(9h) \[ \text{John sank.} / \text{The boat sank.} \]

The verbs in (9g) and (9h) are distinguished from the verbs in (9a) through (9d). The former verbs belong to the BECOME-type that is grammatically categorized as unaccusative verbs, and the latter verbs belong to the DO-type. Thus, we can say that the DO-type verbs specify the causing part and the BECOME-type verbs specify the caused part when they are used to make accomplishment events.

Sentences (9a) and (9b) are characterized in terms of the above test questions as follows: the existence of the object theme is presupposed and the main verbs specify the causing part. Thus, they are roughly represented as (9a) and (9b), respectively.

(9a) \[ \exists x \in \text{Door [DO(Painting) - CAUSE - BECOME(R)(x)]} \]
(9b) \[ \exists x \in \text{Paper [DO(Reading) - CAUSE - BECOME(R)(x)]} \]

With regard to (9c) and (9d), they are characterized on the basis of test questions as follows: their object themes are not presupposed and their main verbs are used to specify the causing activities. Moreover, these sentences have the prominent feature that their object themes come into existence or go out of existence. This paper assumes that sentence (9c) is represented as BECOME (N), and sentence (9d) as BECOME (∼N), an analysis of which will be discussed in more detail below. The form BECOME (N) has a certain semantic relationship with the form BECOME (∼N); the process represented by BECOME (∼N) goes in the opposite direction to the process represented by BECOME(N). The entire forms are roughly represented as follows:

(9c) \[ \text{DO(Drawing) - CAUSE - BECOME(N)} \]
(9d) \[ \text{DO(Eating) - CAUSE - BECOME(∼N)} \]

Sentences (9e) and (9f) are characterized as follows: their object themes are presupposed, and their main verbs plus their object themes constitute the causing activities. The caused achievements are expressed respectively by the adjuncts, which are assumed to denote a semantic terminal, according to Parsons (1990), Dowty (1979) and Pustejovsky (1991). Thus, they are roughly represented as follows:

(9g) \[ \exists x \in \text{Cart [DO(Pushing-x) - CAUSE - BECOME(At-the-store)(x)]} \]
(9h) \[ \exists x \in \text{Clothes [DO(Washing-x) - CAUSE - BECOME(White)(x)]} \]

Sentences (9g) and (9h) are characterized as follows: their main verbs specify the caused events, respectively, and their object themes are presupposed.

(9g) \[ \exists x \in \text{Ground [DO(P) - CAUSE - BECOME(Be-level)(x)]} \]
(9h) \[ \exists x \in \text{Boat [DO(P) - CAUSE - BECOME(∼N)(x)]} \]
(Be-sunken) (x)

When categorizing those sentences on the basis of the three Questions, I, II, and III, we can get a consequence which is illustrated in the following table.

<table>
<thead>
<tr>
<th>Question I</th>
<th>Question II</th>
<th>Question III</th>
<th>(CAUSING PART)</th>
<th>(CAUSED PART)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) OK</td>
<td>--</td>
<td>spec (DO (V-ing))</td>
<td>UNSPEC</td>
<td></td>
</tr>
<tr>
<td>(b) OK</td>
<td>--</td>
<td>spec (DO (V-ing))</td>
<td>UNSPEC</td>
<td></td>
</tr>
<tr>
<td>(c) --</td>
<td>BECOME (N)</td>
<td>spec (DO (V-ing))</td>
<td>UNSPEC</td>
<td></td>
</tr>
<tr>
<td>(d) --</td>
<td>BECOME (~V)</td>
<td>spec (DO (V-ing))</td>
<td>UNSPEC</td>
<td></td>
</tr>
<tr>
<td>(e) OK</td>
<td>--</td>
<td>spec (DO (V-ing))</td>
<td>UNSPEC</td>
<td></td>
</tr>
<tr>
<td>(f) OK</td>
<td>--</td>
<td>spec (DO (V-ing))</td>
<td>UNSPEC</td>
<td></td>
</tr>
<tr>
<td>(g) OK</td>
<td>--</td>
<td>UNSPEC</td>
<td>spec(BECOMEd-a4d)</td>
<td></td>
</tr>
<tr>
<td>(h) OK</td>
<td>--</td>
<td>UNSPEC</td>
<td>spec(BECOMMd-a4d)</td>
<td></td>
</tr>
</tbody>
</table>

where the notation UNSPEC means that the main verb is not used to specify the corresponding part.

From the above discussion, we can categorize those sentences into a few subcategories. When sorting them out from the point of view of test question I, sentences (9a), (9b), (9e), (9f), (9g) and (9h) are classified in one subcategory, and sentences (9c) and (9d) are in the other. When categorizing them on the basis of test question II, (9c) and (9d) are distinguished from the other sentences. When categorizing them by using test question III, (9g) and (9h), in which the main verbs specify the caused achievement, are distinguished from the other sentences. Moreover, sentences (9e) and (9f) are distinguished from (9a) and (9b) because the caused parts are specified by their adjuncts in (9e) and (9f) while (9a) and (9b) do not have such constituents.

When taking all these facts into consideration, we can categorize those sentences into four types: the first category includes (9a) and (9b), which we call Accom I-type; the second includes (9c) and (9d), which we call Accom II-type; and the third includes (9e) and (9f), which we call Accom III-type; and the forth category contain (9g) and (9h), which we called Accom IV-type.

