

Reconsideration of Event Structure in the Generative Lexicon: Event-Related Lexical Inferences*

Seohyun Im

*Department of Linguistics, Seoul National University
seohyunim71@gmail.com*

This paper proposes to add inferential relations – presuppositions and entailments - between an event and its subevents to event structure in the Generative Lexicon (Pustejovsky, 1995). The inferential relations reflect the lexical semantic properties of verbs. For example, the verb *kill* is related semantically with *die* by an inferential relation based on the event structure of the verb *kill*. That is, *kill* lexically entails *die* since the latter denotes a caused subevent in the event structure of the former. In this paper, I present various types of lexical inferences of verbs to support the proposal and suggest a modified event structure.

Key words: *event structure, lexical inference, lexical presupposition, lexical entailment, mereological*

1. Introduction

Event structure, in the Generative Lexicon (hereafter, GL), is a representation level designed to capture lexical aspectual properties of event-denoting expressions. In this paper, I propose to extend event structure by incorporating *lexically inferred subevents* into event structure

*This paper is a developed version of the first part of my PhD dissertation (Im, 2013) and other works (Im & Pustejovsky 2009, 2010), computational linguistic studies to develop an automatic annotation tool of the event structure of English verbs based on the Generative Lexicon theory. In this paper, I give shape to my argument about lexical inferences and event structure in the previous works, focusing on the theoretical issues in linguistics – especially lexical semantics.

and representing inferential relations – presupposition and entailment – between an event and its proper subevents.

There are several motivations for positing lexical inferences as part of event structure. First, event-related lexical inferences offer a standard for classification of event-denoting expressions. For instance, the event structure of creation verbs such as *build*, *create*, *make*, etc. includes subevents inferred lexically due to a particular lexical semantic property of the verbs: a change of existence from *not_exist* to *exist*. Consider the sentences in (1).

- (1) a. John has **built** the house. (perfective reading)
 b. There was not the house.
 c. There is the house.

The creation verb *build* has two lexically inferred states, in addition to the process of building the house. The sentence *John has built the house* presupposes the sentence in (1b) and entails the sentence in (1c). Consider the event structure of *build* according to the GL (Pustejovsky 1995; p. 82).

- (2) Event Structure of *build*
 EVENTSTR = E1 = e1: process
 E2 = e2: state
 RESTR = $<_{\infty}$
 HEAD = e1

Based on the event structure in (2), we cannot exactly capture what changes from what to what, because it does not provide information about lexical inferences of *build* – specially, a lexically presupposed state. Every verb representing a change lexically presupposes a state before the change and entails a result state after that. The presupposed and entailed states provide a semantic clue for lexical semantic classification of verbs.

Secondly, a semantic relation between verb pairs such as *kill* and *die* can only be understood by their inferential relations in the event structure of the verb *kill*. The verb *kill* lexically entails *die*. In addition, the lexical semantic difference between *lead* and *follow* depends on their lexical inferences

related with their event structure. The verbs will be analyzed specifically in section 3.4. A proper lexical semantic theory must have an appropriate mechanism to represent information about lexical inferences related with the event structure of event-denoting expressions, because lexical inferences are crucial to clarify semantic properties of event-denoting expressions and give a criterion for lexical semantic classification of the expressions.

The paper will proceed as follows; I introduce event structure and its components of the GL in section 2. In the following two sections, I describe various types of lexical inferences to support the proposal of this paper. Section 3 is about lexical entailments and section 4 about lexical presuppositions. In section 5, I propose a modified event structure. Section 6 is for conclusion and discussion of future research.

2. Event Structure in the Generative Lexicon

In the GL, event structure is a structured list of events with their types (aspectual classes), the ordering restriction over the events, and the property of headedness. Regarding event types, the GL assumes that subevents can be classified into at least three sorts: processes, states, and transitions. The event structure of process or state verbs is a simplex structure composed of only one subevent. When the event type of an event-denoting expression is a transition, its event structure is a complex structure with plural subevents.

The ordering restriction over event structure represents temporal and mereological (*part-of*) relations between an event and its subevents. It can be one of the three kinds:

- *exhaustive ordered part of* ($<_{\infty}$),
- *exhaustive overlap part of* (\circ_{∞}),
- and *exhaustive ordered overlap* ($<\circ_{\infty}$).

Given that the event e_3 is a complex event structure constituted of two subevents, e_1 and e_2 , the relation of *exhaustive ordered part of* ($<_{\infty}$) states that e_1 temporally precedes e_2 , each is a logical part of e_3 and there is no other event that is part of e_3 (See the event structure of *build* in

(2). RESTR represents the order restriction. The relation of *exhaustive overlap part of* (\circ_{∞}) expresses that e1 and e2 are completely simultaneous temporally as shown in (3).

- (3) a. Mary **accompanied** me while I was walking. (atelic)
 (Pustejovsky, 1995: p. 70)

- b. Mary moved
 c. I moved.
 d. event structure of *accompany*
 EVENTSTR = E1 = e1: process
 E2 = e2: process
RESTR = \circ_{∞}
 HEAD =

The event structure of *accompany*, when it is interpreted as a motion verb, in (3) has two process subevents which happen simultaneously. The relation *exhaustive ordered overlap* ($<\circ_{\infty}$) defines the event e1 containing two subevents e2 and e3, where e2 starts before e3 and overlaps. See an example of an *exhaustive ordered overlap* relation in (4).

- (4) a. I **followed** John to the conference room.
 b. John moved to the conference room.
 c. I moved to the conference room.
 d. event structure of *follow*
 EVENTSTR = E1 = e1: process
 E2 = e2: process
RESTR = $<\circ_{\infty}$
 HEAD =

Unlike *accompany*, the event structure of the verb *follow* presupposes John's moving began slightly earlier than my moving to the conference room. Therefore, the restriction in this case is *exhaustive ordered overlap*.

In addition, event structure of the GL has a way of representing the relative prominence of a subevent comparing with other subevents. The head is the most prominent subevent in the event structure of a

predicate. For instance, the head is assigned to the process subevent $e1$ for accomplishment verbs such as *build*. On the other hand, the GL assumes that an achievement verb like *arrive* assigns the head to the result state ($e2$). See an example of achievement verbs in (5).

(5) *arrive*EVENTSTR = E1 = $e1$: processE2 = $e2$: stateRESTR = $<_{\infty}$ **HEAD = $e2$**

Based on the conceptual design of event structure described above, Pustejovsky (1995) presents twelve kinds of event structure types as shown in (6).

- (6) a. [e^{σ} $e1^* <_{\infty} e2$] – *build* (accomplishment verbs)
 b. [e^{σ} $e1 <_{\infty} e2^*$] – *arrive* (achievement verbs)
 c. [e^{σ} $e1^* <_{\infty} e2^*$] – *give*
 d. [e^{σ} $e1 <_{\infty} e2$] – UNDERSPECIFIED
 e. [e^{σ} $e1^* \circ_{\infty} e2$] – *buy*
 f. [e^{σ} $e1 \circ_{\infty} e2^*$] – *sell*
 g. [e^{σ} $e1^* \circ_{\infty} e2^*$] – *marry*
 h. [e^{σ} $e1 \circ_{\infty} e2$] – UNDERSPECIFIED
 i. [e^{σ} $e1^* <_{\circ_{\infty}} e2$] – *walk*
 j. [e^{σ} $e1 <_{\circ_{\infty}} e2^*$] – *walk home*
 k. [e^{σ} $e1^* <_{\circ_{\infty}} e2^*$] – ??
 l. [e^{σ} $e1 <_{\circ_{\infty}} e2$] – UNDERSPECIFIED

Distinction between accomplishment and achievement verbs depends on the headedness property of the verb classes (See 6a and 6b). (6c) illustrates events involving a subclass of ditransitive transfer verbs such as *give* and *take*. Verb pairs such as *buy* and *sell* are characterized by (6e) and (6f) respectively, where there are two simultaneous events involved in the transaction, but only one is focused by the lexical item (Pustejovsky 1995: p. 73). However, a relational predicate such as *marry* has the heads assigned

on both subevents. Pustejovsky (1995) considers *walk* has an exhaustive ordered overlap restriction.¹ Some verbs are underspecified with no head (6d, 6h, and 6l).

Until now, I explained event structure of the GL in brief. Event structure needs to include lexical inferences of event-denoting expressions in order for it to capture better the lexical meaning of the expressions. In the next two sections, I show several types of lexical inferences. Section 3 treats lexical entailments based on event structure.

3. Event-Related Lexical Entailments

In this section, I explore various types of event structure-related lexical entailments. First, a result state is a subevent in the complex event structure of transition (change) verbs. The GL implies a lexical entailment relation between an event and its result state.² I suggest to represent the entailment relation explicitly. Secondly, some motion verbs have a lexically entailed state – being on the path –, which is simultaneous to the other subevent with a process event type. Section 3.2 discusses this type of entailment. Thirdly, some causative verbs which belong to a process or an accomplishment aspectual class entail a process subevent. In section 3.3, I analyze the lexical entailment of those verbs.

¹ This analysis of the verb *walk* can be arguable. I do not discuss about it in detail here. I just consider *walk* to have the event structure composed of a process and a state which are simultaneous.

² Recent versions of the GL such as Pustejovsky and Moszkowicz (2008) imply more positively the lexically entailed states, as pointed out by a reviewer. A main focus of this paper is to represent lexical inferences including lexical presuppositions as well as lexical entailments explicitly in the event structure. Moreover, I think the types of inferential relations between an event and its proper subevents should be encoded as a component of event structure. Of course, many issues resulting from this change, including relations to other representation levels such as argument structure and qualia structure, must be studied carefully in the future.

3.1 Result States as Lexical Entailment

Most complex event structures consist of a process and a result state. See the event structure of the change-of-location verb *arrive* below.

(7) a. John has **arrived** at school. (perfective reading)

b. John is at school.

c. Event structure of *arrive*

EVENTSTR = E1 = e1: process

E2 = e2: state

RESTR = \langle_{∞}

HEAD = e2

In (7c), e1 represents the process of John's arriving and e2 the result state that John is at school. The sentence in (7a) entails semantically the sentence in (7b) which denotes the result state e2, since the latter is always true when the former is true.³ That is, if John has arrived at school, John is necessarily at school as a result. The entailment is based on the event structure of the verb *arrive*. If the relation between then sentence in (7a) and that in (7b) is a presupposition, the latter sentence must be true under the negation of the former. See the sentences in (8).

(8) a. John has not **arrived** at school.

b. John is at school.

The sentence *John has not arrived at school* (8a) does not entail the sentence *John is at school* (8b (=7b)),⁴ since when the sentence in (8a) is true, the sentence in (8b) is not true. If John has not arrived at school, John cannot be at school. Therefore, the sentence in (7a) does not presuppose the

³ I define an entailment relation semantically, following the GL (Pustejovsky 1995: p. 24). An expression A *semantically entails* B if and only if every situation that makes A true, makes B true.