After accomplishments have been sorted into four categories as shown above and are analyzed on the basis of subevents, the next step is to ask the following questions.

20 Fundamental questions:
What does it mean that the existence of the object theme is not presupposed in Neo-Davidsonian theory?
What kind of semantic relationship exists between subevents of the caused event and subevents of the causing event for each Accom type? (This question is the same as the one in (6.a.).)

21 Questions concerning Accom I-type:
   a. Though the main verb specifies the causing event, how is the caused event represented?
   b. What kind of semantic relationship exists between each subevent of the caused event and the object theme?

22 Questions concerning Accom II-type:
   a. Though the caused event seems to be closely associated with the change in the internal structure of the object theme, how can we represent it?
   b. What kind of semantic relationship exists between non-presupposition of the object theme and the caused event?

23 Question concerning Accom III-type:
   Though the main verb and its object theme constitute the causing event, and the adjunct represents the caused event, how is the object theme associated with each subevent of the caused event?

24 Question concerning Accom IV-type:
   Though the caused event is specified by the main unaccusative verb, how is the semantic relationship between each subevent of the caused event and the object theme represented?

In order to answer these above questions, this paper will continue to analyze accomplishments on the basis of subevents, following Bach (1986), Parsons (1990), Pustejovsky (1991), and Krifka (1992,1998), and then clarify the internal structures in which crucial semantic relationships lie.

3. Algebra of Event Structures

This section will provide means to semantically analyze accomplishment events, mainly along the lines of Bach (1986), Krifka (1992,1998), and Link (1983).
In general, accomplishment and achievement events are named telic events, while activity events are called atelic events. According to Link (1983) and Bach (1986), among others, there is semantic similarity between mass nouns like water and atelic predicates like run. For example, when some quantity of water is divided into two parts, each part is still some quantity of water. Similarly, when an event described by an atelic predicate like run is divided into two parts, each of them still denotes an event of running. Thus, whenever P stands for a mass noun predicate with x as its argument, namely, P(x), and y is a part of x, namely, y ≤ x, the following holds of P.

\[ \forall x, y \ [P(x) \& y \leq x \rightarrow P(y)] \]

Just as in the case of mass nouns, when P stands for an atelic predicate with an event e as its argument, and e' is a part of e, namely, e' ≤ e, it is represented in the same manner as mass nouns.

\[ \forall e, e' [P(e) \& e' \leq e \rightarrow P(e')] \]

Semantic similarity can also be seen between count nouns like a chair, and telic predicates like draw a circle. When an atomic entity represented by a count noun is taken apart, each part does not denote the whole thing. Similarly, when a telic event is divided into two subevents, each subevent does not denote the telic event itself. Thus, the following relation holds for these cases.

\[ \forall x, y [P(x) \& y \subseteq x \rightarrow P(y)] \]

\[ \forall e, e' [P(e) \& e' \subseteq e \rightarrow P(e')] \]

where the notation A ⊆ B means that if A, then B does not hold.

The question arises, however: what kind of predicate applies to the subevent of a telic event or to the sub-object of a count noun?

First, regarding count nouns, as \[\forall y\] shows, the predicate that applies to a count noun does not apply to any sub-object of it; no proper part of a count noun x is the x itself. This fact holds for the case of a telic event as shown in \[\forall e, e' [P(e) \& e' \subseteq e \rightarrow P(e')]\]. In order to begin answering the previous question, though, it is necessary to utilize a predicate applying to a part of a count noun, namely, a part of an atomic entity, as its argument.

For this purpose, an operator k is introduced to contrive such a predicate. Here it is assumed that the operator plays the following role: when it applies to a count noun predicate P, which has an atomic entity x as its argument, it holds that the resultant predicate kP applies to a part of x. The kP is the predicate that is closely associated with the materialization function h used in Link (1983). That is, when x stands for an atomic entity to which the count noun predicate P applies, the kP is a predicate with a part of an atomic entity as its argument. In this case, the operator is a partial operator, and kP is a partial predicate.

\[ \text{When a count noun predicate } P \text{ applies to an atomic entity } x, \text{ the partial predicate } kP \text{ applies to a part of } x. \]

Thus, the relationship between the materialization function h used in Link (1983) and the operator k is defined as follows:

\[ \text{When } P(x) \text{ and ATOM(x), } kP \text{ (a part of h(x)) holds.} \]

\[ \forall x [P(x) \& ATOM(x) \rightarrow kP \text{ (a part of } h(x))] \]

where the notation ATOM(x) means that x is an atomic entity.

Using a count noun a chair as an example and assuming that the chair has a backrest, then, the backrest stands in a part-relation to the chair. When the materialization h is applied to an atomic object x, a chair, the relationship holding between some material part y of x and the predicate kChair is represented as follows:

\[ \text{Chair(x) & Backrest(y) & y } \subset \text{ h(x) } \rightarrow k\text{Chair(y)} \]

where kChair(y) means that y is a material part of a chair.

Thus, when P stands for a count noun predicate, which takes an atomic entity x as its argument, and y is a part of x, the following relation holds:

\[ \forall x, y [P(x) \& ATOM(x) \& y \subset h(x) \rightarrow kP(y)] \]

A similar kind of relation exists in the case of events. With respect to telic events, no subevent e' of a telic event e is the event itself, just as in the case of count nouns. For example, no proper subevent e' of
the event of becoming a circle is an event *becoming a circle*. The predicate that takes a telic event, (namely, an atomic event), as its argument cannot apply to a proper part of the event: \( \forall e, e' [P(e) \& ATOM(e) \& e' \subseteq e \rightarrow P(e')] \). Thus, when \( P \) stands for a telic predicate, which takes an atomic event \( e \) as its argument, and \( e' \) stands for a subevent of \( e \), namely, \( e' \subseteq e \), we can represent the predicate that applied to the subevent \( e' \) as \( kP \).

\[ \exists \exists \text{Telic-Predicate } P \rightarrow \forall e, e' [P(e) \& ATOM(e) \& e' \subseteq h(e) \rightarrow kP(e')] \]

The predicate \( kP \) applies to any subevent of an atomic event.

On the other hand, when \( P \) stands for a mass noun predicate, which takes a non-atomic entity \( x \) as its argument, and \( y \) stands for a proper part of \( x \), the following logical relationship obtains between them.

\[ \exists \exists \text{Mass-Noun Predicate } P \rightarrow x, y [P(x) \& \text{NON-ATOM(x)} \& y \subseteq h(x) \rightarrow kP(y) = P(y)] \]

Let us take a mass noun predicate *Water* as an example. If \( x \) is water, namely, *Water(x)*, and \( y \) is a part of \( x \), namely, \( y \subseteq h(x) \), then \( y \) is a part of water, which is represented as \( kWater(y) \). That means that \( y \) is some quantity of water, namely, *Water(y)*. Thus, the following holds for the mass noun predicate *Water*: \( kWater(y) = Water(y) \). Just as in the case of mass noun predicates, when \( P \) stands for an atelic predicate or an activity predicate, which takes a non-atomic event \( e \) as its argument, and \( e' \) stands for a subevent of \( e \), then the following logical relationship obtains between them.

\[ \exists \exists \text{Atelic-Predicate } P \rightarrow \forall e, e' [P(e) \& \text{NON-ATOM(e)} \& e' \subseteq h(e) \rightarrow kP(e') = P(e')] \]

The object theme that is closely associated with the predicate \( kR(e') \) denotes something that stands in a part-relation to the object theme associated with \( R(e) \). This topic will be discussed in relation to certain semantic relationships in the next section.

The algebra of event structure in this theory can be written as follows:

\[ \exists \exists \text{Algebra of Event Structures} \]

(i) \( E : \) a set of atomic events

(ii) \( D : \) a set of subevents of atomic events.

(iii) \( a \) is a part of \( b \) just in case the join of \( a \) and \( b \) is \( b \) itself. \( b \)

(iv) \( a \) denotes that \( a \) stands in a proper-part-

relation to \( b \).

(v) When \( P \) stands for a telic predicate, the partial predicate \( kP \) is the predicate that takes an element of \( D \) as its domain and yields a meaning of a partial completion of \( P \).

The operator \( k \) is defined as follows: when the predicate \( P \) applies to an atomic event \( e \), \( P(e) \), \( k \) is a operator such that when it applies to \( P \), the resultant predicate \( kP \) applies to a subevent \( e' \) of an atomic event \( e \).

\[ \exists \exists \forall e \in E \forall e' \in D [P(e) \& e' \subseteq h(e) \rightarrow kP(e')] \]

The argument will proceed on the basis of this algebra of events in order to clarify internal structures of accomplishment events in more detail.

4. Semantic Relationships

This paper has assumed, following Dowty (1979), Parsons (1990), Pustejovsky (1991), and Kearns (2000), among others, that an accomplishment event is made up of two parts: the causing activity part and the caused achievement part. Based on Neo-Davidsonian theory, the relationship between the two parts in an accomplishment event \( \exists e [Q(e)] \) is roughly represented in logical form as follows:

\[ \exists \exists (1) \exists e [Q(e)] \Rightarrow \exists e1, e2 [DO(P)(e1) \& \text{BECOME}(R)(e2) \& \text{CAUSE}(e1, e2)] \]

where \( DO(P) \) denotes a causing activity part of \( Q \) and \( \text{BECOME}(R) \) represents a caused achievement part of \( Q \).

This paper will refer to the manner in which an accomplishment event \( \exists e [Q(e)] \) is divided into the two parts as TWO-DIVISION.

Let us analyze further the logical structure \( \exists \exists (1) \) in terms of subevents of the two parts. When analyzing it on the basis of subevents, the first step requires determining the kind of semantic relationship established between subevents of the causing event and subevents of the caused event. Though there are some cases where the causing event brings about the caused event instantaneously, it is generally assumed that accomplishment events gradually unfold. The gradual unfolding can be interpreted as follows: for every subevent \( e'1 \) in the causing activity event that is unfolding, there is a subevent \( e'2 \) of the caused event such that \( e'1 \) operates on \( e'2 \). The semantic
relationship created between them will be referred to here as GRADUALITY. This semantic relationship can be roughly represented in logical form as follows: 

\[ \forall e_1, e_2 \ [(DO (P) (e_1) \& BECOME (R) (e_2) \& CAUSE (e_1, e_2)) \rightarrow \forall e' [e' \subseteq e_1 \rightarrow \exists e' [e' \subseteq e_2 \& CAUSE (e_1, e')]]] \]

A crucial problem arises here; though the part-relation between the whole event \( e_1 \) of the causing activity and its subevent \( e' \) can be represented as \( P (e'1) \subseteq P (e_1) \), as shown above in \#9, the same relation for the caused achievement cannot be represented as \( R (e') \subseteq R (e_2) \). It is because the causing event \( e_2 \) is atomic and cannot be divided into subevents that the same predicate applies: \( \forall e, e' [R (e) \& ATOM (e) \& e' \subseteq e / \rightarrow R (e')] \).