⁴ I adopt the definition of semantic presupposition. A *semantically presupposes* B if and only if both (a) in all situations where A is true, B is true, and (b) in all situations where A is false, B is true (Pustejovsky 1995: p. 24).

sentence in (7b (=8b)). Consider the conjunction of the two sentences in (9).

- (9) a. #John has not arrived at school **and** John is at school.
 b. John has arrived at school **and** John is at school.

The conjunction of the two sentences in (9a) is semantically odd but that in (9b) is acceptable. The conjunction test shows that the sentence *John has arrived at school* entails but does not presuppose the sentence *John is at school*. The change-of-location verb *arrive* entails the result state of the arriving event – John’s being at school. This kind of entailment can be applied to all verbs denoting change.

3.2 Other Lexically Entailed States

In addition to change verbs that have a lexically entailed result state, there are other verb classes with a lexically entailed state in their event structure. Motion verbs such as *walk* and *pass* have a lexically entailed state simultaneous with a moving process. Since a moving event naturally presupposes a path of moving, it always entails the state in which a mover is on the path. Usually, the event type of a typical motion verb *walk* is thought of as a process, whose event structure is simple. But I argue that the event structure of *walk* is composed of a process subevent denoting a motion process and a state in which a mover is on the path, as presented in (10c).

- (10) a. John **walked** slowly.
 b. John was on the path of walking.
 c. Event structure of *walk*
 EVENTSTR = E1 = e1: process
 E2 = e2: state
 RESTR = \circ_{∞}
 HEAD = e1

The sentence which denotes John’s walking in (10a) entails the sentence in (10b), since if John walked slowly, then it is true that John was on the path of walking. In (10a), the walking path is not realized syntactically. But it

is considered as a default argument, in terms of the GL, which is logically necessary for the verbs which denote motion events. The path of moving is syntactically realized in the following sentence in (11).

- (11) a. John **walked** along the street.
 b. John was on the street.

The prepositional phrase headed by *along* is a path argument of *walk* in the sentence of (11). John was on the street while John was walking along the street. Therefore, the sentence in (11a) entails the sentence in (11b). The entailment relation between the two sentences results from the lexical meaning of the motion verb *walk*.

Another example is a change-of-location verb such as *pass*. The verb *pass* takes a path argument realized as a syntactic object.

- (12) a. John is **passing** the bridge
 b. \rightarrow John is on the bridge.
 (13) a. John is not **passing** the bridge.
 b. \nrightarrow John is on the bridge.

From the test of presupposition in (12) and (13), we conclude that the sentence *John is passing the bridge* entails but does not presuppose the sentence *John is on the bridge*.

However, every change-of-location verb does not have a lexically entailed state mentioned above. For example, the verb *transfer* does not take an expression which denotes a path as its necessary argument, even though it is a change-of-location verb. It requires only source and goal arguments as its default arguments. See the sentence in (14).

- (14) The patient **transferred** to another hospital.

The path of the patient's moving is not exactly captured by the sentence in (14). The verb *transfer* is an achievement change-of-location verb which does not require a path argument as its necessary argument. For that kind of change-of-location verb, we cannot postulate the lexically entailed state

of the agent's being on the path when the event occurs. All achievement change-of-location verbs including *arrive* and *leave* belong to this group.

To sum up, I argued that most motion verbs whose aspectual class is a process or an accomplishment have a lexically entailed state – being on the path of moving – which is simultaneous with the process of moving. However, motion verbs which belong to the achievement aspectual class do not entail the state – agent's being on the path –, because a path argument is not necessary logically for them. Until now, I showed some verbs which entail a state subevent. However, some verbs entail a process subevent lexically. In the next section, I show the examples of verbs which have a lexically entailed process subevent in their event structure.

3.3 Lexically Entailed Processes

In this section, I show lexically entailed processes. First, causative motion verbs such as *walk* (causative) have a lexically entailed process as one of its subevents. The verb *walk* can be used as a causative motion verb as presented in (15).⁵

- (15) a. John is **walking** his dog. → His dog is walking.
 b. John is not walking his dog. ↗ His dog is walking.

The sentence *John is walking his dog* entails *his dog is walking* but not presupposes it as the presupposition test in (15) shows it. Causative motion verbs such as *lead* and *guide* also belong to the group of verbs that have a lexically entailed process. The verb *guide* has two process subevents: a causer's moving and a causee's moving.

⁵ As a reviewer pointed out, examples of causative-unaccusative alternations of the kind 'John walked' vs. 'John walked his dog' or 'John broke the vase' vs. 'The vase broke' have been analyzed as instances of subevent foregrounding within the same event structure in a number of previous studies including the GL and Pustejovsky and Busa (1995). Nevertheless, the examples presented in this paper assume a separate event structure for each of them. In this paper, I take a neutral position and leave it for the future research since the main purpose of this paper is to show the motivations for introducing lexical inferences into event structure and propose a modified event structure.

- (16) a. John **guided** me to the conference room.
 b. → John moved (to the conference room).
 c. → I moved (to the conference room).

In (16), John's guiding of me to the conference room entails moving of both John and me to the conference room.