This problem, however, can be coped with by invoking a partial operator \( k \), which is introduced in the later section. Thus, a part of the logical form \#9, namely, \( \exists e' [e' \subseteq e_2 \& CAUSE (e_1, e')] \), should be rewritten as follows:

\[ \exists e' \subseteq e_2 [BECOME k(R) (e') \& CAUSE (e_1, e')] \]

Consequently, the semantic relationship GRADUALITY that holds between subevents of the causing event and subevents of the caused event can be represented using the operator \( k \), as shown in \#2-(m), and can be defined as follows:

\( \#1 \) GRADUALITY: for every subevent \( e'1 \) of a causing activity event \( e_1 \), there is a subevent \( e'2 \) of a caused achievement event \( e_2 \) such that \( e'1 \) stands in a cause-relation to \( e'2 \).

\( \#3 \) \( \forall e'1 \subseteq e_1 \ [(DO (P) (e'1) \rightarrow \exists e'2 \subseteq e_2 \ [BECOME k(R) (e') \& CAUSE (e_1, e')]] \]

Thus, when GRADUALITY holds for events, the following can be said:

\( \#4 \) \( \forall e_1, e_2 \ [(DO (P) (e_1) \& BECOME (R) (e_2) \& CAUSE (e_1, e_2)) \rightarrow \forall e'1 \subseteq e_1 \ [(DO (P) (e_1') \rightarrow \exists e'2 \subseteq e_2 \ [BECOME k(R) (e_2) \& CAUSE (e_1, e'_2)]] \]

The next question concerns the kind of semantic relationship that exists between an accomplishment event and its object theme. In analyzing an accomplishment event, the present theory takes the position that the object theme is directly connected to the caused achievement event and indirectly related to the causing activity event. This conclusion seems self-evident because the caused event describes in more detail how the object theme changes.

\( \#5 \) (i) It is the causing event that exerts a direct influence on the caused event.

(ii) It is the caused event that is directly associated with the object theme.

The semantic relationship \( \#3-(i) \) is referred to as GRADUALITY in the present theory. The present theory is, therefore, markedly different from Krifka's theory where the object theme is directly associated with the causing event in the corresponding event, as shown in the first section.

The present theory assumes that the caused events in \( \#3-(ii) \) are divided into two categories when the relationship GRADUALITY holds. The division depends on whether the whole entity represented by the object theme is found in any subevent of the caused achievement event. Caused events belonging to one category are characterized as follows: (i) the whole of the object theme is not found in any subevent of the caused event, though a part of the object theme might be seen, and (ii) for every subevent \( e' \) of the caused event there is something such that it is closely associated with \( e' \). This semantic relationship will be referred to here as INCREMENTALITY, which is defined as follows:

\( \#4 \) INCREMENTALITY: for every subevent \( e'2 \) of the caused achievement event \( e_2 \), there is something \( y \) such that \( y \) stands in a theme-relation to \( kR (e'2) \).

\( \#5 \) \( \forall e'2 \subseteq h (e_2) \ [BECOME k(R) (e') \rightarrow \exists y [Theme (e', y)] \]

What the semantic relationship \( \#5 \) concretely represents is this: when the caused achievement event is unfolding step by step, something that stands in a theme-relation to the subevent is coming into existence (or going out of existence) gradually. Thus, something complete which is described by \( R \) does not yet come into existence (or go out of existence) when the event is unfolding. What is seen, when the event is in the process of unfolding, is a part of what is described by the predicate \( R \). Consequently, the following can be said:

\( \#3 \) When the semantic relationship \( \#5 \) holds, only a part of what is described by the predicate \( R \) exists. That is represented as \( \exists y [BECOME kR (e') \rightarrow \exists y [Theme (e', y)] \]
(e') & Theme (e', y)]
A question arises here: what is it that is described by R? It is assumed that the thing described by R is what the object theme denotes. Therefore, the point is as follows;

When the semantic relationship INCREMENTALITY holds, the object theme plays a core part of the caused achievement predicate.

By conceiving of the object theme as a core predicate of the caused achievement event, and with the help of the partial operator k, the change that each part of the object theme undergoes can be represented. And a sequence of changes in parts of the object theme can be identified with a gradual change in the internal structure of the object theme. Thus, it is assumed that the gradual change is denoted by the semantic relationship INCREMENTALITY.

The semantic relationship INCREMENTALITY depicts a gradual change in the internal structure of the object theme.

From the above discussion, the following can be inferred.

When the semantic relationship INCREMENTALITY is unfolding, the whole of the object theme is not seen in any caused subevent, but a part of it is found in a gradual change of each caused subevent.

The answer to the question (22b) concerning Accom II-type is given by §8.

On the other hand, when the whole of the object theme is found in all subevents of a caused event, it is assumed that the event has the following semantic relationship which is established between the object theme and the subevents of the caused achievement event:

(v) \exists y [Q (y) & \forall e'2 \subseteq h (e2) [BECOME_{k} (R) (e'2) \rightarrow Theme (e'2, y)]]

In this case, the following can be said from the point of view of the internal structure of the object theme:

Because the object theme is found in all caused subevents, the object theme does not undergo any change in its internal structure.

Then, what kind of change is represented by the semantic relationship (v)? Assuming that the change is the external change on the object theme or specifically, the change on the surface of the object theme or the positional change, it can be said then that the external change is the one that is induced by an external force of the causing event. When the final state of the object theme is specified by the external change, the change is represented by the past participle of the main verb. Thus, the main difference between (v) and (v) depends on whether the object theme undergoes some internal change or some external change.

Summarizing the main semantic difference between (v) and (v), the semantic relationship (v) means that for each predicate BECOME k(R)(e'), there is something, y, such that, when the change described by BECOME k(R)(e') proceeds step by step, y is being completed (or destroyed) stage by stage. Additionally, the predicate BECOME (R)(e) brings something complete into existence (or out of existence), which is represented as §8. That is, what the predicate BECOME k(R)(e') describes is a partial change in the internal structure of something that is described by R.

∃e∃y [BECOME (R)(e) & Theme (e, y)]

where R is represented by the nominal predicate of the object theme.

The derivation of logical form §9 will be discussed in more detail below.

By contrast, the logical relationship (v) means that the whole object theme y exists in all subevents of the caused event, and the predicate BECOME k(R)(e') describes a partial external change that y directly undergoes. In other words, when the partial external change, which BECOME k(R)(e') describes, proceeds gradually, y undergoes a change little by little until it is entirely changed as is represented in §10. This semantic relationship is referred to as AFFECTEDNESS.

∃e∃y [Q(y) & BECOME (R)(e) & Theme (e, y)]

where Q is represented by the nominal predicate of the object theme and R is the past participle of the main verb when the final state of the object theme is specified by the external change.

The two semantic relationships are briefly
described as follows:

a. INCREMENTALITY represents the change of the internal structure (or the internal change) of the object theme.

b. AFFECTEDNESS represents the external change of the object theme.

And the present theory assumes that the internal structure of an accomplishment event \( \exists e [Q(e)] \) is clarified by the terms TWO-DIVISION, GRADUALITY, and INCREMENTALITY, or AFFECTEDNESS.

I. When \( \exists e [Q(e)] \) is divided into two parts by TWO-DIVISION,
\[ \exists e [Q(e)] \Rightarrow \exists e_1, e_2 [DO(P)(e_1) \& \text{BECOME}(R)(e_2) \& \text{CAUSE}(e_1, e_2)] . \]

II. When GRADUALITY holds for I,
\[ \forall e_1 \subseteq e_1 [DO(P)(e_1) \rightarrow \exists e_2 \subseteq h(e_2) [\text{BECOMEx}(R)(e_2) \& \text{CAUSE}(e_1, e_2)]]. \]

III. i. When INCREMENTALITY holds for II,
\[ \forall e_2 \subseteq h(e_2) [\text{BECOME}(R)(e_2) \rightarrow \exists y [\text{Theme}(e_2, y)]] . \]

III. ii. When AFFECTEDNESS holds for II,
\[ \exists y [Q(y) \& \forall e_2 \subseteq h(e_2) [\text{BECOME k}(R)(e_2) \rightarrow \text{Theme}(e_2, y)]] . \]

Now, applying the present theory to some sentences of Accom I-type and Accom II-type, sentences (55a) and (55b) show the difference between INCREMENTALITY and AFFECTEDNESS.

a. John painted a door.

b. John drew a circle.

Sentence (55a) is first divided into two parts by means of TWO-DIVISION, and so it is symbolized as logical form as \( \exists e_1, e_2 [DO(\text{Painting})(e_1) \& \text{BECOME}(R)(e_2) \& \text{CAUSE}(e_1, e_2)] \).

Whenever the event unfolds gradually, the semantic relation GRADUALITY holds, which is represented as in \( \exists e_1, e_2 [\forall e_1, e_2 [DO(\text{Painting})(e_1) \& \text{BECOME}(R)(e_2) \& \text{CAUSE}(e_1, e_2)] \rightarrow \forall e_1 [\forall e_1 \subseteq e_1 \& DO(\text{Painting})(e_1) \rightarrow \exists e_2 \subseteq h(e_2) [\text{BECOMEx}(R)(e_2) \& \text{CAUSE}(e_1, e_2)]]] \).

Unanswered questions remain, including (i) what stands in a theme-relation to the caused subevent \( e_2 \), (ii) what kind of semantic relationship obtains between the caused subevent \( e_2 \) and the object theme? and (iii) what kind of entity is semantically associated with the subevent?

In the case of (55a), because the thing that is directly affected by the subevent \( e_2 \) is a door, it stands in the theme-relation to the subevent. While the event is unfolding, the door is found in all subevents. The relationship between the subevent \( e_2 \) and the door is, therefore, represented as AFFECTEDNESS. As the external change is brought about by the external force of the causing event and the final state of the object theme is specified by the external change, the change is specified by the past participle of the causing verb. Thus, the following logical relationship is established.