- (17) a. John did not **guide** me to the conference room.
 b. ↗? John moved (to the conference room)
 c. ↗? I moved (to the conference room)

The presupposition test in (17) shows that the verb *guide* does not necessarily presuppose that both John and I moved. Causative and interaction verbs such as *walk* and *guide* lexically entail a process subevent. In the next subsection, I show some examples of lexically entailed events – transitions.

3.4 Lexically Entailed Transitions

In the introduction, I pointed out that the semantic relation between *kill* and *die* is defined by their lexical inferential relation based on the event structure of the verb *kill*. Most causative verbs entail their corresponding unaccusative verbs. Consider the two sentences in (18).

- (18) a. John **killed** Mary.
 b. Mary **died**.

If John killed Mary, she has died. But it is not true that she has died in the case that John did not kill Mary. Therefore, the verb *kill* entails the verb *die* lexically. Mary's dying is a subevent in the event structure of the verb *kill* in the sentence of (18a). The event-related entailment relation is different from the ontological entailment relation such as hypernymy or synonymy. Compare the relation between *kill* and *die* in (18) with the semantic relation of *kill* and *murder* in (19).

- (19) a. John **murdered** Mary.

b. John **killed** Mary.

Although the verb *murder* entails *kill*, the latter is a hypernym (or synonym) of the former. It is important that the entailment relation between *kill* and *die* is based on their event structural property, not the other semantic relations such as synonym or hypernym. The event structure-based lexical entailment relation should be encoded as a component of event structure, since it is a relation between the matrix event of killing and its subevent: dying.

Another interesting example of a lexically entailed transition is the so-called interaction verbs such as *lead* and *follow*. Consider the sentences in (20).

- (20) a. John **lead** me to the conference room.
 b. I **followed** John to the conference room.

If John lead me to the conference room, it is true that I followed John to the conference room. Therefore, the verb *lead* entails *follow* lexically. Most interaction verbs such as *lead*, *follow*, *sell*, etc. show this kind lexical entailment relation to their corresponding verbs.

I point out that a specific analysis of the verb groups which have lexical entailments is not the aim of this paper. What I focus on here is the argument that event structure should represent the lexical entailments mentioned above. There can be many verb classes which entail various kinds of subevents lexically and we need to study which verb class has what kind of lexical entailments. I leave the issues for the future research. I turn to event-related lexical presuppositions in section 4.

4. Event-related Lexical Presuppositions

In this section, I explore two types of lexical presuppositions: processes and states. There are some previous studies that mention lexically presupposed processes. In section 4.1, I show a preparatory process for durative achievement verbs, suggested by Caudal (2005), as an example of a lexically presupposed process. Section 4.2 describes another type of

lexically presupposed process that Engelberg (2006) observed. Finally, I introduce several kinds of lexically presupposed states in section 4.3.

4.1 Preparatory Processes for Durative Achievement Verbs

Caudal, in his research paper about the Stage Structure Theory (2005), suggests a preparatory stage as a lexical presupposition for a special kind of achievement verbs named durative achievement verbs.⁶ According to Caudal (2005), preparatory stages are causal stages instantiated for some types of atomic (so-called ‘punctual’) telic situations.⁷ It is a traditional point-of-view on achievement verbs that they do not have a durative process in their event structure. Consider the data from Martin (2010) and Caudal (2005) below.

- (21) a. #He partially/partly **reached** the summit.
 b. *He carefully **won** the race.

Achievement verbs are incompatible with adverbs of completion such as *partially* and *partly* as shown in (21a). Moreover, they cannot co-occur with agentive adverbs like *carefully*. See the sentence in (21b). They cannot be embedded under aspectual verbs like *stop* or *finish*, because one cannot stop or finish a process which has not duration at all (See the sentences in (22)).

- (22) a. *He stopped **reaching** the summit.
 b. *He finished **winning** the race.

⁶ See Caudal (1999) for a full account of durative achievement verbs. I doubt if the preparatory process for the durative achievement verbs is a necessary subevent in the event structure of the verbs. The issue may be related with various questions: what is defined as a presupposition?; what kind of information should be included in the event structure of a lexical item?; how different is lexical semantics from lexical pragmatics?; etc. I leave the issue for the future research. I just cite Caudal (2005) and Engelberg (2006) in order to motivate the incorporation of various kinds of lexical presuppositions into event structure.

⁷ Caudal does use the terms *stage* and *situation* instead of *subevent* and *event*, respectively in his Stage Structure theory (Caudal 2005).

Nevertheless, achievement verbs such as *win* are perfectly compatible with the progressive, contrary to Vendler (1957)'s distinction between achievement and accomplishment. See an example in (23).

(23) He was **winning** the game.

Several researchers argue that the kind of achievement verbs are in fact durative ones which presuppose a durative process that prepare for the culmination of the whole event (Caudal 1999, 2002; Kearns 2003; Engelberg 1999, 2000; etc.). I show an example below to help readers understand what a preparatory process is.

- (24) a. John **reached** the summit.
 b. John did not **reach** the summit.
 c. John was reaching the summit. (John was approaching the summit.)

When the sentence in (24a) is true, the sentence in (24c) is true. The sentence *John was reaching the summit* remains true under the negation of the sentence in (24a). Therefore, the sentence in (24c), a preparatory stage for the culmination, is a presupposition of the sentence in (24a). The preparatory stages are selected under prospective readings of the past progressive. Caudal (2005) argues that the preparatory stage is peripheral to the stage structure and has a presuppositional status.⁸ Engelberg (2004, 2006) support the idea that a preparatory process is a lexical presupposition. I introduce another type of lexically presupposed process observed by Engelberg (2006) in the next subsection.

4.2 Other Lexically Presupposed processes: Engelberg (2006)

The lexically presupposed processes described in this section are different from the preparatory process (or stage) mentioned above, in that it is not a preparing process for culmination of the core event but just an independent

⁸ This issue is closely related with his idea about salience. I leave it for the future research.

presupposed process. Engelberg (2006) shows an example of the lexically presupposed process. Consider the German verb *fangen* ‘to catch’ in (25).

- (25) a. Sie **fang** den Ball. ‘She **caught** the ball.’
 b. Sie *fang* den Ball nicht. ‘She did not catch the ball.’
 c. The ball was flying.

Both sentences in (25a) and (25b) entail the sentence in (25c). Therefore, the verb *fangen* ‘to catch,’ in the sense of ‘catch a flying object,’ presupposes the process ‘the ball’s flying.’ It does not indicate her activity of preparing to catch the ball. It is just a process in which the ball, an affected theme, was flying. The process ends when the catching event culminates. Thus, the ball is no longer flying as a result.

According to Engelberg (2006), verbs of interaction like *folgen* ‘follow,’ *antworten* ‘answer,’ *nachgeben* ‘give in,’ and *trotzen* ‘defy’ are another instances with the kind of presupposed process. I show the LES⁹ of *folgen* ‘follow’ in (26). In the first subevent, a presupposed process, a participant (y) acts. The other participant (x) acts in the second subevent.

- (26) **folgen** ‘follow’
 LES: ($\rightarrow_P e^{1[+DUR]}$; $y^{ACTIVITY/...}$) \circ ($\rightarrow_1 e^{2[+DUR]}$; $x^{ACTIVITY/...}$)

In this section, I showed examples of lexically presupposed processes observed by Engelberg (2006). I agree with Engelberg (2006) about the lexical presuppositions presented in this section. The next subsection turns to lexically presupposed states.

4.3 Lexically Presupposed States

I present another type of lexical presupposition – a lexically presupposed state in this section. All verbs denoting change are supposed to have a (or more) lexically presupposed state(s), since they have the meaning of change

⁹ The Lexical Event Structure (LES) is a structure which represents lexical semantic information in the lexical semantic theory, named the Lexical Event Structure Theory, developed by Engelberg (2004, 2006).

from a state to another state. For example, the change-of-location verb *reach* has a lexically presupposed state. Consider the sentences in (27).

- (27) a. John has **reached** the summit.
 b. John was not on the summit
 c. John hasn't **reach** the summit.

If the sentence in (27a) is true, the sentence in (27b) is also true, since it is impossible for John to be on the summit until John reaches the summit. When the sentence in (27c) is true, the sentence in (27b) is true, too. The test of presupposition shows the sentence in (27b) represents a lexically presupposed state subevent of the event denoted by the sentence in (27a). See a conjunction test for presupposition in (28).

- (28) a. #John_i had been on the summit and he_i reached the summit.
 b. John_i had **not** been on the summit and he_i reached the summit.

The conjunction test in (28) shows the state of John's not being on the summit is a presupposition of the event of John's reaching on the summit.

Another group of change-of-location verbs also presupposes a state before an event happens. The verb *leave* lexically presupposes the state of an agent's being at the source location before the beginning of an event.

- (29) a. John has **left** the library. → John was in the library.
 b. John hasn't **left** the library. → John was in the library.

In (29a), the sentence *John was in the library* is true, when the sentence *John has left the library* is true. As shown in (29b), John's being in the library remains true even under the negation of the sentence. It shows that the verb *leave* presupposes the state of John's being in the library in the sentence *John has left the library*.

Another motion verb *pass*, which belongs to an accomplishment verb class, also has its own lexical presupposition.

- (30) a. John is **passing** the bridge. → John was not on the bridge

- b. John is not **passing** the bridge. → John was not on the bridge.

Before the passing event began, John was not on the bridge. If John was already on the bridge, John could not begin passing the bridge. Under the negation of the sentence in (30b), the sentence *John was not on the bridge* is true. The presupposition test in (30) shows that *pass* presupposes the state that a mover is not on the path.

Until now, I explored the lexically presupposed states of change-of-location verbs. I apply the idea of a lexically presupposed state to all change verbs with complex event structure such as change-of-state and change-of-possession verb classes. Creation verbs such as *build* represent the change of existence from non-existence to existence. That is to say, something which has not existed becomes to exist by the creation event.

- (31) a. John has **built** the bridge. (perfective reading)
 b. There was not the bridge.
 c. There is the bridge.

Since the sentence in (31c) is true if the sentence in (31a) is true, the former entails the latter – a resultant state of the building event. The sentence in (31b) is a presupposition of the sentence (31a). See the sentences in (32)

- (32) a. John has **built** the bridge. (perfective reading)
 b. John has not **built** the bridge. (perfective reading)
 c. There was not the bridge.

Because both (32a) and (32b) entail (32c), the sentence (32c) is a presupposition of the sentence (32a). The presupposition relation results from the lexical semantic property of the creation verb *build*.

Since a change-of-possession verb represents that a theme moves from its possessor to another person, the event denoted by a verb in the class presupposes that someone possessed a theme before the change of possession. I show an example of the typical change-of-possession verb *give* below.

- (33) a. John has **given** the book to Mary. (perfective reading)
 b. John had the book.
 c. Mary didn't have the book.