Then, logical form 60 can be inferred from the logical form 64, which is referred to here as EVENT-PARTICULARIZATION.

The logical form means that there is a door such that it is affected by the predicate \( \text{BECOME k}(\text{Be-painted}) \). In other words, the entity that is semantically associated with the subevent \( e_2 \) is a partially painted door, and the final state to which the object theme leads is obtained by replacing the predicate \( \text{BECOME k}(\text{Be-painted}) \) with \( \text{BECOME (Be-painted)} \); the final state is the one in which the door becomes entirely painted. We will refer to the replacement as FINALIZATION.

Next, considering sentence (55b), repeated here in 60, the internal structure will be examined.

John drew a circle.

As argued above, the major difference between sentences (55a) and 60 is whether the change of an object theme is internal or external. As the whole entity represented by the object theme is not seen in each subevent, sentence 60 describes an internal change of the object theme. Thus, INCREMENTALITY holds for this sentence. The \( R \) is specified by the nominal predicate of the object theme, and the sentence is symbolized in logical form as follows:
The following logical form \( \forall e' \subseteq h \ (e2) \ [\text{BECOME} \ k \ (\text{Circle}) \ (e'2) \rightarrow \exists y \ [\text{Theme} \ (e'2, \ y)] \)

is inferred from the above logical form \( \exists h \) by EVENT-PARTICULARIZATION.

\( \exists e' \subseteq h \ (e2) \ \exists y \ [\text{BECOME} \ k \ (\text{Circle}) \ (e'2) \ & \ \text{Theme} \ (e'2, \ y)] \)

Logical form \( \exists h \) roughly denotes that there is something \( y \) such that it is brought into existence by the predicate \( \text{BECOME} \ k \ (\text{Circle}) \), or, in other words, a part of a complete circle comes into existence. In the case of \( \exists h \), what stands in a theme-relation to \( e'2 \) is a partially completed circle. That is, the entity that is semantically associated with the subevent \( e'2 \) is a part of a complete circle. And from the logical form \( \exists h \), by means of FINALIZATION, logical form \( \forall e \) can be inferred, in which the final state of the achievement event is represented.

\( \exists e2 \ \exists y \ [\text{BECOME} \ (\text{Circle}) \ (e2) \ & \ \text{Theme} \ (e2, \ y)] \)

The logical form \( \exists h \) means that something exists which becomes a complete circle.

It follows from the above discussion that the present theory clarifies in more detail the difference between sentence (55a) and sentence (60) on the basis of internal semantic relationships represented by I, II, III - i, and III - ii. The conclusions can be summarized as follows:

(i) When GRADUALITY holds and the internal change of the object theme is described in subevents of the achievement-part event, INCREMENTALITY holds. Then, the nominal predicate of the object theme acts as the core role of the caused event.

(ii) When GRADUALITY holds and the external change of the object theme is described in the subevents of the achievement-part event, AFFECTEDNESS holds. When the external change is brought about by the agent activity and the termination is specified by the external change, the past participle of the causing verb plays the core role of the caused event.

In addition, the final state of the object theme is inferred by means of EVENT-PARTICULARIZATION and FINALIZATION.

The only topics not addressed so far are some sentences of Accom III-type and Accom IV-type. These sentences will be dealt with in the next section along with sentences of Accom II-type.

5. Internal Structures of Accomplishment Events

In this final section, this paper will consider the semantic relations of GRADUALITY, INCREMENTALITY, and AFFECTEDNESS with sentences of the four Accom types and the kinds of internal structure that the sentences of the four types make up.

The first question is: how are sentences of Accom III-type analyzed on the basis of the present theory? When analyzing sentence \( \exists h \) of the type, the present theory is a little different from Krifka's (1998), where a path argument like GOAL is introduced.

\( \exists h \) John pushed a cart to the store.

When sentence \( \exists h \) is analyzed by means of Krifka's strategy, it is represented as follows:

\( \exists e \exists x \ [\text{Cart} \ (x) \ & \ \text{Pushing} \ (J, \ x, \ e) \ & \ \text{GOAL} \ (x, \ S, \ e)] \)

On the other hand, the present theory assumes, following Tenny (1994), that a motion sense prepositional phrase (PP) like to the store is analyzed as a predicate that denotes a terminal point, where there is a path, and that this predicate corresponds to the caused part of an accomplishment. It is represented as follows:

\( \exists h \) a motion sense PP to the store \( \Rightarrow \exists y \ [\text{Path-to} \ \text{the store} (y) \ & \ \exists e \ [\text{BECOME} \ (\text{Be-traveled}) (e) \ & \ \text{Theme} \ (e, \ y)]] \)

Thus, since the present theory introduces the path argument in analyzing sentences like \( \exists h \), this sentence is analyzed like the sentence John painted a door. When the event described by the sentence \( \exists h \) is divided into the causing part John pushed a cart and the caused event to the store, it is roughly represented as follows:

\( \exists h \) the causing part: John pushed a cart
\( \Rightarrow \exists y \ [\text{Cart} \ (y) \ & \ \exists e \ [\text{DO} \ (\text{Pushing}) (e) \ & \ \text{Agent} \ (e, \ j) \ & \ \text{Theme} \ (e, \ y)]] \)

\( \Rightarrow \exists y [\text{Cart} \ (y) \ & \ \exists e [\text{DO} \ (\text{Pushing-y}) \ (e)]] \)
where A ≡ B means that A is abbreviated to B.