The change-of-possession verb *give* lexically presupposes two states, which are linked to a giver and a receiver, respectively. The sentences in (33b) and (33c) show the presuppositions. First, the sentence *John has given the book to Mary* presupposes that John had the book before the giving event occurred.

- (34) a. John hasn't **give** the book to Mary. → John had the book.
 b. John hasn't **give** the book to Mary → Mary didn't have the book.

Under the negation of the sentence (33a), the sentence *John had the book* is still true, as shown in (34). Therefore, the sentence (33a) presupposes *John had the book* (33b). Likewise, *give* presupposes the state in which Mary didn't have the book before the event happened.¹⁰

Until now, I described various kinds of lexical inferences of verbs related with their event structure¹¹. Based on the observation, I suggest a modified version of event structure in which lexical inferences are encoded.

¹⁰ Assuming it is impossible that both John and Mary have the book at the same time, the two presuppositions might be complementary and thus representing both in the event structure of *give* may be logically redundant. However, the assertion is arguable since there are many things people can share. For instance, information-like things can be shared by many people at the same time. Even though a person give an information to another person, (s)he still has the information. I do not delve into the issue here.

¹¹ There are restitutive verbs with the prefix *re-* which presuppose the occurrence of an event. Since the analysis of the verbs is not so simple, I will prepare a research paper for the verbs in the future. Refer to Marantz (2007) and Wunderlich (2001) for the morpho-syntactic and semantic approaches. In addition, the research papers about the adverb *again* and its presupposition (Pederson 2014; Dobler 2008a, 2008b) will give some insight to the study of restitutive verbs.

5. Modified Event Structure

In section 5.1, I discuss why lexical inferences should be represented in the event structure. I reconsider how to partition an event in section 5.2. Section 5.3 discusses how to incorporate event-related lexical inferences into event structure in the GL and what should be changed as a result of the incorporation, focusing on the mereological treatment of event structure, ordering restriction, and headedness. In the last section, I show the modified event structure frame as a summary.

5.1 Why do Lexical Inferences have to be encoded in Event Structure?

Why do the lexical inferences need to be incorporated into event structure? All kinds of lexical inferences are not necessarily related with event structure. Compare the verbs *build* and *construct* in (35).

(35) John **built** the bridge. \longleftrightarrow John **constructed** the bridge.

The two sentences in (35) have a mutual entailment relation between each other. However, the entailment relation does not rely on the event structure of *build* and *construct*. The verb *build* is a synonym of *construct*. The inferences based on an ontological relation are not subevents represented in the event structure of *build* or *construct*.

On the contrary to the lexical inference mentioned above, the event-related lexical inferences are only derived by a subeventual analysis of the event denoted by a verb. For instance, I analyze the inferences of the sentence in (36a).

- (36) a. John has **built** the bridge. (perfective reading)
 b. There **was not** the bridge.
 c. There **is** the bridge.

The sentence in (36a) presupposes the sentence in (36b) and entails the sentence in (36c). Both the presupposition and the entailment are based on the event structure of the creation verb *build*. The inferences in (36b)

and (36c) cannot be recognized without a subeventual analysis of the verb *build*. Therefore, information about event-related lexical inferences should be encoded in the event structure. In the next section, I discuss about the partition of an event.

5.2 Partition of an Event

The event denoted by an expression, if it has a complex event structure, is usually decomposed to two subevents: e1 (process) and e2 (result state). The achievement verb *arrive* has a bipartite event structure with two subevents, as presented in (37).

(37) *arrive*

EVENTSTR = E1 = e1: process

E2 = e2: state

RESTR = \langle_{∞}

HEAD = e2

However, I showed that there are more than two subevents in the event structure of verbs of change. Event structure does not need to be a bipartite structure. I define event structure as a structured list of event parameters, following the GL. Nevertheless, event structure can be roughly considered to have three semantic parts below.

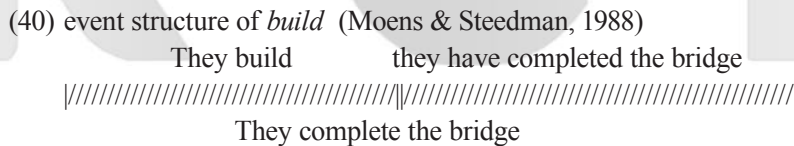
- **Presupposed subevents;**
- **The core process** of the event;
- **Entailed subevents**

Although the number of subevents is not restricted quantitatively, pragmatic inferences cannot be encoded in the event structure. Lexical inferences should be distinguished from pragmatic (contextual) inferences and event structure has to include only lexical inferences. Nishiyama & Koenig, in their paper about a perfect state (2004), separated the lexical entailment (38a) from the conversational implicature (38b) for the sentence *Ken has broken his leg*, as presented in (39).

- (38) Ken has broken his leg.
a. Ken’s leg is broken.
b. Ken is behind in his work.
- (39) a. **Lexically entailed** resultative perfect reading: $X(s) = \text{Ken’s_leg_be_broken}(s)$
b. **Conversationally Implicated** resultative perfect reading:
 $X(s) = \text{Ken_be_behind_in_his_work}(s)$

According to them, the state that Ken’s leg is broken (38a) is a subevent in the event structure of *break* in (38) but the state that Ken is behind in his work (38b) is excluded. The principle that only lexical inferences are to be subevents restricts the number of subevents.

In addition, I reject the approach that treats a culmination as a separate subevent and postulates a tripartite event structure (Moens & Steedman 1988, Kamp & Reyle 1993, and the VerbNet group (Dang et. Al. 2000, Kipper et. Al. 2000)). Consider the event structure of the verb *build* analyzed by Moens & Steedman (1988) in (40).



According to the diagram in (40), the event structure of *build* is composed of three subevents: a preparatory process (*they build*), a culmination (*they complete the bridge*), and a consequent state (*they have completed the bridge*). A culmination is an event which the speaker views as punctual or instantaneous, and as accompanied by a transition to a new state of the world. This new state is referred to as the consequent state of the event. A preparatory process means any process before the culmination of an event. Patrick Caudal, in his paper about stage structure (2005), criticizes the tripartite structure approach, arguing that a culmination is merely the endpoint of the first stage, that is, a process. I adopt Caudal (2005)’s point-of-view.

5.3 Relations between an event and its subevents

In section 5.3, I explore the relational properties of components of the modified event structure. Event structure in the GL has mereological (part-of) relation, order restriction, and headedness as its relational properties. In 5.3.1, I suggest to withdraw the mereological treatment of event structure.

5.3.1 Mereological Treatment of Event Structure

The original approach to event structure in the GL adopts the mereological treatment of the relation between an event and its subevents. That is, all subevents are exhaustive parts of an event. However, researchers such as Caudal criticize the mereological analysis of event structure.¹² I do not delve into Caudal's argument about the *part-of* relation. But we need to think about what is the range of an event. For that purpose, let us consider the embedding of the event-denoting expressions under the aspectual verbs such as *begin* and *finish*.

- (41) a. John **began** to build the house.
 b. John **finished** building the house.

Under the aspectual verbs *begin* and *finish*, the event of building the house only includes the process of building the house. Specifically, a result state is usually included in the event structure as a part of an event but it is not exactly a part of the event as we recognize from the test of the aspectual verb *finish* or *end*. Rather, it is an entailed (or caused) state. Event-related lexical presuppositions also are temporally before the beginning of an event. Nevertheless, lexical semantic approaches interested in lexical aspectual analysis of event-denoting verbs assume the subeventual analysis with event structure-like frames as a part of their lexical semantic representation system. It is because the subeventual analysis gives a big help to explain many linguistic phenomena such as selection restriction, argument

¹² Caudal (2005)'s critic point is that the mereological treatment of event structure cannot account for the salience.

alternation, and lexical inferences. I withdraw the mereological treatment of the event structure.¹³ Instead, I suggest to add inferential relations between an event and its subevents into event structure as its component.

I point out that my analysis is slightly different from Pustejovsky (2000) regarding the temporal ordering relation between an event and its lexically presupposed subevents. Pustejovsky (2000) only considers the time interval in which an event occurs. However, I assume that its lexically presupposed subevent is already in progress when an event begins, considering the time interval before the occurrence of an event.¹⁴ The lexically presupposed subevent does not need to terminate necessarily when an event begins.

5.3.2 *Semantic Relation between Presupposition and Entailment*

Superficially, the relation between presupposed states and entailed result states based on event structure might seem to be just a logical negation relation. Consider the lexical presupposition and the lexical entailment of the verb *build* presented in (42).

- (42) a. SENTENCE: John has built the house.
 b. LEXICAL PRESUPPOSITION: There was not the house.
 c. LEXICAL ENTAILMENT: There is the house.

It is true that the presupposition in (42b) is a logical negation of the entailment in (42c). However, the semantics of opposition (Pustejovsky, 2000) for change verbs provides the grounds of the argument that the opposition relation between the presupposed state and the entailed result state is not simply a logical relation. The logical negation is derived from the lexical semantic property related with subeventual analysis of change

¹³ A reviewer pointed out that the examples with aspectual verbs such as *begin* and *finish* do not necessarily prove that the event of building only includes the process. But I think if subevents are temporally parts of a matrix event, the test with aspectual verbs is appropriate. A problem is what kind of criterion should be applied to decide the boundary of an event. This will be one of the future research topics. I will study more research including Piñón's work on mereological treatment of event structure.

¹⁴ The beginning time of a lexically presupposed subevent is usually unknown.

verbs. Pustejovsky (2000) proposes the *Event Persistence Structure* (EPS) and defines it as in (43), so that it can represent “contradictions of change”.

(43) **Event Persistence Structure**

Event Persistence Structure is an annotated event structure, with event predicates showing the scope appropriate to their opposition structures, relative to the matrix event predication denoting change and persistence of the various arguments.

Pustejovsky (2000) argues that the effect of the activity of fixing the faucets will render the description *leaky* applied to each faucet as contradictory in (44a); similarly, in (44b), the felicity of the description *powdered* applied to the milk is true only before the completion of the event of mixing and not after.

- (44) a. Mary **fixed** every leaky faucet in the house.
 b. John **mixed** the powdered milk into the water.

A finer model of change is needed within semantic theory to handle such phenomena. Furthermore, this model must incorporate the properties of *persistence* over the event as well as *change*.

There are two kinds of opposition structure: binary opposition and polar opposition. When there are only a term and its opposition and there is no middle term between them, the opposition structure is a binary opposition. In that case, if the negation of a term has its lexical form, it also is a binary opposition. On the other hand, if there are middle terms between two polar terms, the opposition is a polar opposition. I show examples of opposition structure in (45).