b. the caused part: to the store
   ⇒ ∃y [Path-to the store (y) & ∃e [BECOME (Be-traveled)(e) & Theme (e, y)]

Thus, the sentence ③ can be analyzed on the basis of TWO-DIVISION and GRADUALITY as follows:

③ By I , ⇒ a. ∃x [Cart (x) & ∃e1 [DO (Pushing-x) (e1) & ∃y [Path-to the store (y) & ∃e2 [BECOME k(Be-traveled)(e2) & Theme (e2, y)] & CAUSE (e1, e2)]]

By II, ⇒ b. ∃x [Cart (x) & ∀e1 ⊆ e1 [DO (Pushing-x) (e1) → ∃e2 ⊆ h (e2)]

[∃y [Path-to the store (y) & ∃e2 [BECOME k(Be-traveled) (e2) & Theme (e2, y)] & CAUSE (e1, e2)])]

The logical form ∃y [Path-to the store(y) & ∃e2 [BECOMEk (Be-traveled) (e2) & Theme (e2, y)]] is interpreted in the present theory as follows: the event of traveling a path to the store partially completes.

The next step is to find out what kind of semantic relationship holds between the corresponding event, the semantic relationship III- i or III- ii. As the path corresponds to an object theme in this case and this path is found in all the caused subevents, it is represented by semantic relationship III- ii.

④ By III- ii, ⇒ c. ∃y [Path-to the store (y) & ∀e'2 ⊆ h (e2) [BECOME k(Be-traveled) (e'2) → Theme (e'2, y)]]

From logical form (71c), the following can be inferred by EVENT-PARTICULARIZATION, which is hereafter indicated as IV.

⑤ ∃y [Path-to the store (y) & ∃e'2 ⊆ h (e2) [BECOME k(Be-traveled) (e'2) & Theme (e'2, y)]]

Logical form ⑤ denotes that the event of a path being traveled partially takes place. Internal structures of accomplishments are clarified by semantic relationships shown in (70b) and (71c): namely, the semantic relationship holding between subevents of the causing activity part and subevents of the caused achievement part, and the relationship created between the subevents of the achievement part and the object theme. And logical form ⑤ is inferred from the logical form ③ by means of FINALIZATION, which is hereafter indicated as V.

⑥ ∃y [Path-to the store (y) & ∃e2 [BECOME (Be-traveled) (e2) & Theme (e2, y)]]

Logical form ⑥ shows that the whole path to the store is traveled.

When the present theory is applied to sentences of Accom II-type, it is necessary to divide these sentences into two parts, one in BECOME (N) style and the other in BECOME (~N) style. A sentence of the former style like ④ provides an example.

⑦ John drew a picture.

⑧ By I , ⇒ a. ∃e1,e2 [DO (Drawing) (e1) & BECOME (R) (e2) & CAUSE (e1, e2)]

By II, ⇒ b. ∀e1 ⊆ e1 [DO (Drawing) (e'1) → ∃e2 ⊆ e2 [BECOME k(R) (e2) & CAUSE (e'1, e'2)]]

By III - i ⇒ c. ∀e'2 ⊆ h (e2) [BECOMEk (Picture) (e'2) → ∃y [Theme (e'2, y)]]

By IV, ⇒ d. ∃e'2 ⊆ h (e2) ∃y [BECOMEk (Picture) (e'2) & Theme (e'2, y)]]

By V, ⇒ e. ∃e2 ∃y [BECOME (Picture)(e2) & Theme (e2, y)]

The nature of II and III- i in ⑦ can be more easily understood as a diagram. In the diagram below ⑦, the activity part is indicated by the horizontal axis and the achievement part by the vertical axis. Logical form (75d) is indicated as the curved line. The point a denotes the point at which some part of activity event X brings about some part of achievement event y, where x and y indicate how much the achievement event proceeds, respectively, and X and Y show how much the activity event proceeds, respectively.

The diagram suggests these: some amount X of drawing activity is associated with some amount x of becoming R by means of GRADUALITY. That is, x stands in a GRADUALITY-relation to X, and the x
shows by means of INCREMENTALITY how much it becomes a circle. Thus, when a complete circle is indicated by $y$, the $y$ is related with some amount $Y$ of drawing-activity by GRADUALITY, and is shown by INCREMENTALITY to be the final thing that the event $e_2$ brings about.

We will look at sentences of the other style of Accom II-type, namely, BECOME (~N) as in (77).

(77) John ate an apple.