(45) Examples of Opposition Structure

- a. <alive, dead>, <alive, ¬alive>: **Binary opposition**
 b. <short, tall>: **Polar opposition**

The opposition relation between presuppositions and entailments is not

simply a logical negation in the modified event structure. Rather, the relation reflects the crucial lexical semantic property of change verbs. In the next subsection, I mention the temporal ordering restriction and headedness.

5.3.3 Temporal Ordering Restriction and Headedness

The temporal ordering restriction in the GL is still important to define the relations among subevents in the modified event structure. I adopt the three temporal ordering relations in the GL: precedence ($<$), overlap (\circ), and ordered overlap ($<\circ$). Consider the following examples.

- (46) E1 = John is walking his dog.
 se1 = John is walking.
 se2 = His dog is walking.
 se3 = John is causing his dog walking.
 RESTR = se1 \circ se2, se2 \circ se3

In (46), the causative verb *walk* entails the subevents se1, se2, and se3, which happen simultaneously. Therefore, the temporal ordering restriction between them is overlap. Now, let us consider the temporal ordering relations between subevents for change verbs with complex event structure.

- (47) E1 = John has arrived in Seoul.
 se1 = John was not in Seoul.
 se2 = John's arriving in Seoul
 se3 = John is in Seoul.
 RESTR = se1 $<\circ$ se2, se2 $<$ se3

The change-of-location verb *arrive* has three subevents as shown in (47). The subevent se1 is a lexically presupposed state and se2 is a process. The last subevent se3 is a lexical entailment, which is a result state. When the state se1 began is unknown but the state remains until the arriving ends. Therefore, the subevent se1 overlaps another subevent se2. On the other hand, se2 precedes se3.¹⁵ Contrastively, the temporal ordering between

¹⁵ Since the end point of the arriving is the beginning point of the result state, the

subevents of the verb *leave* is as shown in (48).

- (48) E1 = John has left Seoul.
 se1 = John was in Seoul.
 se2 = John's leaving Seoul
 se3 = John is not in Seoul.
 RESTR = se1 < se2, se2 <◦ se3

I keep a temporal ordering restriction as a component of the modified event structure.

Because the modified event structure I propose here is roughly composed of three parts, headedness also may be more complicated than that in the GL. I have some questions about headedness. First, is the headedness a necessary component of the modified event structure? Second, what would be the role of headedness? What would be the relation between headedness and Caudal (2005)'s salience? Caudal (2005) argues that the headedness cannot account for the salience relation of subevents. Comparing between headedness and salience will give an insight to research on headedness in the modified event structure.

5.4 A Modified Event Structure Frame

I proposed that event structure should include lexical inferential relations between an event and its subevents. In order to support the proposal, I presented many types of lexical presuppositions and entailments which are related with the event structure of verbs. In addition, I suggested to withdraw the mereological treatment of event structure. Although the event structure need not to be a bipartite structure, it should include only event-related lexical inferences and exclude the other inferences. For now, temporal ordering restrictions between subevents and headedness remain as components of the event structure. Considering what I mentioned, I show the modified event structure frame below.

- (49) Event Structure of an event *eI*

temporal restriction might be an ordered overlap (<◦).

Event ID = e1
Subevents = {se1, se2, ...}
Inference = { \rightarrow_P , \rightarrow_E }
Temporal restriction = {<, o, <o}
Head = *
EVENTSTR = EID =
 SUBEVENTS =
 INFERENCE =
 RESTR =
 HEAD =

The subscripted P represents a presupposition and the subscripted E means an entailment. The inferential relations between an event and its proper subevents are encoded by INFERENCE in the modified event structure. I show the modified event structure of the verb *arrive* as an example in (50).

(50) Event structure of *arrive*

SENTENCE = John **arrived** in Seoul.

EVENTSTR = EID = e1

SUBEVENTS = [se1: state, se2: process, se3: state]

INFERENCE = e1 \rightarrow_P se1; e1 \rightarrow_E se2; e1 \rightarrow_E se3

RESTR = se1 <o se2; se2 < se3

HEAD = se3

The event structure of *arrive* in (50) is a modified version of event structure. The three subevents include a lexically presupposed state, a core process of arriving, and the lexically entailed state (a result state). EID means the id of the matrix event *John's arriving in Seoul*. SUBEVENTS represents a list of subevents. INFERENCE expresses the lexical inferential relations between the matrix event and its subevents. RESTR represents the temporal ordering relations between subevents. HEAD represents headedness.

6. Conclusion

The aim of this paper was to propose that lexical inferences be incorporated

into event structure. In order to support the proposal, I described various kinds of lexical inferences including entailment and presupposition.

Incorporating lexical inferences into event structure results in various changes regarding event structure in the GL. First, an event does not have a part-of relation to its subevents. Rather, the relation between the two is defined as an inferential relation. Secondly, event structure can have as many subevents as possible but the subevents must be event-related lexical inferences, not contextual implicatures. In addition, event structure roughly consists of lexical presuppositions, a core process, and lexical entailment. Thirdly, a temporal ordering restriction can be more complicated than that of the GL because it must show temporal relations between all subevents. Fourthly, headedness also becomes more complicated or it might be changed (or removed). These issues remain for the future research. As well, classification of lexical inferences depending on different verb classes is one of interesting future works.

In spite of many issues not solved yet, I think this research will give some challenge to event structure theory, specially the GL. Furthermore, this work is very useful for textual inferences tasks in computational linguistics, as shown already in Im (2013). Stede (1996) also includes pre-state, activity, and post-state in the event structure of a transition event.

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