(79) By I, $\Rightarrow$ a. $\exists e_1, e_2$ [DO (Eating) (e1) & BECOME (~R) (e2) & CAUSE (e1, e2)]

By II, $\Rightarrow$ b. $\forall e' \subseteq e_1$ [DO (Eating) (e') $\rightarrow$ $\exists e'' \subseteq h$ (e2) [BECOME k(~R) (e'') & CAUSE (e', e'')]]

By III-i, $\Rightarrow$ c. $\forall e' \subseteq h$ (e2) [BECOME k(~Apple) (e'') $\rightarrow$ $\exists y$ [Theme (e'', y)]]

By IV, $\Rightarrow$ d. $\exists e'' \exists y$ [BECOME k(~Apple) (e'') & Theme (e'', y)]

By V, $\Rightarrow$ e. $\exists e_2 \exists y$ [BECOME (~Apple) (e2) & Theme (e2, y)]

Diagram B

The internal structure of sentence (77) can be illustrated as diagram B. And the diagram suggests the following: (i) It illustrates gradual changes holding between parts of the activity part and the achievement part. (ii) $Y$ denotes some amount of the activity event represented as $\exists e_1$ [DO (Eating) (e1)]. $X$ denotes a part of the activity event $Y$, $X \subseteq Y$, and is represented as $\exists e' \subseteq e_1$ [DO (Eating) (e')]. (iii) $y$ denotes the achievement event represented as $\exists e_2$ [BECOME (~Apple) (e2)]. $x$ denotes a part of the achievement event $y$, namely, a subevent of $y$, and is represented as $\exists e'' \subseteq h$ (e2) [BECOME k(~Apple) (e'')]. (iv) $x$ and $y$ are related to an apple which is consumed, respectively, by INCREMENTALITY. That is, $y$ is related to an entirely consumed apple, and $x$ is to a part of it, namely, a partially consumed apple. And $x'$ indicates a part of an apple that is not yet eaten. (v) Thus, $x$ shows by means of INCREMENTALITY that some amount of the apple, namely, a part of the apple, is consumed, that is brought about by some amount $X$ of the activity.

Based upon the argument above, it appears that the present theory can represent the same ideas that MAPPING TO OBJECTS in Krifka’s theory represents. However, the manner in which the present theory represents the mapping is a little different from Krifka’s. The present theory clarifies the mapping through two stages, GRADUALITY and INCREMENTALITY, while Krifka’s theory takes the path in which a subevent of the causing part is directly related to a sub-object of the object theme. Thus, the present theory is able to show the internal structures of accomplishments in more detail than Krifka’s, because it clarifies semantic interrelations between subevents of the causing event and the caused event, and semantic relationships between subevents of the caused event and sub-objects of the object theme. Also, it does not raise the problem with a path argument as indicated in section 1, which Krifka’s theory does.

Finally, the Accom IV-type can be analyzed here.

(80) John sank the boat.

(89) By I $\Rightarrow$ $\exists e_1, e_2$ [DO (P) (e1) & BECOME (Be-sunken) (e2) & CAUSE (e1, e2)]

By II $\Rightarrow$ $\forall e' \subseteq e_1$ [DO (P) (e') $\rightarrow$ $\exists e'' \subseteq h$ (e2) [BECOME k(Be-sunken) (e'') & CAUSE (e', e'')]]

By III-ii $\Rightarrow$ $\exists! y$ [Boat (y) & $\forall e' \subseteq h$ (e2) [BECOME k(Be-sunken) (e'') $\rightarrow$ Theme (e'', y)]]

where the notation $\exists! y$ [Boat (y)] means the definite description.

By IV, $\Rightarrow$ $\exists! y$ $\exists e'$ [Boat (y) & BECOME k(Be-sunken) (e'') & Theme (e'', y)]

By V, $\Rightarrow$ $\exists! y$ $\exists e'$ [Boat (y) & BECOME (Be-sunken) (e'') & Theme (e'', y)]

To summarize the important points of the present theory, the following needs to be highlighted: The present theory can show that the final state of the object theme is inferred by means of FINALIZATION. And a gradual change of the object
theme in an event can be clarified by eitherINCREMENTALITY or AFFECTEDNESS, depending on whether the object theme undergoes an internal change or an external change. With regard to MAPPING TO OBJECTS, the present theory differs from Krifka’s theory. His theory provides that a part of the object theme is directly related to a subevent of the activity event. By contrast, the present theory stipulates that a subevent of the achievement part is first related to a subevent of the causing part by GRADUALITY, and then the subevent of the achievement part is associated with a part of the object theme by INCREMENTALITY or AFFECTEDNESS.

In the present theory, the completeness is brought about by the predicate BECOME (R), and its part is brought about by the predicate BECOME k(R). Thus, the present theory can naturally infer the final state of the object theme without the GOAL argument that Krifka introduces.

The conclusion in the present theory can be summarized as follows:

**$\exists e \forall e' \exists e \exists x [DO (P) (e) & BECOME (R) (e) & Cause (e, e')]$**

(i) When the internal change of the object theme is described in the caused subevent, the existence of the whole of an object theme is not seen in any caused subevent, INCREMENTALITY $\Rightarrow \forall e' \exists e \exists x [DO (P) (e') \rightarrow \exists e' \exists e \exists x [BECOME k(R) (e') & Cause (e', e)]$ where $R$ is represented by the nominal predicate of the object theme.

**$\exists e \exists y [BECOME (R) (e) & Cause (e, y)]$**

(ii) When the external change of the object theme is described in the caused subevent, the existence of the whole of an object theme is seen in all caused subevents, AFFECTEDNESS $\Rightarrow \exists y [Q (y) & \forall e' \exists e \exists x [DO (P) (e') \rightarrow \exists e' \exists e \exists x [BECOME k(R) (e') & Cause (e', e)]]$ where $R$ is represented by the past participle of the main verb when the R is not specified by adjuncts.

FANALIZATION $\Rightarrow \exists e \exists y [Q (y) & \exists e \exists y [\text{BECOME} (R) (e) & \text{Theme} (e, y)]]$

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